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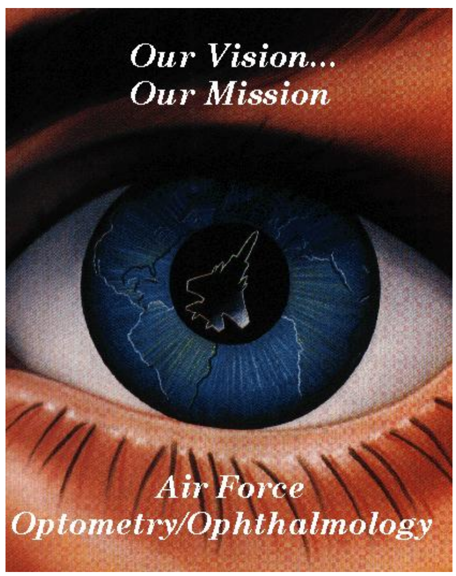
Ophthalmic Journeyman

Volume 3. Ophthalmic Optics and Spectacle Procedures



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Material in this volume is reviewed annually for technical accuracy, adequacy, and currency. For SKT purposes the examinee should check the *Weighted Airman Promotion System Catalog* to determine the correct references to study.

THIS THIRD VOLUME covers ophthalmic math, optics, and spectacle availability and ordering information. Specifically, unit 1 covers math principles, metrics, and US customary measurements; the relationship between diopters and focal lengths; and basic optic theory, reflection, and refraction. After getting this foundation of knowledge, unit 2 will take you to a higher level of optical application by looking at the forms of lenses, the optical cross, transposition, spherical equivalents, and converting multifocals to single vision prescriptions. Then, the unit delves into the specifics of which lenses, tints, coatings, and frames are available from military labs. Finally, unit 2 wraps up with a lesson on selecting the correct frame for a patient and taking spectacle measurements such as interpupillary distance (PD) and segment height measurements. Unit 3 covers the ordering of spectacles both manually and through SRTSweb. Next, the unit discusses how to verify, repair, and adjust spectacles. It concludes with a lesson on how to handle fit issues unique to flight equipment. It sounds like a lot of material, and it is. Most of it should be familiar to you—especially since you have been working in the clinic a while now and have certainly been exposed to some of these topics already.

This entire course is designed to build upon information you received at your technical training, allowing you to then apply your better understanding of the material to your “hands-on experiences” at your clinic.

A glossary is included for your use.

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To get a response to your questions concerning subject matter in this course, or to point out technical errors in the text, unit review exercises, or course examination, call or write the author using the contact information on the inside front cover of this volume.

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This volume is valued at 27 hours and 9 points.

NOTE:

In this volume, the subject matter is divided into self-contained units. A unit menu begins each unit, identifying the lesson headings and numbers. After reading the unit menu page and unit introduction, study the section, answer the self-test questions, and compare your answers with those given at the end of the unit. Then complete the unit review exercises.

Please read the menu for Unit 1 and begin ➔

Unit 1. Ophthalmic Optics and Spectacle Procedures

OPTICS IS A BIG SUBJECT, but it is also very interesting. Understanding optics means understanding principles of math, light, and physics. In the ophthalmic clinic, this information is vital since we apply our knowledge of optics when testing, refracting, and correcting patients' vision. Knowledge of optics and light can help you understand various ocular problems and explain them in a clear manner to your patients. This unit is devoted to optics and those items associated with optics—everything from the mathematical and light principles of geometrical optics to the actual types of lenses and knowledge of prescriptions in ophthalmic optics. The information should be familiar to you since you've already completed 3-level technical school. Consider this a refresher of knowledge you may have received already, with some additional material added to increase your level of understanding.

1–1. Basic Optics

It is important you have the basic theories, facts, and principles of light down so you can apply the information to help your patients. Patients often ask the difference between plus (+) lenses and minus (–) lenses. When patients get the pinhole test, they often ask why they see better looking through the hole. You need to know what to tell them. If you understand principles of light and optics, you should be able to answer these patients intelligently. This will satisfy the patients' curiosity and enhances their respect and trust for you.

In addition to the basics of light and optics, you'll need a basic comprehension of math to assist your patients as well. What does math have to do with optics? Consider how often you use your knowledge of math in the ophthalmic clinic. You do basic addition and subtraction when you convert a prescription from a bifocal (BF) or trifocal (TF) into a single vision near or intermediate prescription. You also use math when you have to transpose a prescription from one cylinder form to another. You use multiplication and division in establishing letter size for eye lanes less than 20 feet in length, for converting dioptric powers into focal lengths (FL), and vice versa. You sometimes convert from centimeters (cm) to millimeters (mm) for prismatic calculations, and sometimes you get measurements in meters and centimeters you really need in feet or inches. As you see, math definitely has a lot to do with optics.

401. Algebraic addition, multiplication, and division

Math does not have to be your favorite subject. You do not even have to be great at it. You only have to be able to add, subtract, multiply, and divide. If these are areas you need a little help or a refresher in, this lesson of instruction should provide that assistance.

Algebraic addition

Algebraic addition is simply combining two or more numbers together: 1+1=2. In the ophthalmic clinic, it is more like the following: (+)1.00 + (+)1.00 = (+)2.00, with the (+) indicating a plus (+) lens. It might help you to think of algebraic addition in terms of dollars and cents. Just using a bunch of numbers without reference can be confusing sometimes, but thinking of the numbers as money can make it much easier to understand. So, occasionally, monetary examples are used in this lesson.

Algebraic addition of two positive (+) numbers

Algebraic addition of two (or more) positive (+) numbers always results in a positive (+) answer. You simply add the numbers together and give the answer a plus sign (+). If the numbers have decimals in them, line the decimal points up, and add each column.

$$\begin{array}{r} +2.50 \\ \underline{+1.75} \\ +4.25 \end{array}$$

Thinking in terms of money, if you have (**+**) $2.50, and you are given (**+**) $1.75, how much do you have together? You have (+) $4.25.

Algebraic addition of two negative (–) numbers

Algebraic addition of two (or more) negative (–) numbers always results in the answer being a negative (–) number. Simply add the negative numbers together, just like in the previous examples, but give the answer a minus (–) sign.

$$\begin{array}{r} -2.50 \\ \underline{-1.75} \\ -4.25 \end{array}$$

In terms of money, say you owe a friend (**–**) **$2.50** and you borrow another (**–**) **$1.75** from them. You now you owe the person a total of (**–**) **$4.25**.

Algebraic addition of a positive (+) and a negative (–) number

Adding a positive and negative number together could result in the answer being positive or negative. How do you know what sign to put in front of the answer? The answer has the same sign as the largest number in the problem, that is, the number that is *greater in value*. In other words, subtract the smaller number from the larger. Now, put the sign of the larger number (+ or –) in front of the answer.

$$\begin{array}{r} +12.50 \\ \underline{-9.50} \\ +3.00 \end{array} \quad \text{or} \quad \begin{array}{r} +12.50 \\ \underline{-09.50} \\ +3.00 \end{array}$$

Putting it in terms of money, if you have (**+**) **$12.50** in your checking account and make a purchase that costs (–) **$9.50,** you would still have (+) **$3.00** in your account.

Notice how the decimal point is kept in line in the problem above. It is important to always do this. Also, note adding a zero after the last digit to the right of the decimal point is perfectly acceptable and may even make the problem seem easier to solve.

Multiplication and division of positive (+) and negative (–) numbers

When multiplying (×) or dividing (÷) two numbers with like signs (e.g., both positive [+] or both negative [–]), **the answer will always be positive (+)**. To be a little redundant, this means if you multiply or divide *two positive* (+) numbers, you *get a positive* (+) answer. If you multiply or divide *two negative* (–) numbers, you *get a positive* (+) answer. It may seem strange, but that's the way it is. Do not forget when you have two parentheses together, as in the example below, this means multiplication.

1. (+5) (+8) = +40	**4. (-2) (-2) = +4**
2. -2 × -3 = +6	**5. +5 × +5 = +25**
3. +15 ÷ +3 = +5	**6. -18 ÷ -9 = +2**

When multiplying or dividing two numbers with unlike signs (e.g., one positive [+] and one negative [–]), the answer is always negative (–).

1. **-3 × +6 = -18**
2. **- 18 ÷ +2 = -9**
3. **(+4) (-8) = -32**
4. **+25 ÷ -5 = -5**

Again, when multiplying or dividing a positive and a negative, the answer will be a negative. When multiplying or dividing two positives or two negatives, the answer is positive.

Multiplication and division of decimal numbers

A decimal number is just a whole number and a fraction written together in decimal form. Think about a prescription: **+2.75 SPH** (sphere). This is a decimal number. In this example, **2** is the whole number and **.75** is the fraction. Any multiplication or division of this number (or any other decimal number) by 10, 100, 1000, and so forth, simply requires moving the decimal place to the left or right the appropriate amount of places, depending on the number of zeros present. For example, multiplying a decimal number by 10 would move the decimal point one place to the right. Multiply +**7.75** by **+10** as an example.

$$\begin{array}{r} (+)7.75 \\ \underline{\times\ (+)10} \\ 000 \\ \underline{+775\downarrow} \\ +77.50 \end{array}$$

In the example above, you see that multiplying +**7.75** by **+10** equals **+77.50.** Essentially, you are moving the decimal point one place to the right. You place a zero after the last number on the right so that you maintain 2 digits to the right of the decimal. By that same principle, dividing by 100 would move the decimal point 2 places to the left. *Divide* **7.75** by **100** and see what happens. (Do not forget, you can add zeros after the 5 in 7.75 if it makes it easier to do the equation.)

$$\begin{array}{r} 0.0775 \\ 100\overline{)7.7500} \\ \underline{-0} \\ 77 \\ \underline{-0\downarrow} \\ 775 \\ \underline{-700\downarrow} \\ 750 \\ \underline{-700\downarrow} \\ 500 \\ \underline{-500} \\ 0 \end{array}$$

You can see the decimal point did, in fact, move two places to the left when you divided by 100, leaving an answer of **0.0775**.

NOTE: The leading zero before the decimal point should remain; as it helps clarify the sum shown is less than a whole number.

Multiplication of decimal numbers

Decimals are multiplied exactly like whole numbers and then the decimal point is added. For example, you would multiply **25** × **25** this way:

```
  25
 ×25
 125
+50↓
 625
```

Now try multiplying **2.5** × **2.5**:

2.5	(the decimal is *one* place from the right here)
×2.5	(the decimal is *one* place from the right here)
125	(no decimal is placed here)
+50↓	(no decimal is placed here either)
6.25	(In this, the final answer, the decimal has been placed *two* places from the right; i.e., *one* place from the right for **2.5** and *one* place from the right for the other **2.5**, for a **total** of *two places to the right* in the final answer.)

The next concept you need to know concerns when leading and trailing zeros (0) in numbers can be dropped and when they must remain. Zeros written to the right of a decimal point at the end of a number may be dropped. Usually, zeros in this position make doing a multiplication (or division) problem more confusing. Thus, **4.20** may be written as **4.2** since the value of the number hasn't changed. Be aware zeros to the right of the decimal point sandwiched between two other numbers ***cannot be dropped***, because doing so would change the value of the number. For example, you cannot drop the zero in the number **6.105** and make it **6.15.** If you do, you change the value of the number. With this understood, you know **1600.00** can be written as **1600,** and **0.40** can be written as **0.4** or even **.4**. However, it is often better to leave a leading zero in front of a decimal point to emphasize the fact the number shown is not a whole number. Look at how removing unnecessary zeros can simplify your math.

(long way): **1600.00 × 0.40 = 1600.00**

```
    1600.00
      x0.40
     000000
    640000↓
  +000000↓↓
  0640.0000
```

(or simply, **640)**

(short way): **1600 × .4 = 1600**

```
 1600
  x.4
640.0
```

(or simply, **640)**

Knowing when you can drop unnecessary trailing zeros can be a real time saver when it comes to multiplying (and dividing, which is coming up soon). Now what about those zeros to the left of a number, called leading zeros?

Zeros to the left of a decimal point, with no numbers before them, are added only to make it very clear the number is a decimal (not a whole number). This leading zero can be dropped when you multiply.

Thus, **0.23** is the same as **.23**, and **0.4** is the same as **.4**. Therefore, dropping the leading zero did not affect the value of the number but it does simplify the math work. Check out the examples below.

(long way): **0.23 × 0.4 = 0.23**

$$\begin{array}{r} 0.23 \\ \underline{\times 0.4} \\ 092 \\ \underline{+000\downarrow} \\ 0.092 \end{array}$$

(short way): **.23 × .4 = .23**

$$\begin{array}{r} .23 \\ \underline{\times\ .4} \\ .092 \end{array}$$

Notice the three (total) decimal places in the problem (two in 0.23 and one in 0.4) need to be applied to the answer. This being the case, a leading zero had to be added to the short way example answer to get the proper number of spaces for the placement of the decimal point. When the final answer is not a whole number, as in our short way example, it is preferred a leading zero be added to emphasize the answer is not a whole number, as shown in the long way example.

This concept is important when writing prescriptions. Without the leading zero, a prescription written as **–.75 SPH** seems to indicate the technician left out a number, and the intended prescription could have been –1.75, – 2.75, – 3.75, and so forth. If the Rx was written as **– 0.75** (i.e., with the leading zero), there is no question what was intended. This is one reason the instructors in your 3-level course at Ft. Sam Houston were so precise about this point. It makes a difference.

Division of decimals

Division problems may be written in various forms, such as:

$$\frac{a}{b} = c \quad \text{or} \quad a \div b = c \quad \text{or} \quad a / b = c$$

Whichever way the problem is written, "**a**" is the dividend (number being divided), "**b**" is the divisor (number the dividend is to be divided by), and "**c**" is the quotient (answer). When you divide decimal numbers, it is very much like dividing whole numbers—only you need to know when to move the decimal and where it goes in the quotient (answer). Here is an example of a division problem using whole numbers first. Divide **126**, by **6**, and you should get the quotient (answer) of **21**.

The problem can be written like this,

$$\frac{126 \text{ (dividend)}}{6 \text{ (divisor)}} = 21 \text{ (quotient)}$$

or like this,

$$\begin{array}{rl} & 21 \text{ (quotient)} \\ 6 \text{ (divisor)} & \overline{)126 \text{ (dividend)}} \\ & \underline{-12\downarrow} \\ & \quad 06 \\ & \quad \underline{-06} \\ & \quad\ \ 0 \end{array}$$

Now, look at what a division problem with a decimal point in the dividend might look like. Divide **12.6** by **6** (written as: **12.6 ÷ 6**).

```
               2.1 (quotient)
6 (divisor) ) 12.6 (dividend)
             -12 ↓
               06
              -06
                0
```

Notice the decimal point in the quotient (answer) of **2.1** is directly above the decimal point in the dividend (**12.6**). The decimal point for the quotient (answer) must come directly from wherever it is located at in the dividend. You cannot move it once its place is set in the dividend.

Anytime there is a space, or number of spaces, between the decimal point and the first number of the quotient (answer), you must put in the filler zeros to complete your answer. Take **0.248 ÷ 8** as an example:

```
              0.031 (quotient)
8 (divisor) ) 0.248 (dividend)
               -24↓
                 08
                -08
                  0
```

In the example above you see that the decimal point always moves directly up from its place in the dividend to its place in the quotient. Since **8** couldn't go into **2**, there ended up being a gap between the decimal place and the first number of value in the quotient. To account for this gap, we simply filled the space with a zero.

To carry out a division problem as far as necessary, you might have to add zeros after the decimal point of the dividend. As you already know, this does not change the value of the number. Thus, in **9 ÷ 2,** it is necessary to add a zero to the 9 to finish the problem. This is acceptable since **9** and **9.0** are the same in value. A look at an example should clear things up:

```
              4.5 (quotient)
2 (divisor) ) 9.0 (dividend)
             -8 ↓
              10
             -10
               0
```

Now you need to look at what to do when the divisor is a decimal number. Take **.88** ÷ .**2** as your example. Since it can be tough to figure out how many **.2**s would go into **.88**, the easiest thing to do is to change the divisor (**.2**) from a decimal into a whole number. You do this by moving the decimal point **to the *right***. So in **.2**, you'll move the decimal point one place to the right to make it a whole number. When the decimal point is moved in the divisor, ***it must be moved the same number of places in the dividend***. If you move the decimal one place in the divisor, you must also move it one place in the dividend. Follow the example below to clarify this point.

.2 (divisor)) .88 (dividend), should be changed to: **2 (divisor)) 8.8 (dividend)**

You moved the decimal one place to the right in the divisor, so you needed to move the decimal one place to the right in the dividend to keep the problem correct. Now, you can accurately complete the problem, as shown:

```
               4.4 (quotient)
2 (divisor) ) 8.8 (dividend)
              -8↓
               08
               -8
                0
```

Now that we've covered basic math, hopefully, any mathematical cobwebs you might've had have been cleared away. In this next lesson, we'll get into a little more complicated math.

402. Metrics, conversions, and solving for unknowns

The metric system is based on decimals. Changing from one metric unit to another requires only the movement of the decimal place. Occasionally we also have to convert from one mathematical form to another or solve for an unknown. These functions ultimately help us to get the correct prescription (Rx) for our patients. They allow us to perform visual acuity tests correctly. Read on, and see how easy this really is.

Metric system

The description below shows the meter and its equivalent metric measurement which is more commonly used in the ophthalmic field. The standard abbreviations are also shown for each unit of measurement.

1 meter (m) = 10 decimeters (dm)

= 100 centimeters (cm)

= 1000 millimeters (mm)

In a way, the metric system is quite similar to our monetary system of dollars and cents. When you are making your conversions from one unit to another, it might help to think in terms of dollars and cents, as shown below.

1 m = 1 dollar

1 dm = 1 dime

1 cm = 1 cent

1 mm = 1 mil (pretend there are 10 mils in 1 cent)

When you follow this idea of metric measurements using the money analogy, you'll find your conversions from one metric unit to another are quite easy. For instance, you know the notation $0.40 means 40 cents, so, in a similar fashion, **0.40 m** equals **40 cm**. When thinking in terms of money, you automatically made the conversion in your head. What you did was move the decimal place in $0.40 (0.40m) two places to the right, to give you 40 cents (or 40 cm). Thus, converting from one metric unit to another simply means moving the decimal point around. All you need to know is (1) how many places to move the decimal point and (2) whether to move it right or left. Below shows you how many places and in which direction you should move your decimal point. For example, if your number is in meters and you want it in centimeters, just move the decimal point two places to the right, as shown in the example.

Meter (m)	**Decimeter (dm)**	**Centimeter (cm)**	**Millimeter (mm)**
☺	☺	☺	
(Mr. Decimal)	**1st move to the right**	**2nd move to the right**	

That's all converting from one metric unit of measurement to another is about: moving the decimal point the correct number of places in the correct direction. A numeric example would be:

34.001 meters (m) becomes **3400.1 centimeters (cm)**.

All you did was move the decimal two spaces to the right to convert meters to centimeters.

A meter is probably the biggest unit of measurement you'll use in the eye clinic. If you have a unit of measurement in meters and want to convert it to a smaller unit of measurement, like decimeters, centimeters, or millimeters, you'll always move the decimal point to the right.

Meter (m) →	Decimeter (dm)	Centimeter (cm)	Millimeter (mm)

A millimeter is probably the smallest unit of measurement you'll be using in the eye clinic. To convert a measurement in millimeters to any larger unit of measurement, which way would you move the decimal point? If you moved the decimal point to the left, and you would be correct.

Meter (m)	Decimeter (dm)	Centimeter (cm)	**← Millimeter (mm)**

Using this information, what would you do if you wanted to convert a measurement from millimeters to centimeters? You'd move the decimal one place to the left.

For a numeric example, convert **50.1 mm** to centimeters (cm). You would move the decimal point one place to the left and end up with **5.01 cm**.

Here are several examples for you to review and ensure you understand the conversion concept. Remember, move the decimal point to the right for conversions to a smaller unit and to the left for conversions to a larger unit.

Problem	**Solution**
How many cm are there in 0.2m?	Move the decimal *two* places to the *right:* 0.20m = 020. = 20cm
Convert 358cm to mm.	Move the decimal *one* place to the *right:* 358.0 cm = 3580. = 3580mm
Convert 0.0008mm to m.	Move the decimal *three* places to the *left:* 0.0008 mm = .0000008 = 0.0000008m
How many cm are there in 250mm?	Move the decimal *one* place to the *left:* 250 mm = 25.0 = 25.0cm
34.7dm is the same as____mm.	Move the decimal *two* places to the *right:* 34.7 dm = 3470. = 3470mm
Convert 0.0057m to cm.	Move the decimal two places to the *right:* 0.0057 m = 000.57 = 0.57cm

Some people feel more comfortable with a chart listing the rules for converting from one metric unit to another. For those who remember better this way, the table below is given to help you convert from one metric unit to another.

Conversion Between Metric Units	
When converting	**Move the decimal point**
Meters to decimeters	1 place to the right (i.e., 3m = 30dm)
Meters to centimeters	2 places to the right (i.e., 3m = 300cm)
Meters to millimeters	3 places to the right (i.e., 3m = 3000mm)
Decimeters to meters	1 place to the left (i.e., 3dm = 0.3m)

Conversion Between Metric Units	
When converting	**Move the decimal point**
Decimeters to centimeters	1 place to the right (i.e., 3dm = 30cm)
Decimeters to millimeters	2 places to the right (i.e., 3dm = 300mm)
Centimeters to meters	2 places to the left (i.e., 3cm = .03m)
Centimeters to decimeters	1 place to the left (i.e., 3cm = 0.3dm)
Centimeters to millimeters	1 place to the right (i.e., 3cm = 30mm)
Millimeters to meters	3 places to the left (i.e., 3mm = 0.003m)
Millimeters to decimeters	2 places to the left (i.e., 3mm = .03dm)
Millimeters to centimeters	1 place to the left (i.e., 3mm = 0.3cm)

Converting metric units to US customary units and vice versa

If someone asks you how many centimeters there are in 10 meters, you would be able to tell him or her there are 1,000 cm, since you just learned how to switch back and forth from one metric unit to another. What if you were asked how many inches there are in 10 meters? Or in 300 millimeters? Now your conversion is not as simple as just moving a decimal point around. You are going to have to do some math to get the answer.

While metrics are quite popular in most of the world, the United States still uses inches, feet, and yards. Since this is the case, it is useful to be able to switch back and forth from the metric system to the US customary system and vice versa. As an example, say you are trying to check a patient's near visual acuity (NVA), and you can only find a test card that says, "Test at 40 centimeters." How far away is it in inches? During this lesson, you will learn how to convert from metric to the US customary system of measurement. By applying the information you get here, you'll be able to do the math and determine that 40 cm is the same distance as 16 inches. This will allow you to conduct your NVA test with confidence since you'll know you have the test card at the correct distance.

To convert metric measurements to US customary measurements, you'll need to know how long a meter is so you have a reference point. A meter is exactly 39.37 inches, slightly over a yard. How long is a decimeter? It is exactly 3.937 inches long. Pretty close to 4 inches. How long is a centimeter? If you are catching on, you have probably figured out it is 0.3937 inches long and a millimeter is 0.03937 inches long. Remembering the number 39.37 may be a bit tough, and doing math is definitely easier without decimal numbers. So, for the sake of simplicity, and because it is close enough for our purposes in the ophthalmic clinic, we'll round up and just say 1 meter is equal to 40 inches (1 m = 40 in.) This makes it much simpler to remember. It also makes the mathematical calculations of converting metrics to US customary units much easier also.

Going with the **1 m = 40 inches** rule, a comparison between the two units of measurements would look something like this:

- 1 meter is about **40 inches** long.
- 1 decimeter is about **4 inches** long.
- 1 centimeter is about **3/8 inches** long.
- 1 millimeter is about **1/32 inches** long (or about the thickness of a dime)!

Converting metrics to inches

Converting meters to inches is very easy. Just take the number of meters you have and multiply by 40. It is as simple as that. To prove it, try the simple problem below.

Say you have 2 meters and you want to know how many inches it is. Take 2 × 40 and you get an answer of 80 inches. Makes sense, one meter was equal to 40 inches, so 2 meters should equal

80 inches. Try another example. How many inches are there in 3.7 meters? Just take 3.7 and multiply it by 40. This is shown here:

$$
\begin{array}{r}
\mathbf{3.7} \\
\times\ \underline{\mathbf{40}} \\
\mathbf{00} \\
\underline{\mathbf{+148\downarrow}} \\
\mathbf{148.0}\ \textbf{inches}
\end{array}
$$

It is pretty straightforward. An easy way to remember this is to remember, "If I have meters, I need to multiply." **M**eters = **M**ultiply. Think of it as the **M&M** rule.

Now that you see how easy it is to convert meters to inches, let's look at converting decimeters, centimeters, or millimeters to inches. The easiest way to do this is to first get your metric units of measurement into meters, then convert to inches. For example, say you want to know how many inches there are in 500 mm.

First, convert the 500 millimeters into meters. This requires moving the decimal point three places to the left, which gives you 0.5m. Now that you have your answer in meters, simply multiply by 40 to convert it to inches: 0.5 m × 40 = 20 inches. This same concept applies to converting decimeters or centimeters to inches. Just convert them to meters first and then do the multiplication (× 40). Keep it simple. Do not make it more work than it really is.

Here are some more examples for you to look at to reinforce this concept:

If you have:	Do this:	To get this in inches:
5.5 m	5.5 × 40	220
4.0 m	4.0 × 40	160
1.25 m	1.25 × 40	50
10 dm	10 dm is 1.0m; 1 × 40	40
490 dm	490 dm is 49m; 49 × 40	1960
0.55 cm	0.55 cm is 0.0055m; 0.0055 × 40	0.22
1250 cm	1250 cm is 12.50m; 12.50 × 40	500
9000 mm	9000 mm is 9.000m; 9.000 × 40	360
64 mm	64 mm is .064m; .064 × 40	2.56

Converting inches into meters, decimeters, centimeters, and millimeters

We've discussed how to convert metric measurements to US customary units of measurement. Now you need to learn how to convert US customary units of measurements into metric measurements. Here is an example:

Say you decide you want to do a Tangent screen visual field test on a patient. It has been a long time since you have done one and you're questioning whether the correct test distance is 1 meter or 30 inches. You ask your coworker and he says, "1 meter and 30 inches are the same." You know that is not right, but you need to convince your coworker. The best way to do that is to show him mathematically that 30 inches is definitely less than 1 meter. Thinking logically, you know there are 40 inches in 1 meter. What if you just divided the number of inches (**30,** in this example) by the number of inches in a meter (**40**)? Taking **30 ÷ 40** tells you (and your coworker) how many meters there are in 30 inches. Let's see how it works out:

```
    00.75
40 )30.00
   -00
    30
   -00↓
    300
   -280↓
     200
    -200
       0
```

You can now say definitively 30 inches is actually 0**.**75 meters. As you see with the above example, to convert inches to meters all you had to do was take the number of inches and divide by 40 (since 40 is the number of inches in a meter). If it helps, here's a (albeit, bad) rhyme that might help you remember what to do:

"To get from ***inches to meters***,

simply ***divide by 40***;

what could be sweeter!"

While not the most poetic rhyme, it may help you remember what to do when converting inches to meters. (To get back to our scenario, what *is* the test distance for Tangent screen test, anyway? Start testing at 1 meter. If you think the patient is malingering, move out to 2 meters and test again.)

Now that you know how to convert inches to meters, what do you do if you want to go from inches to decimeters, centimeters, or millimeters? You'll use the same concept as before. Convert from inches to meters, and then convert the meters to the metric unit desired. Let's do an example to help convey the technique.

Pretend you want to tell your friend, an ophthalmic technician in England, how to do an Amsler grid test. You know the test distance is 12 inches, but your friend is completely "metri-fied" and needs to know the test distance in centimeters. You'll need to convert 12 inches into centimeters to help your friend out.

First, you'll convert 12 inches into meters by dividing 12 by 40 (12 ÷ 40). Let's do that:

```
    00.3
40 )12.0
    -0
    12
     -0↓
    120
   -120
      0
```

Now you know 12 inches is equal to 0.3 meters. Next, you'll want to convert meters to centimeters. To do that, you know you simply move the decimal point two places to the right and end up with 30 centimeters. You can now pass the metric answer on to your friend in England. Here are some more examples for you to look at to see if you're getting the hang of converting US customary units of measurement into metric measurements.

Number of inches	Divided by 40	Gives you number of meters (decimeters, centimeters and millimeters)
16	16 ÷ 40 =	0.4m (4dm, 40cm, or 400mm)
60	60 ÷ 40 =	1.5m (15dm, 150cm, or 1500mm)
6	6 ÷ 40 =	0.15m (1.5dm, 15cm, or 150mm)
400	400 ÷ 40 =	10m (100dm, 1000cm, or 10000mm)
14	14 ÷ 40 =	0.35m (3.5dm, 35cm, or 350mm)

Converting fractions to decimals

A fraction is a portion of a whole number. Examples of common fractions would be:

¼, ½, ¾, etc.

While fractions have their place, you won't be using them often as an ophthalmic technician. For instance, when you want to put in an order for glasses, you wouldn't write the prescription as +1¼ SPH. Instead, you would write +1.25 SPH. Since it is rare for you to use common fractions, you'll need to be able to convert them to decimal numbers. Let's look at how to do this. Take 2/5 as an example. To convert it to decimal number form, just do what the fraction is telling you to do. It is showing the 2 is divided by the 5 (written more understandably as 2 ÷ 5). Do the math and see what you get.

0.4
5)2.0
-0↓
20
-20
0

Now you can see the common fraction **2/5** is the same as the decimal number **0.4**. Decimal numbers are easier to work with mathematically.

This may seem fairly easy. In fact, you may be able to just look at common fractions such as ¼ and ½ and know they equal 0.25 and 0.50, respectively. Instead of a common fraction, how would you convert a decimal fraction? Take the equation 2.50/5.00. Just looking at that problem you might guess the answer is **2;** if so, you'll want to try again. Do the actual math as shown: **2.50 ÷5.00**. You'll come up with **0.5**. You see, converting fractions to single decimal numbers is as easy as dividing the fraction (whether common or decimal) just as it is shown. Look at these examples and see if you can work out the math and match the answers.

Fraction	Decimal
1/8 =	0.125
3/5 =	0.6
3/8 =	0.375
1.4/5.6 =	0.25
0.50/5.00 =	0.1
8.88/4.44=	2

Solving for an unknown in an algebraic equation

In a simple algebraic equation, a letter symbolizes any unknown quantity. For example, **2n = 8** is a simple algebraic equation. Writing **2n** is the same as writing **2 times (×) n**. Since this is an easy problem to solve, you can probably figure the answer in your head—2 × **4**= 8, so "n" must = **4**.

Figuring out the answer in your head is great when the problem is simple, but when you get into bigger numbers or decimal numbers, you'll need a system for figuring out what the unknown quantity is. We'll stick with our **2n = 8** problem to show the steps you'd need to use to solve more complicated equations.

In an equation such as **2n = 8**, the unknown quantity (in this case, **n**) must be isolated on one side of the equation. The easiest way to accomplish this is to divide **2n by 2 (2n ÷ 2**). This leaves "n" all by itself. You can do this as long as you divide the other side of the equation by **2** also. Meaning, you'd have to divide the **8** by **2 (8 ÷ 2)** as well. Keep in mind, you may do just about anything to isolate the unknown (**n** in this case), as long as you do the same thing to BOTH sides of the equation. So in **2n = 8**, you can divide both sides of the equation by 2 in order to isolate **n**.

$$\frac{2n}{2} = \frac{8}{2}$$

Doing this cancels out the **2** on the left side of the equation and leaves **4** on the right side of the equation.

$$\frac{\cancel{2}n}{\cancel{2}} = \frac{8}{2} \quad \textit{so} \quad n = \frac{8}{2} \quad \textit{so} \quad n = 4$$

This leaves you with "n" **= 4**, which is the answer. The key rule to remember is whenever you do something to one side of the equation, you *must* do the same thing to the other side. This keeps the problem accurate. Try doing another problem:

6y = 24

To isolate the **y**, divide both sides of the equation by **6**:

$$\frac{\cancel{6}y}{\cancel{6}} = \frac{24}{6} \quad \textit{so} \quad y = \frac{24}{6} \quad \textit{so} \quad y = 4$$

To isolate an unknown you may add, subtract, multiply, or divide as needed, just as long as you do the same thing to both sides of the equation. Do you have a negative four (–4) you need to get rid of? Then add four (+4) to make it go away. Just remember to add four to the other side, too.

Below are some more problems that have already been worked. Study them so you can understand how the answer was solved. If you're not getting the concept, read this information again. If you can understand how the problems were solved, you know you're on the right track. One more thing to keep in mind when trying to isolate an unknown quantity: Always do any addition or subtraction first, then multiply or divide as needed to isolate the unknown.

To solve this equation	Do this	To get this
30x = 15	divide each side by 30	x = 0.5
250a = 1500	divide each side by 250	a = 6
2.50t = 17.50	divide each side by 2.50	t = 7
14f + 7 = 175	subtract 7 from each side; then divide each side by 14	f = 12
22z - 4 = 40	add 4 to each side; then divide each side by 22	z = 2

Solving for an unknown in a proportion

Finding the answer to an unknown in a proportion is very much like finding the unknown in algebraic equations. Here is an example of a proportion:

$$\frac{2}{3} = \frac{4}{y}$$

This proportion is saying **2 ÷ 3** equals **4 ÷ y**. To solve the proportion, two basic steps are necessary. First, cross multiply the numbers (i.e., multiply the figures that are diagonally opposite of each other). Therefore, you have **2** × **y** and **3** × **4**.

$$\begin{matrix} 2 & 4 \\ 3 & y \end{matrix}$$

This leaves an equation looking like this: **2y = 12**. Now, the equation looks familiar, doesn't it? The next step is to solve for the unknown in this algebraic equation just as you did in the previous section. You need to get **y** by itself on one side of the equation. So, divide each side by **2**.

$$\frac{\cancel{2}y}{\cancel{2}} = \frac{12}{2} \quad \textit{so} \quad y = \frac{12}{2} \quad \textit{so} \quad y = 6$$

There's nothing else to it. You only have one unknown in a proportion, and by cross-multiplying, you can turn any proportion into a simple algebraic equation. You already know how to solve a simple algebraic equation. Here are some more examples:

$$\frac{14}{24} = \frac{n}{48} \quad \textit{so} \quad 24 \times n = 48 \times 14 \quad \textit{so} \quad 24n = 672 \quad \textit{so} \quad n = 28$$

$$\frac{t}{14} = \frac{3}{7} \quad \textit{so} \quad t \times 7 = 3 \times 14 \quad \textit{so} \quad 7t = 42 \quad \textit{so} \quad t = 6$$

Study the examples carefully so you can see how they are done. Make sure you can solve these types of problems without trouble. You'll have the opportunity to do some of them on your own in the self-test question section.

Now, let's start looking at how to apply the math to the optics side of the equation.

403. Angular measurements, dioptric power, and focal lengths

To better understand how moving a lens closer or further from the eye affects a prescription, we must learn some basics. This includes an understanding of angle measurement, lens power, and focal length. Having a general knowledge of these concepts will help you understand how they all come together to make our patients see well.

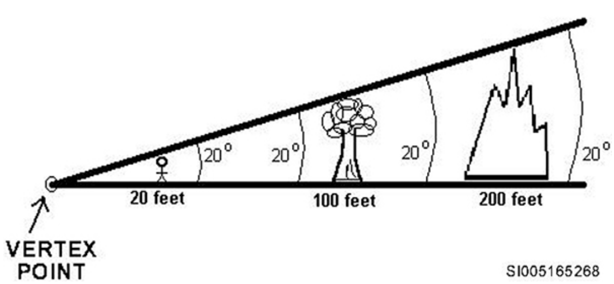


Figure 1–1. Acute angle.

Units of angular measurements

An angle is the figure formed by two lines diverging from a common point. The space between the two lines determines the degree of the angle. Figure 1–1 shows a 20° angle.

In figure 1–1, you'll notice the two lines get farther apart from each other as they get farther from the point where they began (the vertex point). However, the degree of the angle remains constant at 20°. Even though the space between the two separate and diverging lines grows wider, the angle remains the same. This is an important concept to understand.

The measurement of angles is made in degrees (°), minutes ('), and/or seconds ("). Here's the breakdown of this system of angular measurement:

- A circle equals 360 degrees (°).
- 1 degree (°) equals 60 minutes (').
- 1 minute (') equals 60 seconds (").

This concept of different angular measurements becomes important again later when you study visual field testing (dealing with degrees), visual acuity testing (dealing with minutes), and depth perception testing (dealing with seconds). For now though, all you need to know is a degree has 60' in it. Therefore, 2° would equal 120'. How many minutes would there be in 100°? Since there are 60' in every 1°, you multiply 60 times 100 (60 × 100) and end up with 6000' in 100°.

Every minute has 60 seconds in it. Therefore, 2' would equal 120". How many seconds would there be in 100 minutes? You got it right if you came up with 6000". It becomes apparent that while a degree (°) is not a large unit of measurement, a minute is even smaller, and a second of an angle is extremely small. Using your math skills, see if you agree with the following calculations.

If you have:	It equals:	Calculations:
5°	18,000"	(5 × 60 = 300', then 300 × 60 = *18,000*")
90°	5,400'	(90 × 60 = *5400*')
900'	15°	(900 ÷ 60 = *15*°)
40"	0.01°	(40 ÷ 60 = 0.66', then 0.66 ÷ 60 = *0.01*°)
10'	600"	(10 × 60 = *600*")

The ophthalmic career field uses all three of these angular units of measurement, so knowing what symbol represents each unit of measurement is important. When you see in a medical record that a person's depth perception level is 400" of arc, you should be able to recognize this as meaning seconds of arc, not inches of arc. The ability to convert from one angular unit of measurement to another, if necessary, can be a valuable skill. For instance, how many minutes of arc does 400" of arc calculate out to be? Because there are 60 seconds in each minute, just divide the 400 seconds by 60 (400 ÷ 60). Once you do, you'll have your answer: 6.66' (minutes) of arc.

Dioptric power and focal length

Here is where you have a chance to put some of your mathematical skills to practice. In the ophthalmic career field, you are dealing with optics continuously. Whether it is a simple pair of glasses or the high power aspheric lens used by a doctor to examine the fundus, optics play a role. Prescription and examination lenses are identified by the amount of dioptric power they have.

A diopter (D) is a unit of measurement indicating the degree of refractive power a lens has to converge or diverge light. The more dioptric power a lens has, the more it bends light. A plus lens converges light, whereas a minus lens diverges light. So which is more powerful, a +5.00D sphere lens or a –5.00D sphere lens? Neither one.

They both have 5.00D of power, meaning they'll both have a focal length of 8 inches.

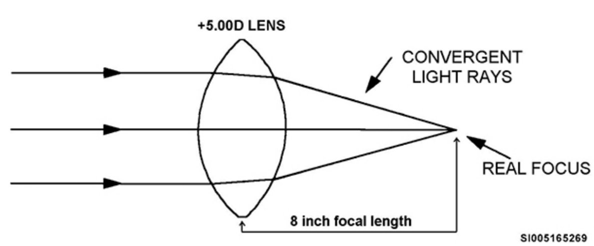


Figure 1–2. Focal length of a +5.00 lens.

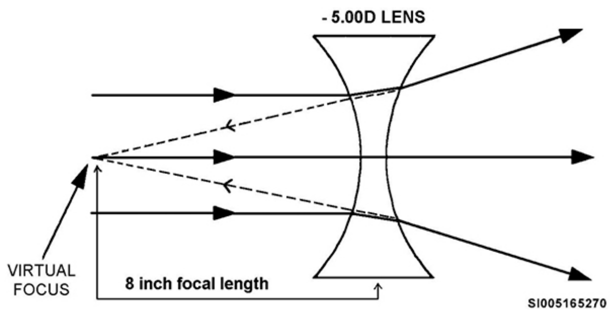


Figure 1–3. Focal length of a -5.00 lens.

The difference between them is one converges light and one diverges light, but they both bend light to the same degree (figs. 1–2 and 1–3).

A simple way to understand a diopter is to look at it this way: A one-diopter lens brings light rays to a focus at 1 meter. One meter would be termed the focal length for the one diopter lens. If you do research on lenses and optics, you may read that the dioptric power of a lens is equal to the reciprocal of the focal length of the lens (in meters). This sounds more confusing than it actually is. It may be easier to understand if stated another way—the dioptric power of a lens is related directly to its focal length. This is also true in reverse—the focal length of a lens is directly related to its dioptic power.

Here's an example: A **2.00D** lens has a focal length of **0.5 meters** and a **0.50** diopter lens has a focal length of **2 meters**. See how they are related? This is what's meant by reciprocal—a change in one results in a proportional change in the other.

If you increase dioptric power, you shorten the focal length. If you increase the focal length, you decrease the dioptric power. (Remember, the closer an object is, the more powerful a lens needs to be to focus on the object.) So once again, a diopter is equal to the reciprocal of the focal length (in meters). This means that if you know the dioptric power of a lens, you can determine its focal length. Of course, you'll need to do a little math to solve for it. If you know the focal length of a lens, you can calculate its dioptric power. Focal length and dioptric power are directly related.

One more point to remember: A minus lens forms a virtual focal point and a plus lens forms a real focal point. You can see this with any magnifying glass. You can burn things with a magnifying glass (which is a plus lens) because of its ability to bring light rays to a real point of focus. A negative lens, on the other hand, diverges light. So where do you measure the focal length? It is measured by tracing an imaginary line backward from the diverging light rays until the imaginary lines cross. That is its virtual focal point (refer back to fig. 1–3).

Therefore, again, which is more powerful, the +5.00 lens or the –5.00 lens? Neither. They both have the same focal length. The difference lies in what *type* of a focal point they provide. The positive lens provides a real focal point and the negative lens provides a virtual focal point. They both have their uses and they both have 5.00 diopters of power, so they both have a focal length of 8 inches. But how do you determine that the focal length is 8 inches? That's what the next lesson will cover.

Calculating focal length based on dioptric power

Calculating the focal length of a lens based on its dioptric power is a straightforward process. An easy way to remember the formula for the calculation is to think of a pyramid with 1 meter at the top of the pyramid divided by the focal length (FL) and dioptric power at the base of the pyramid (fig. 1–4).

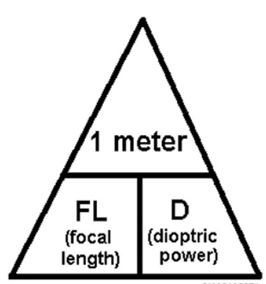


Figure 1–4. Pyramid for calculating dioptic power or focal length.

For example, let's say you have a lens with 10.00 diopters of power. You would simply divide **1** (meter) by **10.00** (diopters), just like the pyramid formula shows in figure 1–5. The answer would show a 10.00D lens has a focal length of **0.1 meters**.

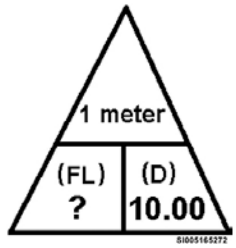


Figure 1–5. Pyramid showing setup to calculate focal length for a 10.00D lens.

How about a lens with 0.50 diopters of power? Again, **1** (meter) is on top and **0.50D** is on the bottom of the pyramid, so it will be **1 ÷ 0.50**. The answer tells you the **0.50D** lens has a focal length of **2 meters**. Figuring out the focal length for various lens powers is as easy that **-** doing a simple division problem.

What if you need the focal length in inches, decimeters, centimeters, or millimeters? You can use two methods to accomplish this.

Method 1

With this method, you use the unit of measurement desired (inches, dm, cm, or mm) in your formula from the start. This saves you from having to convert from meters to the desired unit of measurement at the end of your math work. Remember **1 meter** (or its equivalent) goes at the top of our pyramid formula (fig. 1–6). Therefore, whatever unit of measurement you use to replace 1 meter at the top of the pyramid must always stay equal to 1 meter for the calculation of diopters to focal length to work.

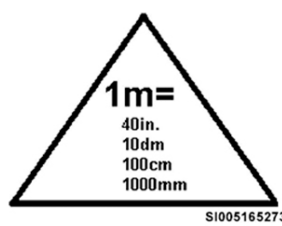


Figure 1–6. One-meter equivalents that can be used to calculate FL in inches, dm, cm, or mm.

Example 1:

Let's say you want your answer in inches. Remember, 40 inches is the same as 1 meter. Therefore, if you want your focal length in inches, substitute the 1 meter at the top of your pyramid with 40 inches (fig. 1–6). If we use our 10.00D lens example as before, to set up the problem correctly you should have **40 (inches)** ÷ **10.00D**, which gives a focal length of **4 inches**. The nice thing about using the unit of measurement you want in place of the 1 meter in your formula is your answer is complete as soon as you finish your division. No need to convert.

Example 2:

Here's another problem. Let's stick with a 10.00D lens, but this time you want your focal length in millimeters. At the top of our formula pyramid is 1 meter, but since you want millimeters, you need to substitute 1 meter with the equivalent amount of millimeters, (fig. 1–6). There are 1,000 millimeters in 1 meter, so place it at the top of the pyramid for this problem—**1000 (mm)** ÷ **10.00D = 100 millimeters**. This gives the focal length in millimeters for a 10.00D lens.

Method 2

Instead of using the unit of measurement desired in the formula, you could just figure out the focal length in meters and convert it to the desired unit.

Example 1:

As a way of demonstrating, we'll use this method to calculate the focal length of a 10.00D lens in inches. First, figure out the focal length in meters. So, **1 (m)** ÷ **10.00D** would equal a focal length of **0.1 m**. Now, just convert meters to inches. To do this, simply multiply the number of meters you have by 40 (since there are 40 inches in a meter). In this case, you'll have **0.1 × 40**, which equals **4 inches**. Compare to the answer you got for the same problem using *Method 1*. The answers match.

Example 2:

How would you covert the focal length of a 10.00D lens from inches to millimeters? Simply take the focal length you calculated in meters from the previous example (**0.1 m**) and convert it to millimeters by moving the decimal point three places to the right. If you do this correctly, you see a 10.00D lens has a focal length of **100 mm**.

Whether you use *Method 1* or *Method 2* to achieve your answer doesn't really matter. You just need to stay consistent using one method or the other. Here are some more examples to look at to see if you understand how you can calculate the focal length of a lens based on its dioptric power.

Dioptric Power of Lens	**Method 1**	**Method 2**	**Focal Length**
2.50D (give FL in *inches*)	40 ÷ 2.50	1 ÷ 2.50; then convert your answer (0.4 meters) to inches by multiplying by 40.	*= 16 inches*
3.00D (give FL in *meters*)	1 ÷ 3.00	1 ÷ 3.00	*= 0.33 meters*
1.75D (give FL in *dm*)	10 ÷ 1.75	1 ÷ 1.75; then convert your answer (0.571 meters) to decimeters by moving the decimal one place to the right.	*= 5.71 decimeters*
4.50D (give FL in *cm*)	100 ÷ 4.50	1 ÷ 4.50; then convert your answer (0.2222 meters) to centimeters by moving the decimal two places to the right.	*= 22.22 centimeters*
12.00D (give FL in *mm*)	1000 ÷ 12.00	1 ÷ 12.00; then convert your answer (0.08333 meters) to millimeters by moving the decimal three places to the right.	*= 83.33millimeters*

As you can see, solving the problems using *Method 1* requires fewer steps and may be faster, but either method works. Use the system you prefer.

Did you happen to notice while looking through the examples the stronger a lens is, the shorter its focal length? This makes sense as more dioptric power means more bending of light, which logically should cause the focal point to occur sooner, giving a shorter focal length. Figure 1–7 illustrates this idea.

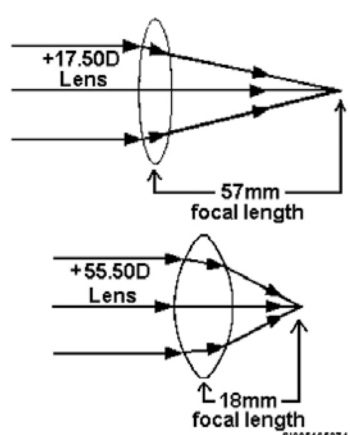


Figure 1–7. Focal length is dependent on lens power; stronger lens = shorter focal length.

Knowing the focal length of a lens based on its dioptric power can be useful in your job. After all, the vast majority of the spectacles prescribed for patients are meant to adjust the focal length of the light entering the eye so the light is brought to focus on the retina rather than in front of it or behind it.

A simple example showing the everyday relationship between dioptric power and focal length would be the reading glasses needed by a 70-year-old male presbyope. He has virtually no accommodation (focusing ability) left at this age. He sees clearly in the distance, but cannot read a newspaper at 16 inches because the newsprint is too blurry. The doctor examines the patient and prescribes +2.50D reading glasses. But why +2.50D? Calculate the focal length of a +2.50D lens. It is 16 inches! If the patient wears the prescribed glasses, he can clearly see the newsprint again at 16 inches. Hopefully this example helps to make the relationship between dioptric power and focal length a little clearer.

Calculating dioptric power based on focal length

In the previous examples, you were given the dioptric power of a lens and were able to calculate its focal length. Since the dioptric power and focal length are reciprocally related, it makes sense you should be able to calculate dioptric power when only the focal length is given.

To calculate dioptric power based on the focal length of a lens, we use the pyramid again as the setup for our calculations. At the top of the pyramid is 1 meter; at the bottom of the pyramid are diopters and focal length. This time you know the focal length but not the dioptric power. The beauty is the formula remains the same as before. Divide the 1 meter at the top of the pyramid by whatever number you have at the bottom of the pyramid. Since you know the focal length, use it.

Take an example where you have a focal length of 2 meters. You want to know what the dioptric power is for this lens. According to the pyramid, you divide 1 (meter), which is at the top of the pyramid, by the 2 (meter) focal length, as shown in figure 1–8. **1 ÷ 2 equals 0.50**, so the dioptric power for a lens with a 2-meter focal length is 0.50D.

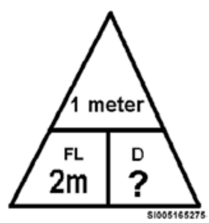


Figure 1–8. Pyramid for calculating dioptric power when focal length is known.

Let's try another one. This time you have a lens with a focal length of 0.4 meters. The formula says to take 1 meter (top of the pyramid) and divide it by your focal length of 0.4 (meters). **1 ÷ 0.4 equals 2.50D**. Notice you had a shorter focal length and the dioptric power turned out to be stronger. This concept is important to understand.

As before, we'll discuss what to do if you need to convert your answer from one unit of measurement to another. Once again, you have two methods available to you.

Method 1

Substitute the 1 meter at the top of the pyramid formula with the equivalent length that is the same unit of measurement as your focal length. If your focal length is in inches, substitute the 1 meter with 40 inches. If your focal length is in decimeters, substitute the 1 meter with 10 decimeters. For centimeter measurements, substitute the 1 meter with 100 centimeters, and for millimeters, substitute 1 meter with 1,000 millimeters. Sounds familiar, right? As long as the unit at the top of the pyramid is 1 meter, or its equivalent, the formula works.

Example 1:

Let's say you come across a lens with a focal length of 10 inches and you need to know what the dioptric power is. Because your known focal length is in inches, start by replacing the 1-meter at the top of the pyramid with its equivalent in inches, which would be 40. Now, divide 40 inches by the 10-inch focal length to get the dioptic power value. **40 ÷ 10** equals **4.00** diopters. Since you already plugged in the appropriate “1-meter equivalent” at the top of the pyramid, there is no conversion required.

Example 2:

You now have a lens with a focal length of 90 decimeters. Take 10 decimeters, which is equal to the 1 meter at the top of the pyramid, and divide it by the focal length, which was 90 (decimeters). **10 ÷ 90** equals **0.11** diopters. Again, the math is quite simple to do.

Method 2

Take your focal length, be it in inches, decimeters, centimeters, or millimeters, and convert it to meters. Then work out the math following the pyramid formula as just shown previously.

Example 1:

Since you only have a US standard measurement ruler, you found the lens has a focal length of 20 inches. To convert inches to meters, you must divide by 40. So, **20 ÷ 40 equals 0.5 meters**. Now, you can work the problem out. 1 (meter), which is the top of the pyramid, divided by 0.5 m (the focal length of the lens) equals a dioptric power of 2.00D. Simple math.

Example 2:

Assume you have a lens with a focal length of 50 millimeters. Using method 2, the first thing you need to do is convert to meters, which is done by moving the decimal point three places to the left, leaving you with a focal length of 0.050 meters. Now, work the problem according to the pyramid. Take 1 (meter), which is at the top of the pyramid, and divide it by 0.050 meters (which was the focal length of the lens). The problem would look like this: **1 ÷ 0.050**, and your answer would be 20.00D.

As you can see, whether you use method 1 or method 2, the results remain the same as long as you do the math correctly. Which method you use is up to you. Just be consistent.

In the following table, there are some more examples of converting focal length to dioptric power. Study the examples and do the math to ensure you understand the process.

Focal length	**Method 1**	**Method 2**	**Dioptric power**
6 in.	Divide 40 by 6	Convert 6 in. to meters by dividing 6 by 40 (6÷40); then divide 1 m by your answer (0.15).	*= 6.66 diopters*
0.25 m	Divide 1 by 0.25	Divide 1 m by 0.25 m.	*= 4.00 diopters*
3 dm	Divide 10 by 3	Convert 3 dm to meters by moving the decimal point one place to the left; then divide 1 m by your answer (0.3).	*= 3.33 diopters*
40 cm	Divide 100 by 40	Convert 40cm to meters by moving the decimal point two places to the left; then divide 1 m by your answer (0.40).	*= 2.50 diopters*
500 mm	Divide 1000 by 500	Convert 500 mm to meters by moving the decimal point three places to the left; then divide 1 m by your answer (0.500).	*= 2.00 diopters*

Converting focal lengths into dioptric power can be a useful tool. Think about our 70-year-old presbyope from the previous example. Assume he cannot get in to see the doctor right away, and is interested in getting some over the counter (OTC) reading glasses until he can. You want to help him out, so you hand him a piece of paper with writing on it and ask him to hold it at the distance he would like to see it clearly. Then, measure the distance from the paper to his eyes. The focal length he seems to like is 16 inches. Since you understand the focal length is related to dioptric power, you can now calculate what power lenses might be suitable for him. You take 40 inches (the 1-meter equivalent) and divide it by 16 inches (the patient’s reading distance). 40 ÷ 16 gives you a dioptric power of 2.50. You can now advise the patient to give the +2.50 reading glasses at the local drugstore a try. At least until he can get in for a complete exam with the doctor. You have applied your knowledge of dioptric power and focal lengths to help a patient.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

401. Algebraic addition, multiplication, and division

1. Algebraically *add* the following numbers:

   a. + 2.75 + 6.75 =

   b. –13.00 + 15.25 =

   c. –10.25 – 8.25 =

   d. + 1.75 - 1.25 =

   e. + 14.50 + 2.25 =

   f. –2.75 – 22.25 =

   g. –5.50 + 2.75 =

   h. + 1.25 – 1.25 =

   i. –0.25 – 0.75 =

   j. + 4.25 + 5.37 =

2. Solve the following by completing as indicated (multiply, divide, or a combination of both). Carry out answer to two decimal places. Do not round up or down.

   a. $-4 \times -7 =$

   b. $\frac{+36}{-2} =$

   c. $(+40)\,(-2) =$

   d. $\frac{+4}{+8} =$

   e. $\frac{-21}{-3} =$

   f. $\frac{-15}{+3} =$

   g. $\frac{(+8)\,(-2)}{-4} =$

   h. $\frac{-36}{(-3)\,(-2)} =$

   i. $\frac{+10}{(-5)\,(+2)} =$

   j. $\frac{(+6)\,(-2)}{-2} =$

3. Multiply or divide the following (as appropriate).
   a. $+0.19 \times -0.20 =$

   b. $-0.034 \times -0.025 =$

   c. $+12.48 \div +8.0 =$

   d. $-0.008 \div -800.0 =$

   e. $+4.12 \times -5.75 =$

   f. $-0.0012 \div +0.002 =$

   g. $+0.890 \times -6.50 =$

   h. $\dfrac{-0.800}{+8.00} =$

402. Metrics, conversions, and solving for unknowns

1. Convert from the metric unit shown to the metric unit indicated.
   a. 42 m = __________cm.

   b. 500 mm = __________m.

   c. 0.025 cm = __________mm.

   d. 25 cm = __________m.

   e. 0.47 m = __________mm.

f. 150 mm = _________cm.

g. 0.765 dm = _________m.

h. 0.467 mm = _________dm.

i. 50 m = _________cm.

j. 1000 dm = _________mm.

2. Convert from the unit of measurement shown to the indicated unit of measurement.

   a. 58 dm = _________in.

   b. 10 in = _________dm.

   c. 600 cm = _________in.

   d. 2.8 m = _________in.

   e. 36 in = _________mm.

   f. 0.95 m = _________in.

   g. 200 mm = _________in.

   h. 16 in = _________m.

i. 80 in = _________cm.

j. 10 cm = _________in.

3. Solve for the unknown in the following equations:

a. $3n = 12$; $n =$

b. $4a = 20$; $a =$

c. $4c = 26$; $c =$

d. $9y = 27$; $y =$

e. $6y = 12$; $y =$

f. $12n = 144$; $n =$

g. $44t - 7 = 1489$; $t =$

h. $10.25x = 66.625$; $x =$

i. $2.75h + 2.25 = 27$; $h =$

j. $0.12b = 0.60$; $b =$

4. Solve for the unknown in the following proportion problems. Carry your answers out 2 decimal places.

   a. $\frac{5}{a} = \frac{7}{35}$; a =

   b. $\frac{3}{8} = \frac{15}{k}$; k =

   c. $\frac{7}{30} = \frac{n}{21}$; n =

   d. $\frac{5}{100} = \frac{20}{y}$; y =

   e. $\frac{8}{400} = \frac{20}{m}$; m =

403. Angular measurements, dioptric power, and focal lengths

1. Convert from the angular unit of measurement shown, to the unit requested.

   a. 60' = _______".

   b. 60° = _______'.

   c. 360" = _______°.

   d. 3600' = _______°.

   e. 8° = _______".

2. For the following dioptric powers, calculate the focal length in the unit of measurement shown.
   a. 2.25D = _________ dm.

   b. 0.50D = _________ in.

   c. 2.50D = _________ mm.

   d. 3.33D = _________ m.

   e. 10.00D = _________ cm.

   f. 5.00D = _________ in.

   g. 0.25D = _________ mm.

   h. 1.00D = _________ m.

   i. 50.00D = _________ cm.

   j. 20.00D = _________ dm.

3. A stamp collector has a +5.00 diopter-magnifying lens. What is the focal length of this lens? Calculate the answer in inches, meters, dm, cm, and mm.

4. A pair of dime store reading glasses has a dioptric power of +2.00. At what distance (focal length) would the lenses be most useful? Calculate the answer in inches, meters, dm, cm, and mm.

5. Convert the following focal lengths to diopters taking your answer to two decimal places (i.e., 4.00; not just 4).

   a. 200 mm = _________D.

   b. 25 dm = __________D.

   c. 80 in = ___________D.

   d. 0.20 m = _________D.

   e. 16 in = ___________D.

   f. 50 mm = __________D.

   g. 33 cm = __________D.

   h. 0.75 m = _________D.

   i. 100 cm = _________D.

   j. 5 dm = __________D.

1–2. Ophthalmic Optics

Your doctor manipulates the light rays entering the eye when he/she prescribes glasses or contact lenses. To understand light and optics, it is easiest to begin with some theories about light and then look at how it is reflected, refracted, polarized, absorbed, and emitted.

404. Theories, facts, and principles of light

Over time, our understanding of light has changed dramatically. The detection of light is a very powerful thing that allows us to understand the universe around us. Human vision is remarkable in its ability to receive and process a wealth of information involving light intensity, colors, motion, and depth. However, as amazing as our vision is, we are only able to see a small portion of the electromagnetic spectrum that determines the visible world. Our ancestors and recent scientists continue to theorize about the nature of light.

Light

What follows are some theories about light and how it travels and acts in the world around us.

Theories of light propagation

There are many theories on how light travels through air and various mediums, also known as light propagation. Most hypotheses can fit into two basic categories: the particle (corpuscular) theory and the electromagnetic wave theory. Neither perfectly explains all the characteristics or behavior of light, but each has proven information that will help you understand light—how it travels and what it does when it strikes or passes through various mediums. It is important to examine both theories if you are to have an intelligent comprehension of light, optics, and our physiological visual abilities.

Particle (corpuscular) theory

The particle (corpuscular) theory states *light is composed of a stream of invisible particles (photons), or corpuscles, emitted by objects and gathered by the eye*. These particles of light are given off directly by self-luminous objects such as the sun, a flame, or the filament in a light bulb. Then the particles strike nonluminous objects and are reflected or absorbed. Sir Isaac Newton (an English mathematician, scientist, and philosopher) first introduced this idea as his corpuscular theory and Max Planck (a German physicist) later expanded on the idea in his quantum theory, which Albert Einstein supported a few years later.

The quantum theory basically added to the particle theory by adding, *particles of light are actually packets of quanta energy*. The amount of energy a particle carries depends on its frequency. This is easily explained after a discussion of the wave and electromagnetic wave theory, but it essentially says a longer wavelength (one less frequent) has less energy than a shorter wavelength (one that is more frequent). Knowing this, we can safely say red particles of light have less energy than violet particles of light. The particle and quantum theories work very well to explain the emission and absorption of light rays.

We know light **is** energy because lasers concentrate light so powerfully it can burn holes in metal! Therefore, the particle (corpuscular) and quantum theory are quite valid in explaining certain characteristics of light.

Electromagnetic wave theory

This is the most complete theory of light as it developed from the basic wave theory, which borrows from the particle theory and includes principles from the quantum theory. This being the case, a quick look at the basic wave theory is in order before explaining the more complete electromagnetic wave theory.

A Dutch physicist and astronomer named Christian Huygens proposed the basic wave theory in 1678. His wave theory states light particles travel as energy along waves. He felt the waves were caused by some kind of vibration to the light particles. He theorized that while the wave of light is going up and down, the light as a whole is traveling in a particular direction. To picture this better, imagine throwing a rock in a pond. The rock causes waves in the water, and yet, while the waves are cycling up and down, the wave itself is traveling from the impact point of the rock, out toward the bank of the pond. The wave action occurs as the wave front moves in a specific direction. Picturing light as traveling along in waves helps explain diffraction, interference, and polarization of light.

The electromagnetic wave theory is an extension of all the theories. What it really does is explain the energy portion of the wave and quantum theories and refines them. A Scottish physicist named James Maxwell developed it in 1864. The electromagnetic wave theory states the vibrating particles (proposed in the wave theory) are actually mobile electrical charges and the wave motion of the light itself is a magnetic radiation. In 1887, Heinrich Hertz (a German physicist) experimentally verified the existence of electromagnetic radiations from oscillating electrical disturbances, proving visible light radiations are, in fact, electromagnetic. Hertz verified light oscillates (travels in waves) and light is the energy (quanta) of electrical and magnetic forces. Most modern-day scientists now accept the electromagnetic wave theory. It helps explain the transmission of light through various transparent and translucent mediums (e.g., glass, plastic, water). This, in turn, helps explain the refraction of light quite well.

Cosmic rays, gamma rays, X-rays, ultraviolet rays, along with infrared radar waves and broadcast waves for television and radio, are all forms of radiant energy of different wavelengths and frequencies. Together, with visible light, they form the electromagnetic spectrum. As you can see in figure 1–9, the visible portion of the electromagnetic spectrum is very small and consists of wavelengths within a variable range of about 400 and 750 nanometers (nm).

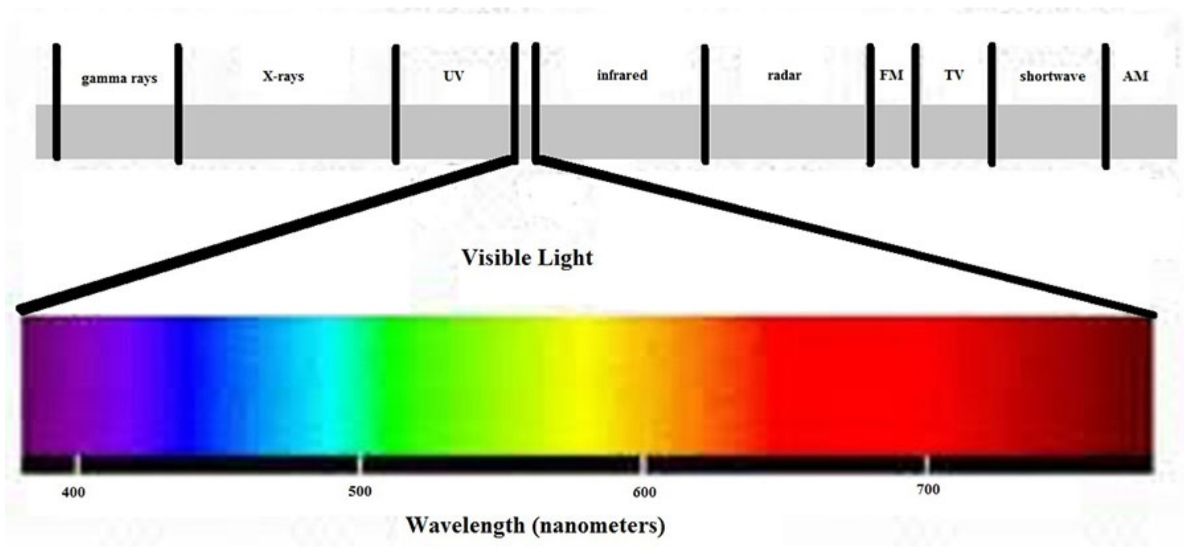


Figure 1-9. The very small area of the electromagnetic spectrum that represents visible light.

The different wavelengths within this range correspond to different colors of light. This is an important concept, so we'll say it again: each wavelength in the visible spectrum corresponds to a different color of light. When you look at figure 1–9, you see there is a variable range of wavelengths that make up each color. Red is a relatively long wavelength at an average of about 750 nm, and violet is a relatively short wavelength, at only an average of about 400 nm long. The other colors fall between these two lengths. The colors in the visible portion of the electromagnetic spectrum are easy to remember because they spell out the mnemonic ROY G BIV. This stands for: **r**ed, **o**range, **y**ellow, **g**reen, **b**lue, **i**ndigo, and **v**iolet.

Application of light theories

The theories described previously are relevant in explaining actions of light and optics. As stated before, the particle (corpuscular) theory is beneficial for explaining the emission and absorption of light. Let's take a closer look at emission and absorption.

Emission

Emission is the sending out of light energy. The light emits in all different directions as little luminescent particles of energy. When you are close to the luminous source, the emitted particles of energy are still rather concentrated and seem quite bright. Farther away from the luminous source the particles of light energy spread out and are less concentrated, therefore seeming less bright.

Examples of things emitting light are the sun, fire, and light bulbs. If you go out on a sunny, summer day, you'll experience quite a bit of the sun's luminescence. Now imagine if you were only 10 miles from the sun, you would definitely experience a lot more light energy at this close distance.

The spectral qualities of the light emitted from a source affects how things appear to us. If you look at a person outside, under the sunlight, and then see the same person again inside, under fluorescent lights, the person's clothes may not look exactly the same color or the person's skin may appear more tan or pale. Think about "black" lights. They emit a blue-like light, which makes the colors of your clothes look different, especially light colored clothing. In these settings, it is obvious the light emitted from a source affects the way we see things.

It was long ago believed that the eyes emitted light or energy of some sort. This was used to explain why people were able to see. We now know the eyes are more like receivers. They receive the light emitted from a source and convert it to an electrochemical impulse the brain then deciphers as a visual message. Simply put, if there is no light-emitting source, we cannot see. However, we are able to see more than only luminous objects (like the sun, fire, or light bulbs). The reason we see nonluminous objects is that the light rays from the luminous objects strike them and reflect into our eyes. It is actually reflected light we see coming from these nonluminous objects.

Absorption

Absorbed light is neither transmitted through nor reflected off an optical system. The amount of absorption taking place in a lens depends on several factors including index of refraction and degree of lens tint. To simplify this process, think of a very darkly tinted ophthalmic lens. As white light strikes this tinted lens, some light is reflected off the front surface, a lot of light enters the lens, and some percentage of light is actually transmitted through the lens to the eye. If 95 percent of the light entered the lens, and only 21 percent came through to the other side, it would mean the lens absorbed 74 percent of the light.

What happened to the 74 percent of absorbed light? Light is energy after all, and energy doesn't just disappear. In the case of absorption, the light is converted into a different form of energy, usually heat. You have most likely learned this through life experience. Black seats in a car might look nice, but in the summertime and when you're wearing shorts? They're not as nice. This is because black seats absorb a large quantity of light energy and convert it into heat. This, in turn, makes those seats extremely hot in the sun.

While the particle theory is good at explaining emission and absorption, the electromagnetic wave theory is good for explaining the transmission of light through any medium—air, water, lenses or any other optical device, including the eye. This is a more complex subject than emission and absorption, so transmission of light through various mediums is explained completely in the section on refraction.

Both theories—the particle and the electromagnetic wave—agree on one subject: light travels in straight lines. The ancient Greeks figured this out long ago by studying shadows. This principle of light traveling in straight lines, through a constant medium, is known as the rectilinear propagation of light. (Rectilinear means *moving in a straight line*). If light leaves the light bulb above your head and passes through the air, it just keeps traveling in its original direction until it reflects off an object or passes through a denser medium like a lens, water, window, and so forth.

Put another way, the rectilinear propagation of light says a light ray travels in a straight line as long as it stays in a particular medium. When it transfers to a new medium, whether it is denser or less dense, the light ray changes direction. While it is in the new medium, it continues in a straight line until it once again encounters a different medium. As the light ray continues on its path, this process continuously repeats. This concept is explored more thoroughly in the section on refraction.

Wavelength

Before we get further into definitions or explanations, let's cover some basic terminology. Using a "rock in a pool" analogy, if you throw a rock into a pool of water, you'll get waves. The crest is the top of the wave and the trough is the bottom. They are also called *maxima* (crest) and *minima* (trough), as indicated in figure 1–10. One complete waveform (one crest and one trough) is called a *cycle*. A *wavelength* is the *distance between any point on a wave to the same point on an adjacent* *wave*. Figure 1–11 shows the different points one could use to measure a complete wavelength. Remembering the “rock in a pool” analogy may help you with this terminology.

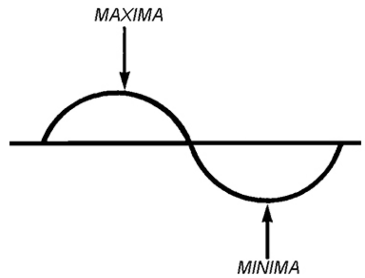


Figure 1–10. One complete waveform showing the maxima and minima.

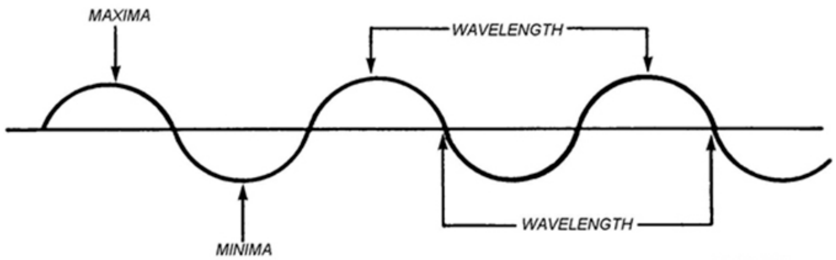


Figure 1–11. Illustration of various ways to measure a wavelength.

A light ray’s wavelength determines the color of the light. Violet light is a short wavelength (around 400-446 nm) as opposed to red light, which is a long wavelength (around 650-750 nm). Figure 1–12 shows the relative differences in wavelengths determines a light wave’s color.

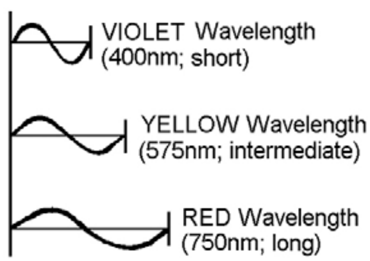


Figure 1–12. Illustration of the relative lengths of a violet, yellow, and red wavelength.

Amplitude

Amplitude is the maximum displacement of the waveform, or put another way, how high the crest (maxima) rises and how low the trough (minima) falls. Figure 1–13 shows where the amplitude of a waveform is measured.

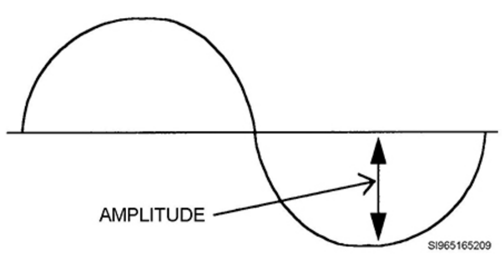


Figure 1–13. Amplitude of a waveform.

The greater the amplitude of a light wave, the brighter the light appears to be. In other words, if two lights of the same color (wavelength) are side by side and one is brighter than the other is, it is due to the greater amplitude of its waveform. The waveforms are the same length (since they are the same color), just the displacement of the maxima and minima are greater on the brighter waveform. Another way to look at it is the crest and trough of the brighter light rise and fall farther from the centerline. Amplitude correlates to brightness of the light.

Frequency

Frequency is the number of waveforms (cycles) passing a given reference point in a measured amount of time. Frequency is usually measured in 1-second intervals.

If you were to put a stake in a pool of water as a reference point, throw a rock in the pool to cause waves, and then count the number of waves passing the stake in a given unit of time, you could calculate the frequency of the wave cycles. Say 15 waves (each representing a complete cycle) pass the stake in the pool every second. The frequency can be stated to be 15 cycles per second, as shown:

$$\frac{\textbf{15 cycles}}{\textbf{1 second}} = \textbf{15 cycles/second}$$

Light frequencies are measured in much the same fashion, but bear in mind *frequency is dependent upon the wavelength and velocity of the light*. Just to illustrate this point, consider the frequencies of a violet light ray (400 nm wavelength) and a yellow light ray (575 nm wavelength).

The speed of light is constant for both at 186,000 miles per second, but the wavelength is different for each. The violet light ray passes by at a rate of 750,000,000,000,000 cycles per second and the yellow light ray passes by at a rate of only 510,000,000,000,000 cycles per second. See the difference wavelength can make in frequency? If you change velocity by sending one light ray through glass and the other through air, the velocity of the light ray in the glass is slower, since glass is denser than air, so the frequency of the light ray is less. You cannot change wavelength or velocity without affecting the frequency.

Velocity

Because light travels at such a high velocity, it was years before anyone could measure its speed with any accuracy. Light is so fast, many early scientists felt its speed was infinite, or incalculable. However, in 1676, a Danish astronomer named Römer was able to calculate (with a reasonable amount of accuracy) the speed of light based on his observations of stars and planets.

Today, modern physicists have computed the speed of light with great accuracy. In a vacuum, the *speed of light is 186,000 miles per second* (MPS). In a more open-air existence (when not in a vacuum), the speed is ever so slightly slower, but we'll stick with 186,000 MPS. In media more optically dense than air, such as spectacle lenses, the speed of light is slowed down. Through a typical glass lens, light slows down to around 120,000 MPS. However, consider that a bullet from an M–16 rifle travels at a speed of only 0.615 MPS. This helps to put into perspective the fact that light is incredibly fast by any standard, even when slowed by passing through media such as a glass lens.

All the colors of light travel at the same speed in air or empty space, but in denser media, the speed of light varies for different colors. This means a violet light travels at just a slightly different speed through a refractive medium (i.e., a lens or water) than any of the other colored light rays. This slowing down of the wavelengths by differing amounts is proven by the dispersion of light through a prism. White light, which is really a combination of all the colors in the visible spectrum, enters the prism and then all the colors of the visible spectrum emerge from the prism individually. This dispersion also occurs in spectacle lenses and accounts for one of the five types of aberrations spectacle lenses can cause. Aberrations are covered later in this career development course (CDC).

An important fact to remember is light rays slow down when entering a dense media and then speed up upon entering a less dense media. It is at these interfaces (different media densities) light rays can be bent. This bending of light rays is referred to as refraction of light and doctors use this principle of refraction when they prescribe glasses or contacts.

Vergence of light rays

During the latter part of the 18th century, scientists recognized radiation of heat from hot objects consisted of electromagnetic waves of the same fundamental nature as light waves. Luminous light sources such as the sun or the glowing filament of an electric light bulb radiate energy in the form of light waves (and heat), and these waves spread in all directions from the source (fig. 1–14).

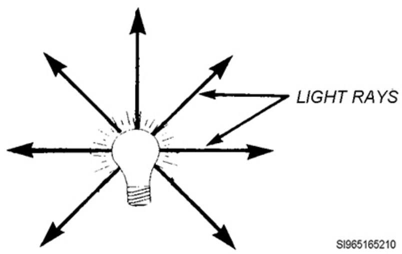


Figure 1–14. Light rays diverging from a source.

Because light travels outward in all directions from its source, the individual rays actually form wave fronts of light diverging out from the source like ever-growing circles.

Look at figure 1–15. You can see light is diverging from the light bulb and, as the wave front first emerges from the light source, it is quite curved and divergent. This diverging wave front of light is considered to have minus power. As the wave front moves farther from the source, it gradually becomes less curved and less divergent. After the wave front of light rays has traveled from the light source, the wave fronts become flat and parallel to each other. Since light rays in the wave front are now traveling parallel to each other and no longer diverging, the light (wave front) is considered to have zero, or plano power.

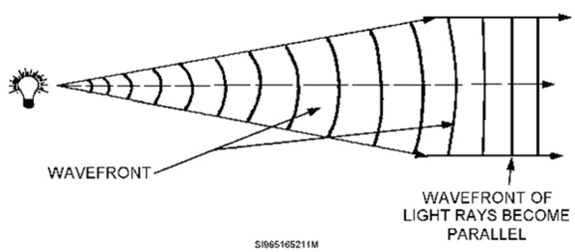


Figure 1–15. Curved, divergent wave front leaving a light source, then becoming flat and parallel.

If divergent light, which is spreading out from an illuminant source (or reflecting off an object) is said to have negative power, and parallel light is said to have zero, or plano power, then converging light rays must have positive power (fig. 1–16). Diverging light rays occur in nature as do parallel light rays, but the only way to get convergent light rays is for diverging or parallel light to pass through a convergent (plus powered) optical system.

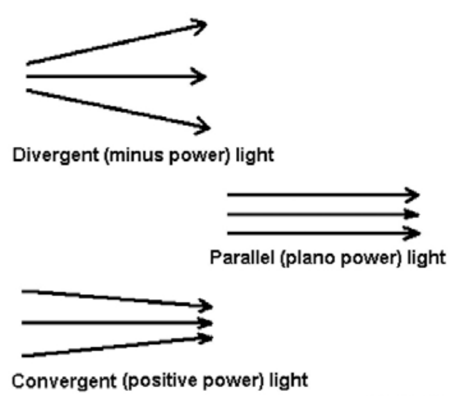


Figure 1–16. Divergent, parallel, and convergent light rays.

405. Reflection, refraction of light, and polarization

Reflection allows us to see ourselves. Refraction allows us to see others clearly. Polarization helps to eliminate glare and allows us to see more comfortably. Of course, each of these concepts does a lot more than just that. The next lesson expands on each of these topics.

Reflection

You know from experience mirrors reflect images. In reality, they reflect the light diverging from an object and you see an image of the object. When you look at yourself in the mirror, you are seeing the light rays bouncing off you. The light rays struck the mirror, and bounced back to your eyes.

Mirrors have predictable and explainable effects on light. While patients do not run around wearing mirrors, you still need to understand how light reflects from them to better understand light and optics. In a sense, every object around you is a reflective surface, similar to a mirror in many respects. You are seeing this page because light is striking it and reflecting into your eyes.

Since reflection is occurring around us all the time, we'll take a quick look at mirrors and reflection before moving on to principles of refraction.

Terminology

In order to discuss reflection, you need to be know some basic terminology. These terms are defined in the following table, and are shown in relation to a plane (flat) mirror in figure 1–17.

Term	Definition
Incident ray	Ray of light striking the mirror.
Reflected ray	Ray bouncing off a mirror
Normal	Imaginary line perfectly separating the incident ray and the reflected ray (and which is perpendicular, or at a 90° angle to the mirror).
Angle of incidence	Angle between the incident ray and the normal.
Angle of reflection	Angle between the normal and the reflected ray.

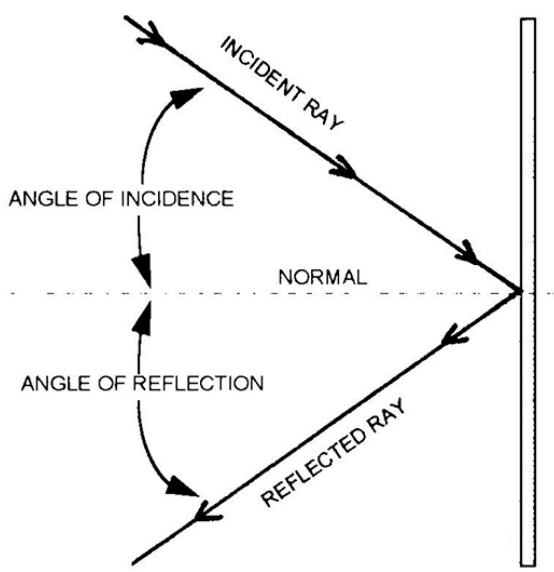


Figure 1–17. Labeled illustration of a light ray striking a plane mirror.

The same terms apply when a light ray strikes a curved mirror. Even with a curved mirror, the normal is still perpendicular (at a 90° angle) to the mirror's surface. It is just tougher to visualize where this would be on a curved surface. To construct a normal to a curved surface, pretend to complete the circle formed by the curve of the mirror. Find the center of the circle. Now, draw a line from that point to where the incident ray strikes the mirror. This gives you the normal. This concept is illustrated in figure 1–18.

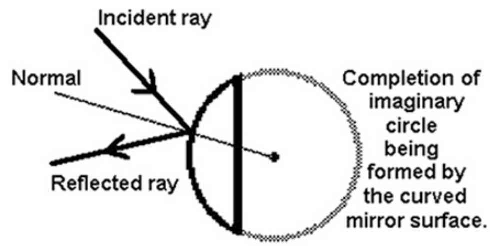


Figure 1–18. Constructing a normal for a curved surface.

Laws of reflection

Since reflection is predictable, there are laws of physics stating what is known about reflection. They are as follows:

- The angle of incidence equals the angle of reflection.
- The incident and reflected ray lie on opposite sides of the normal.
- The incident ray, the normal, and the reflected ray all lie along the same plane.

By applying the laws of reflection, you know if the angle of incidence is 20°, the angle of reflection is 20°. You know the normal is always an equal distance *between* the incident and reflected ray. Now, you know the light rays are going to travel in straight lines on the same plane or flat, level surface.

Regular and diffuse reflection

Regular reflection occurs when light strikes a smooth, highly reflective surface and is reflected in a manner that is very predictable, such as with a mirror. You can plot the direction in which any single ray of light is reflected by applying the laws of reflection. Regular reflection is what you want in your car mirrors so you can tell exactly what is behind you, where it is, and how far away it is.

Diffuse reflection occurs when light strikes a rough surface, such as the walls around you. The rough surface reflects the light but it is very hard to determine where any given ray of light will go since the rough surface abnormalities of the wall can send light rays in all directions. This would be an example of diffuse reflected light. Diffused reflected light is good light for photographers to use since it is spreading all over and "softens" the subject being photographed.

Curved mirrors

A plane (flat) mirror neither converges nor diverges the light striking it. It merely reflects the light. If convergent light strikes a flat mirror, it reflects the light and the light continues to converge. If divergent light strikes a flat mirror, it reflects off and continues to diverge. If parallel light strikes a flat mirror, it reflects off and continues to be parallel. However, it is important to understand what happens to light when it strikes a curved mirror. The curve can be outward, (i.e., convex mirrors) or the curve can be inward (i.e., concave mirrors). (You can remember con***cave*** by thinking of a cave, which curves inward).

When parallel light coming from an object strikes a convex mirror, the light rays reflect off and diverge. Since the light rays are diverging further apart, they have minus power and the image of the object, when viewed in the mirror, seems to be smaller and farther away than it really is. Think about the mirror on the passenger side of most cars. What does it say? "Objects in mirror are closer than they appear." Why? Because it is a convex mirror. The mirror made this way to give you—the driver—a wider field of view and minimize blind spots. The down side is a convex mirror makes objects appear smaller and farther away because it is diverging the light rays striking it. Figure 1–19 illustrates the diverging of parallel light rays striking a convex mirror.

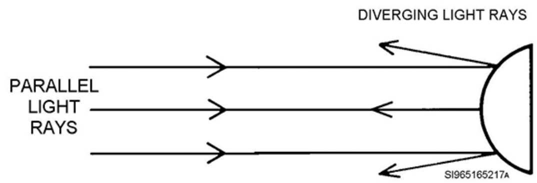


Figure 1–19. Parallel light rays striking a convex mirror and then diverging.

When parallel light comes from an object striking a concave mirror, the light rays reflect off and converge toward each other. Since the light rays are converging together, they have plus power and the image of the object (when viewed in the mirror) seems bigger and closer than it really is. Take a shiny spoon as an example. Hold it in front of you and look into the part you use to scoop your cereal. You'll see your big beautiful face looking back at you! (It is going to be upside down, which we will discuss in the next paragraph.) The light rays from your face are converging after hitting the shiny concave side of the spoon, causing a magnification of your features. You look bigger and closer than you really are. Figure 1–20 illustrates the convergence of parallel light rays striking a concave mirror.

Before we move on, let's go over why your image was upside down in the concave spoon. Look again at figure 1–20. You see that the light rays converge. Imagine that after the light rays come to the focus, they continue (which they do). The light ray striking the top of the mirror is now shooting off in a downward direction and the light ray striking the bottom of the mirror passed the focal point and continued on an upward direction. The light rays have crossed, so the top light ray (from your forehead) is now on bottom and the bottom light ray (from your chin) is now on top. These light rays enter your eyes and you see yourself upside down.

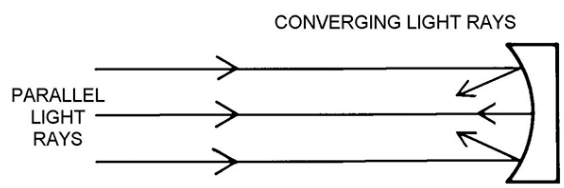


Figure 1–20. Parallel light rays striking a concave mirror and then converging.

Real and virtual images

An image is the optical counterpart of an object. Light from a source or an object acted upon by a lens, mirror, or other optical system (to include prisms) produces an image. Two types of images can be produced—real image or virtual image.

A real image is formed by convergent light rays and can actually be projected on a screen. A projector beaming a picture on a screen is a great example of an optical system producing a real image. The lenses in the projector took the object, converged the light rays coming from the object, and converged those light rays at a point (the screen). The image is real because you can hold a piece of paper in front of it and still see it. Convergent light rays can only form a real image, and light rays only get converged by passing through some type of optical system. Since you just finished learning about mirrors, let's use a concave mirror as an example of an optical system causing a real image. If parallel light rays were projected at a concave mirror and you held a piece of paper a few feet away from the mirror, you would get a real image, since the concave mirror converged the light rays to a real point of focus. Figure 1–21 illustrates this.

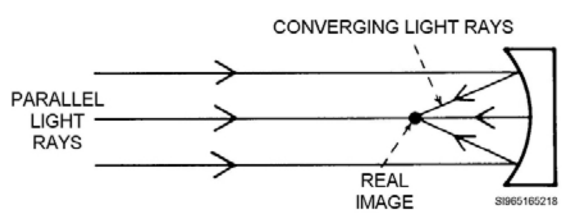


Figure 1–21. A concave mirror forming a real image by converging light.

A virtual image is formed by divergent light rays and cannot be projected on a screen. Your image in a plane (flat) mirror is a good example of a virtual image. The light rays reflecting off you and striking the plane mirror, are divergent. The plane mirror does not converge or diverge the light rays, but merely reflects them off again, so the light rays are still diverging as they come off the mirror. Your eyes see the divergent light rays as a virtual image because it cannot be projected on a screen or a piece of paper. It is only visible to you because your eyes converged the divergent light rays from the mirror into a real image on your retina. Figure 1–22 illustrates this concept.

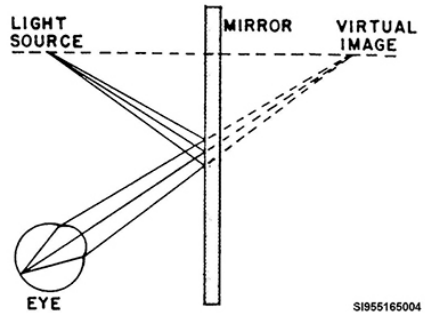


Figure 1–22. A plane mirror reflecting divergent light, causing a virtual image.

If parallel light rays were to strike a convex mirror, a virtual image would occur. Holding a piece of paper a few feet from the mirror does not result in any visible image as the convex mirror diverges the parallel light. The only image visible would be in the mirror, and it cannot be projected anywhere, so the image is proven to be virtual. Figure 1–23 illustrates this divergence of light rays from the convex mirror and shows where the virtual point of focus would appear to be if you were to look in the mirror.

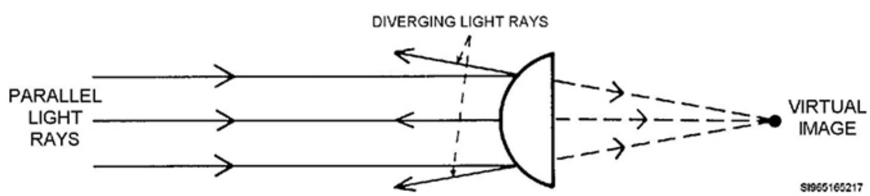


Figure 1–23. A convex mirror forming a virtual image by diverging parallel light.

Erect, inverted, and reversed images

Refer to figure 1–24 as we define erect, inverted, and reversed images.

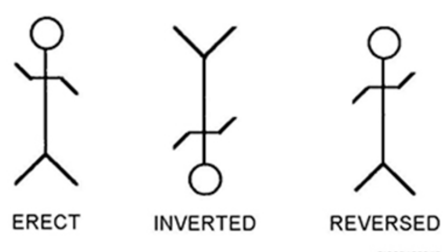


Figure 1–24. Depiction of erect, inverted, and reversed images.

Erect is the optical term for a right-side-up image. Think about looking at yourself in the plane (flat) mirror. Your image was erect, meaning you still appeared as standing upright. *Inverted* is the optical term for an upside down image. Think about when you looked at yourself in the concave side of the spoon. The image of your face was upside down, or inverted. *Reversed* is the optical term used to describe a backwards image. Think about when you wave to yourself in the plane mirror with your right hand. The image in the mirror waves back with the left hand. That image is reversed.

Normal, magnified, and minified images

Refer to figure 1–25 as we define normal, magnified, and minified images.

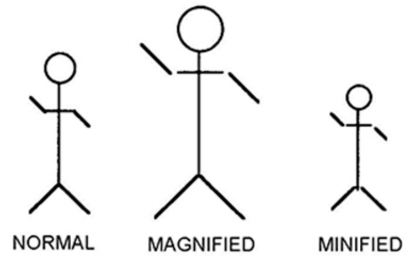


Figure 1–25. Illustration of normal, magnified, and minified images.

Normal is the optical term for an image correct in size to the object itself, meaning the image is actual size—not larger nor smaller. *Magnified* images appear to be bigger than the actual object. This occurs when light rays of the object are converged. An example was your face in the concave side of the spoon. Your face looked bigger and puffier than it really was. It was magnified by an optical system—in this case a concave mirror (shiny inside of a spoon)—having a positive or convergent power.

Minified images appear to be smaller than the actual (normal) object (fig. 1–25). The best examples are convex mirrors (the ones stating, "Objects in mirror are closer than they appear" common on the passenger sides of most cars). The images of the objects viewed in the mirror look small, or minified, and, therefore, appear to be farther away than they really are. The images seen are minified by an optical system, in this case a convex mirror, which has negative or divergent power.

To recap, you can describe an image (as opposed to the actual object) as being:

- Real or virtual.
- Erect or inverted.
- Normal or reversed.
- Magnified (larger), minified (smaller), or normal (the same size).

Refraction

Refraction is defined as *the bending of light rays as they travel from a medium of one density to another medium of a different density*. Figure 1–26 is an example of the effects of refraction of light between the mediums of air and glass. Refraction of light is a bit more involved than reflection, as it has to do with the bending of light rays as they pass through an optical system rather than just bouncing off.

Terminology

Refraction uses some of the same terms as reflection. The ray hitting a lens is still called the incident ray. There is still a normal perpendicular (at a 90° angle) to the surface the light ray passes through. Instead of a reflected ray, however, we have a refracted ray. The refracted ray is the light ray having passed through the lens system and bent along the way.

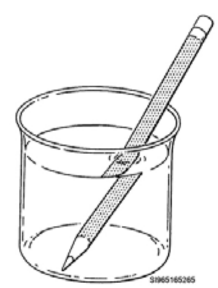


Figure 1–26. Example of refraction.

Medium is a word used here to describe the material light rays are traveling through. Air is a medium. Glass, plastic, and diamonds could all be considered mediums. We discuss the medium light travels through because the medium determines how the light is affected. Essentially how much bending of the light occurs depends on the medium. This becomes more apparent as you continue reading this section.

Laws of refraction

As with reflection, there are laws of refraction. Light obeys certain physical laws when it passes through an optical medium. With an understanding of these laws, you could look at any lens and predict its effect on the light passing through it. Listed below is a simplified version of the technical laws of refraction.

- When light travels from a medium of **lesser density** (like air) to a medium of **greater density** (like a lens), the path of the light *is bent toward the normal.*
- When light travels from a medium of **greater density** (the inside of a lens) to a medium of **lesser density** (back out into the air again), the path of the light is *bent away from the normal*.
- The incident ray lies on the *opposite side* of the normal from the refracted ray.
- The incident ray, the normal, and the refracted ray all *lie in the same plane*.

Study figure 1–27 and compare what is illustrated in the figure to the laws of refraction you just read. Note the normal, the angle of incidence, and the angle of refraction. Understanding what you see in relation to the laws of refraction is extremely valuable in understanding how various mediums affect light.

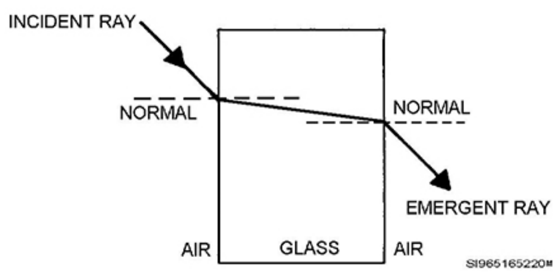


Figure 1–27. Labeled diagram showing the refraction of light through a plano lens.

Light through a plano lens

The rectilinear propagation of light means light travels in a straight line within a constant medium. If light hits a medium of lesser or greater density, it changes direction and then continues to travel straight in the new direction while in the new medium. When it departs from one medium to another, it once again changes direction and then continues in a straight line, in its new direction, in the new medium. This just keeps going on and on as the light goes from medium to medium. The laws of refraction tell you which way the light bends. Bending of the light depends on the medium the light is in and the medium it enters. If you can draw a normal, you can figure out where light will go.

A logical beginning for visualizing refraction is to see what happens when light is traveling through the medium of air and strikes a medium of a flat piece of glass, like the window of a house. The glass is flat on both sides and has no convergent or divergent power. You’ll look at what happens when light strikes the plane glass head on (perpendicular) and what happens when light strikes the plane glass at an angle. You’ll start with the perpendicular example.

As light moves through the air, it travels at 186,000 MPS. It strikes the glass plane head on, perpendicular to its surface, right along the normal. The light wave hits the glass and slows down in this denser medium. The light does not change direction because the entire wave front of the light hits the surface of the glass at exactly the same time, right along the normal of the glass surface. It is not as if one side of the wave front slowed down while the other side continued at full speed (which would have caused the light wave to change direction). The entire wave front hits at the same time. Now the light is in the glass and slows to about 120,000 MPS, going in a straight line. When it gets to the other side, the entire wave front exits the glass at exactly the same time, again perpendicular to the surface of the glass, right along the normal. Again, since the entire wave front of light exited at the exact same time, right along the normal for the surface of the glass, it does not change direction. Now it is back in the less dense medium of air, it speeds back up to 186,000 MPS, and continues in a straight line. This whole process is illustrated in figure 1–28.

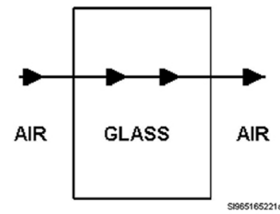


Figure 1–28. Light ray striking plane glass perpendicular to its surface.

If light strikes a medium at an angle, its course is changed, bent, or refracted, as it enters the new medium. Having said this, look at a light ray striking the surface of a plane glass at an angle and see what occurs. Refer to figure 1–29 as you read so you can visualize what is being described.

Once again, you'll start with the light wave traveling through the air at 186,000 MPS. The wave front of the light hits the plane glass at an angle, and the portion of the wave front contacting the glass has slowed down to 120,000 MPS. The rest of the wave front is still traveling at full speed, at this point it begins to pivot toward the slowed point. Soon, the rest of the light ray has struck the denser medium of the glass, and the light ray continues to travel at its new speed of 120,000 MPS, but it is obvious the light ray has deviated from its original direction of travel. This refraction of the light ray proves the first law of refraction: *when light goes from a low-density medium (the air) to a higher density medium (the glass), the light is bent toward the normal*.

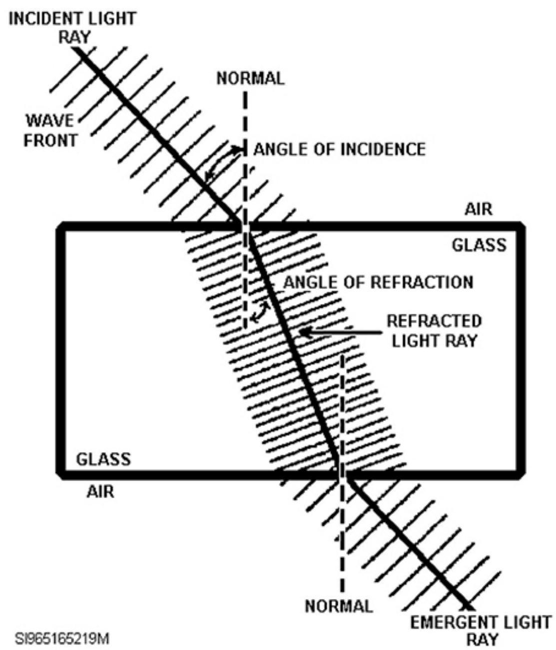


Figure 1–29. Light ray striking the surface of plane glass at an angle.

The light wave is now traveling through the glass and continues to go straight along its new path (in the glass) as long as it is in this medium. Since the light is now in the denser medium of glass, it is only traveling at 120,000 MPS. As it gets to the other side of the glass, one edge of the light ray's wave front escapes the glass first. This portion of the wave front speeds up, but the rest of the light wave is still in the lens. Once again, the faster light rays pivot toward the slower ones. Soon, the rest of the light wave escapes the lens and the entire light wave resumes its original speed in the air of 186,000 MPS. However, the light wave is not going in the same direction it was traveling while it was in the glass. It has now demonstrated the second law of refraction: *light going from a dense medium (the glass) to a less dense medium (the air) is bent away from the normal*.

The pivoting, or bending, of light waves (wave fronts)—as just explained—describes refraction. If the glass (lens) has parallel surfaces (i.e., plano, neither convex nor concave), the emergent light ray emerges from the glass at the same angle the incident light ray entered. The light was bent toward the normal upon entering the glass, but was bent an equal amount away from the normal upon exiting. Therefore, the light did not become more convergent or divergent. Overall, the power and ultimate direction of the light was not changed in the example just described. This happened because the glass was plano, or had zero power.

The amount of refraction occurring as light travels from one medium to another depends on several factors:

- The angle at which the light strikes the medium.
- (This means the greater the angle of incidence between the light and the new medium, the greater the angle of refraction).
- The curvature of the surface of the new medium (if it is curved).
- (This means the more curvature the new medium has, the greater the angle of refraction).
- The density of the new medium.
- (This means the higher the difference in index of refraction between the two mediums, the greater the angle of refraction).

Prisms

A prism is essentially an optical triangle. It has three surfaces that are not parallel. The thickest portion of a prism is called the base and the thinnest portion is the apex (fig. 1–30). A prism has two effects on white light: deviation and dispersion.

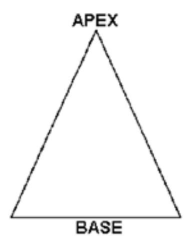


Figure 1–30. Prism showing the apex and the base.

If you apply the laws of refraction to a prism (fig. 1–31), you'll find that the light ray is deviated toward the base of the prism. This concept is worth remembering: *light is always deviated toward the base of a prism*. The concept also applies to curved lenses, since they are essentially two prisms put together. The deviation of light depicted in figure 1–31 is only one effect of a prism.

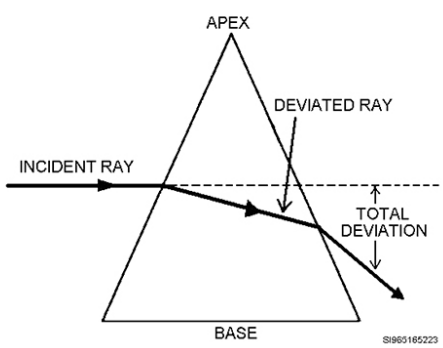


Figure 1–31. Prism deviating light towards its base.

The other effect a prism has on light is the ability to disperse it. Dispersion is the breaking down of white light into its component colors (ROY G BIV). When white light passes through a prism, it is deviated toward the base. This bending of the light affects all wavelengths, from the longer red wavelengths through the shorter violet wavelengths. However, the prism is not refracting every wavelength exactly the same. The violet light rays are refracted the most and the red light rays are refracted the least. The colors in between are also being refracted at slightly different rates. When the original white light finally emerges, it has been broken down into its component colors, ROY G BIV, which is called dispersion (fig. 1–32).

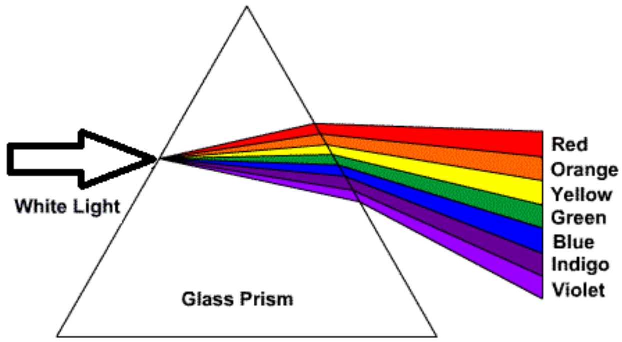


Figure 1–32. Prism dispersing white light.

Since prisms deviate light toward their bases, the use of prisms in glasses can help some strabismic (i.e., those with misaligned eyes) patients whose eyes do not normally line up correctly when viewing an object. When the light passing through a prism gets deviated toward the base, it appears to the person on the other side of the prism as if the light was actually coming from an area more toward the apex. This optical illusion effectively shifts the image of the object toward the apex of the prism (fig. 1–33). This image shifting, when done in front of a deviating eye, can help a strabismic person see the same thing, with both eyes, at the same time. The prism effectively moved the image of the object to where the deviating eye normally looks.

Therefore, when you see prism in a prescription, you know that the doctor is trying to get both of the patient's eyes to see an object (or the image of that object) at the same time.

To recap: light going through a prism is deviated toward the base, but the image of the object appears to move toward the apex. See figure 1–33 for an illustration.

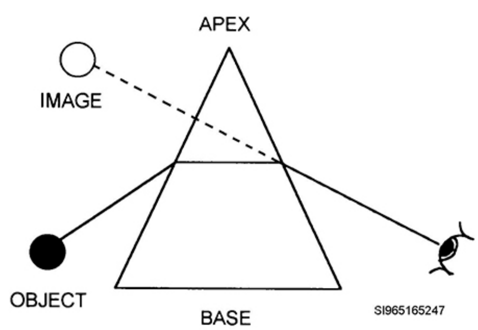


Figure 1–33. A prism makes an object's image appear to move toward the apex.

Remember that prisms are responsible for two actions: deviation and dispersion. The deviation of light by a prism can have a positive effect when used in the glasses of strabismic patients. Prismatic power is rated in diopters, just like lenses. Figure 1–34 gives an example of how a prism's dioptric power is determined. When used in optical systems, such as glasses, the orientation of the prism in the lens is listed in terms of the base's orientation—base up (BU), base down (BD), base in (BI), or base out (BO). An example of prism written on a prescription pad would look like this: –2.00 SPH 2▲BU. This is how you would read it, minus two sphere and two diopters of prism base up.

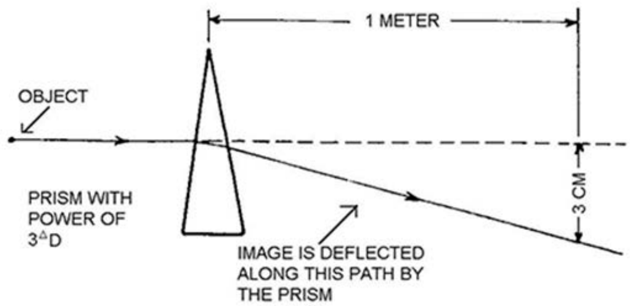


Figure 1–34. Illustration of how dioptric power of a prism is determined.

Curved lenses

Curved lenses, with plus or minus power, can really be thought of as being two prisms placed together. If you want a lens to have plus, or convergent power, you put two prisms together base to base (fig. 1–35). Remember, light gets deviated toward the base of each prism, so the light is effectively converged. If you want a lens to have minus, or divergent power, you put two prisms together apex to apex (fig. 1–36). Again, the light deviates toward the base of each prism, so the light exits and diverges.

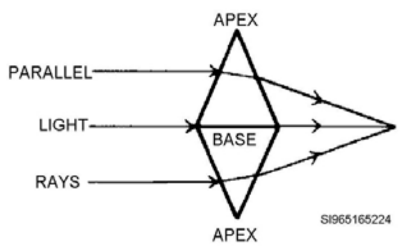


Figure 1–35. Two prisms put base to base to form a plus lens.

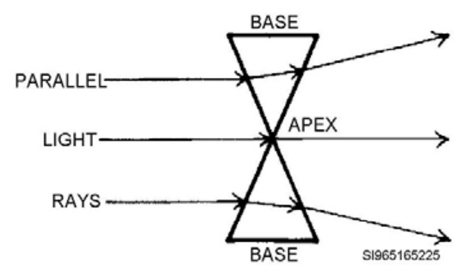


Figure 1–36. Two prisms put apex to apex to form a minus lens.

Curved lenses are, in simple terms, just two prisms put together with their edges rounded off. Lenses can be made in all sorts of shapes with a variety of curves. However, when you simplify things, a convergent lens is essentially two prisms base to base and a divergent lens is essentially two prisms apex to apex. You can still apply your laws of refraction, draw the normal, and calculate which way the light bends. If you can remember light is bent toward the base of a prism, you can easily tell which way a lens bends light.

Think about two prisms put together to form lenses. A lens formed by putting two prisms base to base makes a plus lens, which is convex in shape (fig. 1–37). This lens converges light. When trying to recall how a convex-shaped lens works, think *convex converges.*

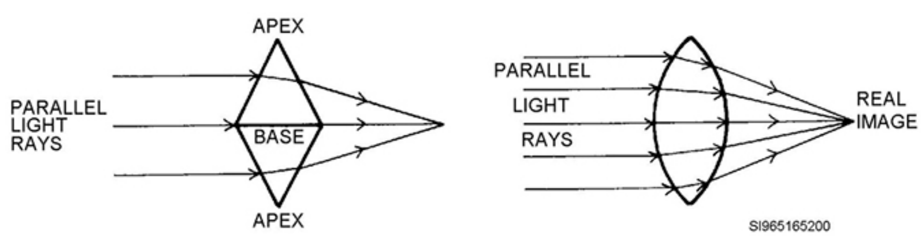


Figure 1–37. Plus lenses.

Putting two prisms together apex to apex makes a minus lens, which is concave in shape (fig. 1–38). When trying to recall how a concave shaped lens works, think *concave sends light away*, as it diverges light. These rules apply only to lenses. Lenses work the opposite of mirrors. Be careful not to confuse the two**.**

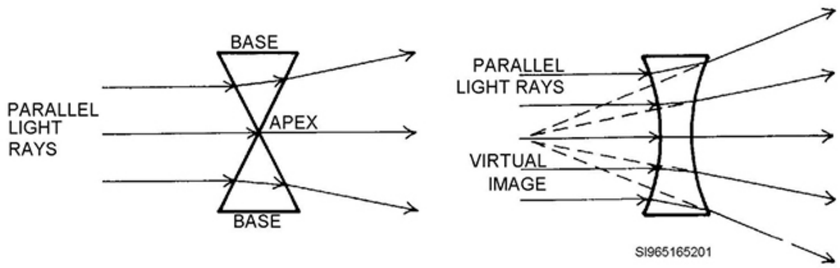


Figure 1–38. Minus lenses.

Now that you can identify the power of a lens by looking to see if it is convex (plus power) or concave (minus power), you need to move your thinking a step further and be able to look at a meniscus-type lens and determine whether it has plus or minus power. *Meniscus* means *crescent shaped* and is how spectacle lenses are actually shaped. If you think about your patients' spectacles, the lenses have not been biconvex or biconcave. Spectacles have crescent-shaped meniscus lenses. They have both a convex front surface and a concave back surface.

If one side of a lens is convex (plus) and the other side is concave (minus), there are several ways to tell the overall power of the lens. The most obvious way is to use a lensometer. Another way is to use a lens clock and measure the convex (front) curve and the concave (back) curve of the lens; the side with the most powerful curve determines the overall lens power. For example, if you measure the front curve as a +7.00 and the back curve as a –5.00, the overall lens power in this case would be +2.00. You determine this by algebraically adding +7.00 and –5.00, and coming up with the overall lens power of +2.00.

Let's practice a few more by using the lens clock method. The convex surface measures +2.75. The concave surface measures –3.50. The overall power would be –0.75. Try one with a lens that has a +9.50 front curve and a –9.50 back curve. The overall lens power would be plano, or zero. This lens would not converge or diverge light. Figure 1–39 has more examples for you. Study it to make sure you understand this concept.

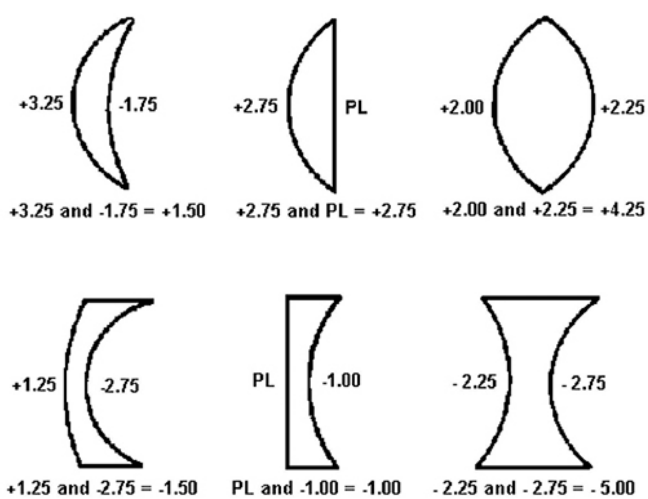


Figure 1–39. Using lens curve measurements to determine overall lens power.

The other way you can tell the overall power of a meniscus lens is even easier. Think about two prisms making lenses as we previously discussed. Put the two prisms base to base, as shown in figure 1–40. This is a plus lens. Now, put the two prisms apex to apex, as shown in figure 1–41. This is a minus lens. What is different about the two lenses besides one being biconvex and the other being biconcave? Notice the plus lens is thicker in the middle than at the edges. In addition, notice the minus lens is thin in the middle and thick at the edges. This is a great way to tell whether a lens is a plus or a minus power—just by looking at it!

Remember:

- Plus lenses are thick in the middle and thin at the edge.
- Minus lenses are thin in the middle and thick at the edge.

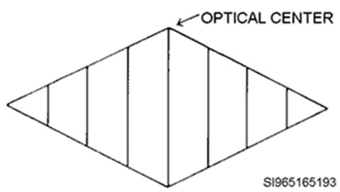


Figure 1–40. A plus lens made by putting two prisms base to base.

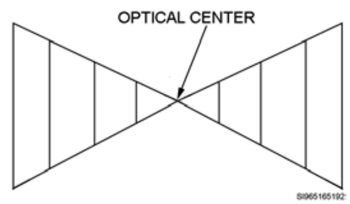


Figure 1–41. A minus lens made by putting two prisms apex to apex.

These rules are true whether the lenses are meniscus shaped, formed from two prisms, or ground flat on one side and curved on the other. Plus lenses are thick in the middle. If you eat a lot, you put on plus pounds, and get thick in the middle. Minus lenses are thin in the middle. If you do not eat, you're going to be minus some weight and get thinner in the middle.

Look at figure 1–42 and you'll see the plus lenses are all thick in the middle. Figure 1–43 shows minus lenses are thin in the middle, and figure 1–44 shows plano lenses, which have no convergent or divergent power, are equal thickness throughout.

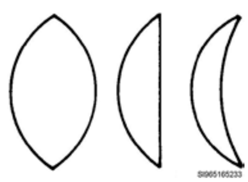


Figure 1–42. Plus lenses (biconvex; plano convex; positive meniscus).

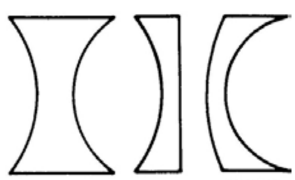


Figure 1–43. Minus lenses (biconcave; plano concave; negative meniscus).

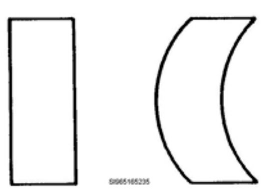


Figure 1–44. Plano and plano meniscus lenses.

Factors influencing lens power

There are many subtle factors influencing the power of a lens, but the two primary variables are surface curvature and index of refraction. Of the two, surface curvature has the most influence regarding lens power. It is also much easier to manipulate the surface curvature than index of refraction.

Surface curvature (radius of curvature, or r)

Simply put, the more curve a lens surface has, the more light bending power it has. A lens surface with a very sharp, steep curve has more power than a lens with a very gently curved, almost flat surface.

A better way to describe the steepness of a curve is to refer to its radius of curvature (r). Radius refers to the length of a line drawn from the center of a circle out to the edge. The more curve a circle has, the shorter its radius (r) (fig. 1–45). Think about the curvature of a racquetball compared to the curve of a basketball. From the center of the racquetball to its outer cover is about an inch, so it would have an r of 1 inch. From the center of a basketball to the outer cover is about 6 inches, so it would have an r of 6 inches. The racquetball obviously has a steeper curvature than the basketball. If you were to cut each one in half, touch it with a magic pupillary distance (PD) ruler, and make them lenses, the racquetball lens would have more power than the basketball lens.

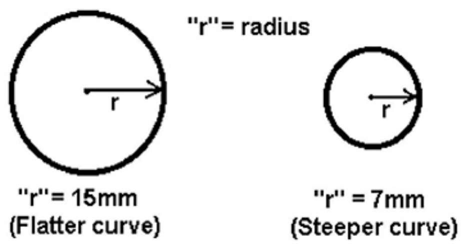


Figure 1–45. Length of radius affects degree of surface curvature.

Index of refraction (n)

Index of refraction (n) is the other variable influencing lens power. The technical description of index of refraction is the ratio between the speed of light in a vacuum and the speed of light in a given medium. The formula is as shown:

$$\frac{\textbf{velocity of light in a vacuum}}{\textbf{velocity of light in a medium}} = \textbf{Index of Refraction (n)}$$

As stated earlier, the speed of light in a vacuum is 186,000 MPS, while in other substances light travels slower because they are optically denser. In effect, index of refraction is just a way of relating the speed of light to a medium's optical density. Put another way, the slower light travels in a medium, the denser the medium is, and the higher that medium's index of refraction. An example for calculating a medium's index of refraction (in this example, plastic) is shown below:

$$\frac{\text{Speed of light in a vacuum } 186{,}000 \text{ MPS}}{\text{Speed of light in the plastic } 120{,}000 \text{ MPS}} = \mathbf{1.55} \text{ n for the plastic}$$

To simplify the concept, we describe index of refraction as a rating of an optical material's density, or ability to slow down and bend light. A higher index of refraction indicates a more optically dense material slowing and bending light to a greater extent than a lens with a lower index of refraction. A vacuum has an index of refraction of 1.000. The air you are breathing right now has an "n" of 1.000293. A table is provided showing various mediums and their related "n" values. Do not try to remember them as they are only listed to give you a better idea of how "n" changes as the density of materials change.

Medium	Index of Refraction ("n")
Vacuum	1.00000
Air	1.000293
Water	1.333
Boro-silicate crown glass	1.517
Gelatin	1.530
Light Flint glass	1.588
Medium Flint glass	1.617
Dense Flint glass	1.963
Diamond	2.416

From the table above, compare the diamond to the boro-silicate crown glass. If all other factors are equal, the diamond has a sizably larger index of refraction. It, therefore, has an improved ability to slow and refract light. If you had lenses of each material made up with equal curvatures and thickness, the diamond would have more refractive power due to its higher "n" value. Another way to think of this would be the diamond lens could be made substantially thinner than the boro-silicate lens and still be able to accomplish the same amount of refraction.

Understanding index of refraction does help explain those commercials where optical shops are advertising the latest terminology for their "thin," "polycarbonate," or "high index" lenses. These lenses are generally lighter than conventional lenses because they can be made thinner and still do the same job due to their higher "n" value. Most of these high index lenses have an "n" value of around 1.6 or so. This enables them to bend light just as much as a thicker lens with a lower "n" value, but keep the weight down. An easy way to think of this; the higher "n" means increased benefits and *more "n" = less lens/weight*. Nobody likes to carry a lot of weight around on his or her face, so high "n" lenses continue to be popular.

So, remember the two major ways to influence the power of a lens: change the surface curvature or change the index of refraction of the lens material.

Snell's law

Willeborough Snell, a mathematician and astronomer, determined if a person knew the angle of incidence of a light ray and the angle of refraction of the light ray, the index of refraction of the material the light passed through could be calculated. This concept is referred to as Snell's law.

Another discovery of Snell's was that light does exactly the same thing whether it goes through an optical system in one direction or from the other. Put another way, if a light ray's direction of travel was reversed through an optical system (no matter how many prisms, mirrors, or lenses there are in the system), the light ray retraces its path exactly. This is what is referred to as the Law of Reversibility. This means that a convergent lens is still convergent and a divergent lens is still divergent, regardless of whether you flip the lens around and shine light through it from one side or the other. The lens still does the same thing to the light, regardless of which way the light passes through it.

Polarization

The technical definition of polarization is *the act, process, or result of altering the presumed transverse wave motion of radiant energy, such that it is not uniform in amplitude in all directions in a plane perpendicular to the direction of propagation*. Simplified, it means that polarization is the process of totally eliminating the light waves in one meridian and allowing all the light rays in the meridian 90° away to pass through.

An analogy would be looking through a set of horizontally oriented mini blinds. The vertical light waves trying to come through are blocked, but the horizontal rays pass through (fig. 1–46).

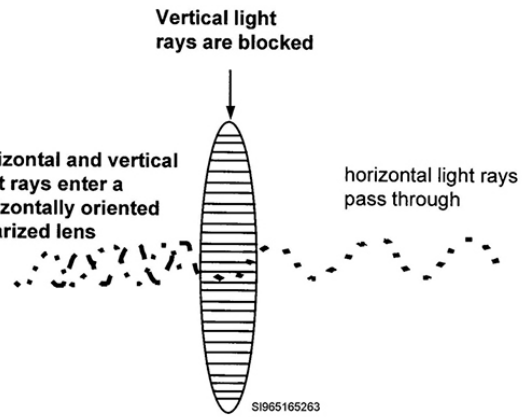


Figure 1–46. Polarized lens oriented to block vertical light rays.

If you had vertical mini blinds, the horizontal light waves trying to come through are blocked while the vertical light waves pass through (fig. 1–47).

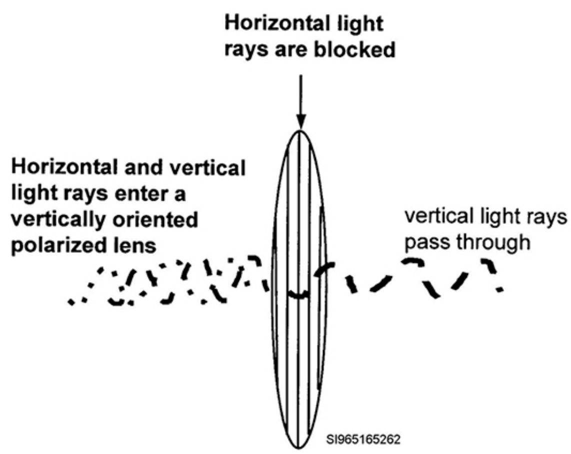


Figure 1–47. Polarized lens oriented to block horizontal light rays.

If you had vertical and horizontal mini blinds in the same window, you could effectively block out all the light waves (fig. 1–48).

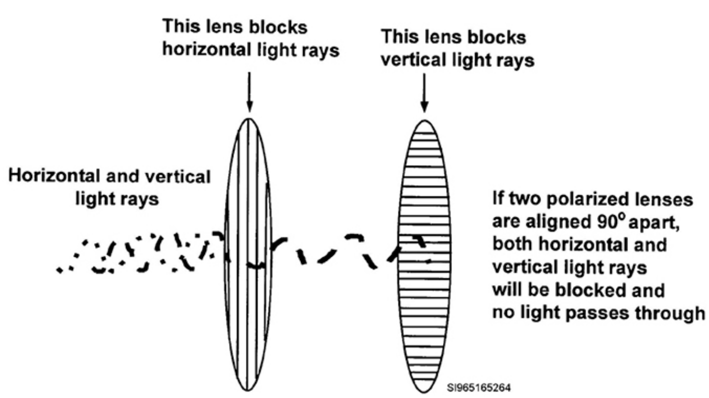


Figure 1–48. Two polarized lenses oriented 90° apart so one lens blocks the horizontal light rays and the other the vertical light rays.

Polarization of light can occur in nature. When light strikes the surface of smooth water and you look at the water, you'll just see glare off the surface. The water is allowing half the light rays to enter and the other half are being blocked and reflected back. This is an example of natural polarization and is why people who work around bodies of water often buy polarized glasses. The polarized glasses can polarize (block) the light coming off the water surface, but allow the light rays traveling at an angle 90° away to pass through. This allows them to see, as light is still passing through the glasses, just not the glaring light coming off the water surface. The polarized lenses in the glasses, which are oriented at the correct angle to do this, are eliminating the glaring light.

Polarized lenses are useful in some of the testing you do in your clinic. Think about the Titmus® stereo fly test, used when checking for suppression and depth perception. The spectacles included with the test have polarized lenses. One lens is polarized for vertical light waves and the other lens is polarized for horizontal light waves. If a person with normal fusion and depth perception puts on the polarized spectacles, he or she can see everything in the stereo fly test booklet. However, if a person who is suppressing an eye puts on the polarized glasses and looks inside the test booklet, he or she can only see some of the images. The polarized lenses are what make the test work.

If you would like to verify that the mini blind theory is true, you can put a pair of polarized spectacles on at the same time as your patient (or have a coworker stand in as the patient). If you look at them with both of your eyes open, you can see both of their eyes through the lenses. Try closing one eye. You will now only see one of their eyes. Now switch eyes—open and close the opposite eye. You should have noticed that the patient's opposite eye is now visible but not the other. Of course, this only works if you do not have a suppression problem yourself!

Before we end this lesson, let's briefly recap some of the main points about refraction. Remember convergent light rays are considered to have positive power, divergent light rays are considered to have negative power, and parallel light rays are said to have plano or no power. Prisms always deviate light toward their base, which, in turn, causes the image of the object (from which the light rays are coming from) to appear to move toward the apex. Any lens with convergent power (a plus lens) can be thought of as being two prisms placed base to base and any lens with divergent power (a minus lens) can be thought of as simply two prisms placed apex to apex. Plus lenses are thick in the middle; minus lenses are thin in the middle. Above all else, do not confuse lenses with mirrors. They are not the same and do not affect light the same.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

404. Theories, facts, and principles of light

1. What are the two basic theories of light propagation?

2. Which theories are best used to explain the emission and absorption of light?

3. Who proposed the basic wave theory?

4. According to the electromagnetic wave theory, what are the vibrating particles and the wave motion of light?

5. Which theory helps explain the transmission of light through various transparent and translucent mediums?

6. What is the visible portion of the electromagnetic spectrum?

7. To what do the different wavelengths within the visible portion of the electromagnetic spectrum correspond?

8. Define emission.

9. What is it about the light that is emitted from a source that affects how things appear to us?

10. If an object is not actually emitting light, how can you see it?

11. Define absorbed light.

12. What happens to absorbed light?

13. Give the name for the principle that states, “Light travels in a straight line through a constant medium.”

14. What are the top and bottom of a waveform called?

15. What color light is formed by a 400 nm long wavelength? How about one 750 nm long?

16. To what does amplitude correspond?

17. Frequency is dependent upon what two variables?

18. What power does divergent light have?

19. What kind of power does parallel light have?

20. How do light rays become convergent?

405. Reflection, refraction of light, and polarization

1. List the laws of reflection.

2. What is always found an equal distance between the incident ray and the reflected ray?

3. What happens to parallel light that hits a convex mirror? A concave mirror?

4. What is the optical counterpart of an object?

5. How can you tell if an image is real or virtual?

6. Imagine your image in a plane (flat) mirror. Is your image real or virtual? Are you erect or inverted? Are you normal or reversed?

7. Define refraction.

8. List the four laws of refraction.

9. List the three factors that influence the amount of refraction that takes place when light goes from one medium to another.

10. What two effects does a prism have on light?

11. When light enters a prism, which way is it deviated, or bent?

12. Define dispersion.

13. If a person looks at an object through a prism, where does the image of that object appear to move?

14. When a prism is used in glasses, what needs to be specified about the orientation of the prism?

15. How do you make a convergent lens using two prisms? A divergent lens?

16. A lens has a +6.75 curve on its front surface and a –5.00 curve on its back surface. What would be the approximate overall lens power?

17. What kind of lens is thick in the middle?

18. What is the major factor that influences the power of a lens?

19. What does "r" stand for?

20. Which lens would have a steeper curve, one with an "r" of 7 inches or one with an "r" of 14 inches?

21. What is index of refraction?

22. All other factors being equal (i.e., lens thickness, surface curvature, and angle of incidence), which lens would refract light more, one with an "n" of 1.5 or one with an "n" of 1.9?

23. Explain Snell's law.

24. If light passing through a lens traveling from left to right is converged, what would the light do if it passed backwards through the lens going right to left? Why?

25. Give the simplified definition of polarization.

Answers to Self-Test Questions

401

1. a. +9.50.
   b. +2.25.
   c. –18.50.
   d. +0.50.
   e. +16.75.
   f. –25.00.
   g. –2.75.
   h. 0.00.
   i. –1.00.
   j. +9.62.
2. a. +28.00.
   b. –18.00.
   c. –80.00.
   d. +0.50.
   e. +7.00.
   f. –5.00.
   g. +4.00.
   h. –6.00.
   i. –1.00.
   j. +6.00.
3. a. –0.038.
   b. +0.00085.
   c. +1.56.
   d. +0.00001.
   e. –23.69.
   f. –0.6.
   g. –5.785.
   h. –0.1.

402

1. a. 4,200 cm.
   b. 0.5 m.
   c. 0.25 mm.

d. 0.25 m.
e. 470 mm.
f. 15 cm.
g. 0.0765 m.
h. 0.00467 dm.
i. 5000 cm.
j. 100,000 mm.

2. a. 232 in.
b. 2.5 dm.
c. 240 in.
d. 112 in.
e. 900 mm.
f. 38 in.
g. 8 in.
h. 0.4 m.
i. 200 cm.
j. 4 in.

3. a. n = 4.
b. a = 5.
c. c = 6.5.
d. y = 3.
e. y = 2.
f. n = 12.
g. t = 34.
h. x = 6.5.
i. h = 9.
j. b = 5.

4. a. a = 25.00.
b. k = 40.00.
c. n = 4.90.
d. y = 400.00.
e. m = 1000.00.

403

1. a. 3600".
b. 3600'.
c. 0.1°.
d. 60°.
e. 28,800".

2. a. 4.44 dm.
b. 80 in.
c. 400 mm.
d. 0.3 m.
e. 10 cm.
f. 8 in.

   g. 4,000 mm.
   h. 1 m.
   i. 2 cm.
   j. 0.5 dm.
3. 8 in., 0.2 m, 2 dm, 20 cm, 200 mm.
4. 20 in., 0.5 m, 5 dm, 50 cm, 500 mm.
5. a. 5.00 D.
   b. 0.40 D.
   c. 0.50 D.
   d. 5.00 D.
   e. 2.50 D.
   f. 20.00 D.
   g. 3.03 D.
   h. 1.33 D.
   i. 1.00 D.
   j. 2.00 D.

404

1. Particle (corpuscular) theory and electromagnetic wave theory.
2. The particle and quantum theories.
3. Christian Huygens, a Dutch physicist and astronomer.
4. Vibrating particles are actually mobile electrical charges and the wave motion is a magnetic radiation.
5. The electromagnetic wave theory.
6. The wavelengths between 400 and 750 nm.
7. Different colors of light.
8. The sending out of light energy.
9. The spectral qualities of the light.
10. Light rays from a luminous object strike a nonluminous object and reflect into our eyes.
11. That which is neither transmitted through nor reflected off of an optical system.
12. It is converted to a different form of energy, usually heat.
13. Rectilinear propagation of light.
14. The top is the crest or maxima; the bottom is the trough or minima.
15. Violet; red.
16. Brightness of light.
17. Wavelength and velocity.
18. Negative power.
19. Zero or plano power.
20. Diverging or parallel light must pass through a convergent (plus powered) optical system.

405

1. (1) The angle of incidence equals the angle of reflection.
   (2) The incident and reflected ray lie on opposite sides of the normal.
   (3) The incident ray, the normal, and the reflected ray all lie along the same plane.
2. The normal.
3. It gets diverged. It gets converged.
4. An image.
5. If you can hold a piece of paper in front of the light rays and see the image on the paper, it is a real image. If not, it is a virtual image.

6. Your image is virtual, erect, and reversed.
7. The bending of light rays as they travel from a medium of one density to another medium of a different density.
8. (1) When light travels from a medium of lesser density (like air) to a medium of greater density (like a lens), the path of the light is bent toward the normal.
   (2) When light travels from a medium of greater density (like the inside of a lens) to a medium of lesser density (like back out into the air again), the path of the light is bent away from the normal.
   (3) The incident ray lies on the opposite side of the normal from the refracted ray.
   (4) The incident ray, the normal, and the refracted ray all lie in the same plane.
9. (1) Angle of incidence.
   (2) Curvature of the new medium.
   (3) Density of the new medium.
10. Deviation and dispersion.
11. Toward the base of the prism.
12. The breaking down of white light into its component colors (ROY G BIV).
13. Toward the apex of the prism.
14. Where the base of the prism goes (e.g., base up [BU], base down [BD], base in [BI], or base out [BO]).
15. Convergent—put the prisms base to base. Divergent—put the prisms apex to apex.
16. +1.75.
17. Plus lenses.
18. Surface curvature.
19. Radius of curvature.
20. The lens with an “r” of 7 inches would have a steeper curve.
21. The ratio between the speed of light in a vacuum and the speed of light in a given medium.
22. The one with an “n” of 1.9.
23. If the angle of incidence and the angle of refraction are known, the index of refraction of the material the light passed through could be calculated.
24. It would still be converged. The Law of Reversibility has proven this happens.
25. The process of totally eliminating the light waves in one meridian and allowing all the light rays in the meridian 90° away to pass through.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the Air Force Career Development Academy (AFCDA).

1. (401) What is the result of algebraically *adding* +3.75 and +1.50 together?
   a. –5.25.
   b. +5.25.
   c. –2.25.
   d. +2.25.

2. (401) What is the result of algebraically *adding* –2.25 and –4.25 together?
   a. –2.00.
   b. +2.00.
   c. –6.50.
   d. +6.50.

3. (401) What is the result of *multiplying* +15 and +3?
   a. –45.
   b. +45.
   c. –18.
   d. +18.

4. (401) What is the result of *multiplying* –7 and –8?
   a. –56.
   b. +56.
   c. –15.
   d. +15.

5. (401) What is the result of *multiplying* –9 and +6?
   a. –15.
   b. +15.
   c. –54.
   d. +54.

6. (401) What is the result of *dividing* –45 by –15?
   a. –3.
   b. +3.
   c. –60.
   d. +60.

7. (401) What is the result of *dividing* –80.50 by +4?
   a. –2.0125.
   b. +2.125.
   c. –20.125.
   d. +20.125.

8. (401) What would be the result of *dividing* –0.88 by –0.2?
   a. –44.
   b. +44.
   c. –4.4.
   d. +4.4.

9. (402) One meter is the same as 100
   a. inches.
   b. decimeters.
   c. centimeters.
   d. millimeters.

10. (402) 53.48 meters equals how many millimeters (mm)?
   a. 534.8.
   b. 5348.
   c. 53480.
   d. 534800.

11. (402) Approximately how many inches are there in 65 millimeters (mm)?
   a. 0.62.
   b. 1.625.
   c. 2.6.
   d. 2600.

12. (402) Approximately how many meters are in 30 inches?
   a. 0.75.
   b. 1.33.
   c. 7.5.
   d. 1200.

13. (402) Approximately how many centimeters (cm) are in 40 inches?
   a. 0.4.
   b. 2.5.
   c. 10.
   d. 100.

14. (402) Solve for “x” in this equation: 24 x = 96.
   a. 0.25.
   b. 4.
   c. 6.
   d. 2304.

15. (402) Solve for “y” in this proportion: $\frac{14}{24} = \frac{y}{48}$.
   a. 0.012.
   b. 28.
   c. 48.
   d. 672.

16. (403) How many minutes (‘) are in 1 degree (°)?
   a. 60.
   b. 90.
   c. 360.
   d. 3600.

17. (403) What is the focal length (FL), in meters, for a 1.00 diopter (D) lens?
    a. 0.5.
    b. 1.0.
    c. 1.5.
    d. 2.0.

18. (403) What is the approximate dioptric power (D) of a lens with a focal length (FL) of 6 inches?
    a. 0.15D.
    b. 0.66D.
    c. 2.40D.
    d. 6.66D.

19. (404) What characteristic of light is the particle (corpuscular) theory very good at explaining?
    a. Refraction.
    b. Luminescence.
    c. Energy concentration.
    d. Emission and absorption.

20. (404) Light that is neither transmitted through, nor reflected off, an optical system, is considered to have been
    a. stopped.
    b. refracted.
    c. absorbed.
    d. dissipated.

21. (404) The top of a waveform is called the crest or the
    a. minima.
    b. maxima.
    c. amplitude.
    d. displacement.

22. (404) The wavelength of light determines its
    a. color.
    b. velocity.
    c. saturation.
    d. brightness.

23. (404) If one light wave has a greater amplitude than another, you could tell because it would be
    a. brighter.
    b. barely visible.
    c. refracted more.
    d. deeper in color.

24. (404) The frequency of light is dependent upon its
    a. amplitude and color.
    b. wavelength and velocity.
    c. waveform and amplitude.
    d. emission and direction of travel.

25. (404) In a vacuum, the speed of light is how many miles per second?
    a. 120,000.
    b. 164,000.
    c. 186,000.
    d. 202,000.

26. (405) Parallel light rays striking a concave mirror will
    a. diverge.
    b. converge.
    c. become diffuse.
    d. become regular.

27. (405) The optical counterpart of an object is the
    a. image.
    b. symbol.
    c. facsimile.
    d. integument.

28. (405) What type of mirror would form a real image?
    a. Plano.
    b. Convex.
    c. Concave.
    d. Magnifying.

29. (405) "The bending of light rays as they travel from a medium of one density to another medium of a different density" is the definition of
    a. refraction.
    b. diffraction.
    c. polarization.
    d. transmission.

30. (405) When light goes from a medium of *greater* density to a medium of *lesser* density, it gets bent
    a. toward the normal.
    b. away from the normal.
    c. toward the surface medium.
    d. away from the surface medium.

31. (405) The amount of refraction that occurs as light travels from one medium to another is dependent upon all of the following *except*
    a. index of refraction.
    b. angle of incidence.
    c. surface curvature.
    d. amount of light.

32. (405) What are the two effects a prism has on white light?
    a. Deviation and dispersion.
    b. Refraction and compression.
    c. Absorption and transmission.
    d. Spectral shift and dioptric increase.

33. (405) The image of an object viewed through a prism will appear to move toward the
    a. base.
    b. apex.
    c. ground.
    d. aperture.

34. (405) What type of lens converges light?
    a. Convex.
    b. Concave.
    c. Polarized.
    d. Contoured.

35. (405) Which has the *most* influence regarding a lens's power?
    a. Surface curvature.
    b. Index of refraction.
    c. Density of medium.
    d. Thickness of material.

36. (405) A lenses curvature (i.e., how steep or flat it is) is determined by its
    a. apical edge height.
    b. radius of curvature.
    c. diameter divided by pi.
    d. "r" value divided by its "n" value.

37. (405) A light ray sent backwards through an optical system will follow the exact same route as a light ray going forward through the optical system. This has been proven by the law of
    a. Snellen.
    b. reversibility.
    c. optical physics.
    d. polarity constancy.

38. (405) What type of lens can totally eliminate the light rays in one meridian and allow all the light rays in the meridian 90°away to pass through?
    a. Convex.
    b. Concave.
    c. Polarized.
    d. Transverse.

Please read the unit menu for unit 2 and continue ➔

Unit 2. Ophthalmic Lenses and Military Prescription Eyewear

THE INFORMATION and skills covered in this unit will help you in your everyday clinical operations and are essential to any ophthalmic professional. The topics covered include lens types, aberrations, computation of prismatic effect, figuring out spherical equivalents, transposing from one cylinder form to another, and converting multifocal prescriptions to single vision (SV) prescriptions. Additionally, information is given regarding the lenses, tints, and coatings available from military optical labs. Also included is information on military frames and ophthalmic measurements required prior to placing a spectacle order to the optical fabrication lab. There is a lot of ground to cover, but much of the information should be familiar due to your on-the-job experience.

2–1. Ophthalmic Lenses

Optics is where light and lenses come together, and wonderful things happen to make vision clearer for those in need. We are now going to build upon what you have learned about optics through the previous lesson and job experience and apply your knowledge to lenses. This includes studying the different ways a prescription can be written, the differences between SV and multifocal (MF) lenses, and lens aberrations. The next lesson covers topics such as transposition, spherical equivalents, and converting MF prescriptions to SV prescriptions. This is valuable information that will help you in your job.

406. Types and characteristics of lenses

The first written record of people wearing glasses is from a note written by Marco Polo after he visited the court of Kublai Khan in China in 1270 A.D. He noted the elderly used convex lenses to read fine print.

By the 17th century, spectacles were in common use. In 1784, Benjamin Franklin glued two lenses together; one lens piece was for distance vision, the other for near work. Essentially, he was the first to create what we now consider a bifocal. Despite the increasing use of glasses, early spectacles lens quality was poor and many defects were inherent. It wasn't until the 20th century spectacles began to be manufactured with quality glass.

Today, ophthalmic lenses come in a variety of forms and materials. This lesson is concerned with giving you information on the types of lenses available and their refractive qualities—to include aberrations and their corrections.

Terminology

Let's start by defining some terms before we get further into the lesson.

Term	Definition
Geometrical Center	The physical center of a lens. This is not necessarily where the optical center of the lens is located. When people refer to “frame pupillary distance (FPD)”, they are referring to the distance from the geometric center of one lens to the geometric center of the other lens when both lenses are mounted in a particular frame.
Optical Center (OC)	The actual, optical, center of a lens. It is the point of a lens where light passes through *without being refracted* (bent). This point of a lens is not necessarily the geometric (physical) center, although through coincidence, it may be. It is the thickest point on a plus lens or the thinnest point on a minus lens. Ideally, the optical centers of the lenses in spectacles should be lined up directly in front of the wearer’s pupils.
Meridian	An imaginary line drawn across the optical center of a lens. When we speak of how much power a lens has in any given area, the area is identified by its meridian. In spectacle prescriptions with cylinder power in them, the axis of the prescription describes the meridian where the patient needs the light rays from the cylinder power to come into focus in the eye.

Forms of lenses

The physical form of a lens is determined by center thickness and surface curvature. The same power lenses may be made in different forms, depending on their final application. Regardless of the lens form, lenses must be designed to provide optical clarity, visual comfort, and safety—without any significant aberrations.

A plano-convex lens is flat, or plano (has zero power), on one surface and curved outward, or convex (has plus power), on the other surface. A plano-concave lens is flat, or plano, on one surface and is curved inward, or concave (has minus power), on the other surface (fig. 2–1).

When both surfaces are of the same type curvature, the lenses are called biconvex (plus lens) or biconcave (minus lens) (fig. 2–2). Their advantage is they can incorporate high dioptric power into a single lens. The disadvantage is they amplify certain aberrations. Aberrations are discussed more in depth later.

Figure 2−1. A plano convex and a plano concave lens.

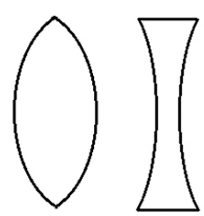


Figure 2−2. A biconvex and a biconcave lens.

The most common ophthalmic lenses used in glasses are of the meniscus variety. Meniscus lenses have surfaces of opposite power (i.e., one surface is convex and the other is concave). This gives them a crescent shape, which fits nicely in frames minimizing aberrations. When naming meniscus lenses, the first term in the name identifies whether the lens is plus (positive meniscus), plano (plano meniscus), or minus (negative meniscus) (fig. 2–3). To determine whether a lens is plus, plano, or minus, compare the center thickness to the edge thickness. If the lens is thick in the middle and thin on the edge, it’s a plus lens. If the lens is equally thick in the middle and at the edges, it’s a plano lens. If it’s thin in the middle and thick at the edges, it is a minus lens.

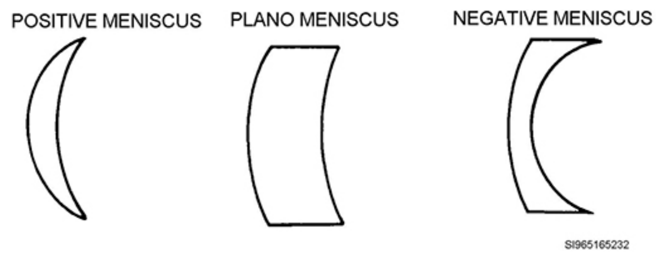


Figure 2–3. Positive meniscus, plano meniscus, and negative meniscus lenses.

Ophthalmic lens types and refractive qualities

There are three basic types of ophthalmic lenses used today—spheres, cylinders, and spherocylinders. Each has some unique characteristics you need to understand so you can explain to your patients what kind of lens they have and why they need them.

Spheres

A spherical lens is a lens with the same power in all meridians. The radius of curvature is the same in each meridian. Think of a basketball. It's a sphere. No matter which side of the ball hits the ground, it bounces predictably because it has the same curvature everywhere.

Another characteristic of spherical lenses is they have only one curve on their front surface and only one curve on their back surface. This gives the lens only one power. For example, say the front of the lens has a curve of +4.00 in all meridians and the back of the lens has a curve of –3.00 in all meridians. This lens has an approximate overall lens power of +1.00 no matter which meridian you measure on the lens.

Another characteristic of spherical lenses is they form a point focus. This happens since each meridian of a sphere lens is refracting light the same amount (fig. 2–4). All the light comes to a single point of focus.

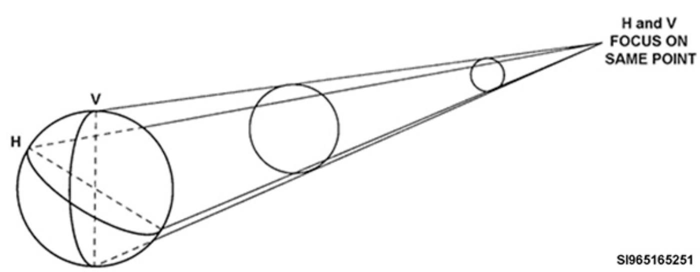


Figure 2–4. Horizontal and vertical meridians refracting light the same amount.

If it is a plus sphere, you'll see a real point of focus of the light (fig. 2–5). A magnifying glass is a good example of a plus sphere lens. You can focus the light to a specific point. This is why you can burn things with a magnifying glass using the sunlight. A spherical, positive meniscus lens has more power on the front (convex) surface than it does on the back (concave) surface (fig. 2–6), and it forms a real point focus.

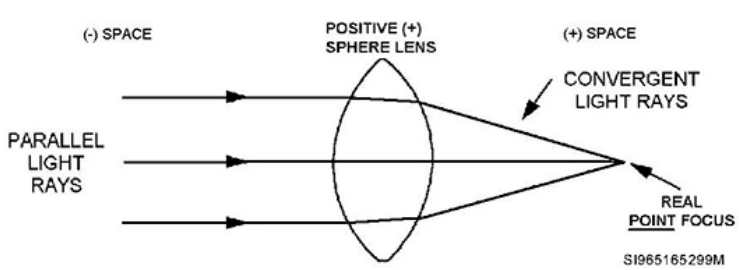


Figure 2–5. Plus sphere showing a real point focus.

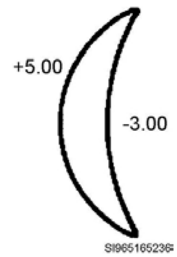


Figure 2–6. A spherical, positive meniscus lens.

A minus sphere lens forms a virtual point of focus (fig. 2–7). Since a minus lens diverges light, you cannot see its virtual focus point on paper. Its focus point is found by tracing an imaginary line back along the path of the divergent light rays. The virtual focal point is where the imaginary lines you trace back come together. A negative sphere meniscus lens has more power on the back surface than on the front (fig. 2–8), and it forms a virtual point focus.

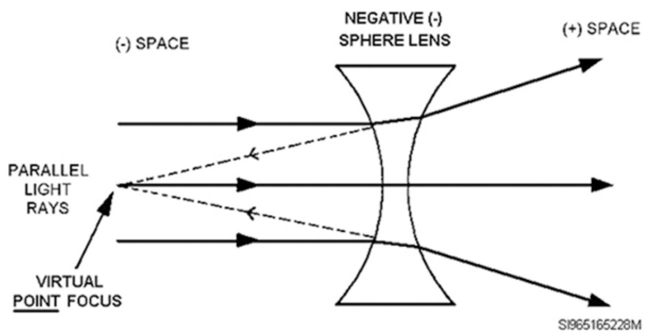


Figure 2–7. Negative sphere lens illustrating a virtual focal point.

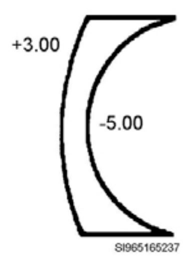


Figure 2–8. A spherical, negative meniscus lens.

Spherical lenses are good for correcting vision in people with simple refractive errors such as simple myopia (SM) or simple hyperopia (SH). These people do not have astigmatism, which would require a different correction in one meridian than the rest of the lens. Patients needing a spherical lens prescription are simply nearsighted or farsighted. Each meridian of their eyes refracts light in the same amount, just not the right amount. They need a lens with the same correction in all meridians to compensate for their eyes' inability to focus light correctly.

A spherical lens is denoted in prescriptions by the abbreviation SPH after the power of the lens. An example is shown below.

OD: +2.00 SPH
OS: +2.25 SPH

Notice there is no cylinder power or axis shown. The letters SPH, indicating a spherical lens having the same power in all meridians, replace them.

Plano (0.00D) spheres neither converge nor diverge light. Plano meniscus lenses have the same curvature on the front and back of the lens, but because the front has a convex (+) curve and the back has a concave (–) curve, the opposing curvatures cancel each other out, giving the lens an overall power of plano, or zero (fig. 2–9).

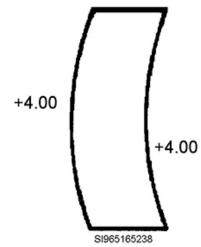


Figure 2–9. Spherical, plano meniscus lens.

Plano meniscus spherical lenses are used in making nonprescription sunglasses. Think about it. If you are making a pair of sunglasses for a person who does not need correction, you want the lenses to have the same curvature in all meridians, and you want the overall power of the lenses to be zero. Nonprescription sunglasses bought at a drug store have a prescription of:

OD: PL SPH
OS: PL SPH

Quickly recapping spherical lenses, remember these points:

- They have the same power in all meridians.
- They have one curve on their front surface and one curve on their back surface.
- They form a point focus.
  - Plus spheres form a real point focus.
  - Minus spheres form a virtual point focus.

Cylinders

A cylindrical lens has a meridian of zero power, 90° away, and it has a meridian of maximum power. The zero power meridian is called the axis meridian (fig. 2–10). A cylindrical lens gets its name from its resemblance to a cylinder cut in half. You can picture a cylinder as being similar to the shape of a Coke® can.

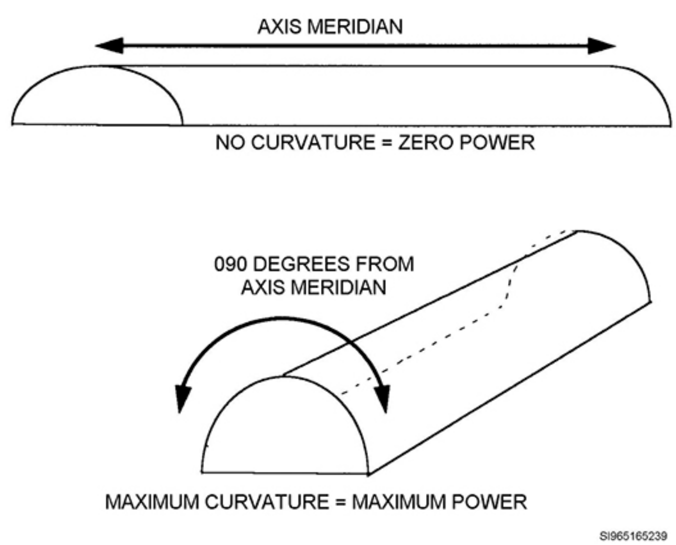


Figure 2–10. Positive (convergent) cylinder lens.

In your mind, visualize a Coke® can. Notice the sides of the can are straight. They go from the top to the bottom of the can in a straight line. If the surface is straight, it can't have any power to it. This would represent the meridian of zero power (the axis meridian). Now, grab the can and hold it so you are looking at the bottom of the can. From this view, you can see the can is curved. This represents the meridian with maximum power. Remember: flat = no power; curved = power. The flat surface of the can is 90° away from the curved surface. Therefore, a cylinder truly does have zero power in one meridian (the axis meridian) and maximum power 90° away.

A characteristic of cylindrical lenses is their formation of a line focus. A way to remember this concept is to think cy-**line**-drical lenses form a **line** focus. In a cylinder lens, the light rays get refracted by the curvature of the lens 90° away from the axis meridian (which is flat). Those refracted light rays are brought to a focus in a line along the axis meridian. Although the axis meridian has zero power, it is along this meridian the light rays (which are refracted 90° away) come to a line focus.

This is why the axis is specified in a prescription. It tells the optician where you want the light rays to focus. In order to get the light rays from a cylinder to focus along the axis meridian, the actual cylindrical curvature of the lens needs to go 90° away from that point.

When you get to figures 2−11 and 2−12 below, depicting convergent and divergent cylinder lenses, notice the line focus is along the axis meridian, even though the meridian has no refractive power. The meridian actually refracting the light is 90° away, but it bent the light to a focus along a line corresponding to the axis meridian.

Plus (convergent) cylinders

Plus cylinders are not used in spectacles anymore. There is no benefit to grinding lenses in plus cylinder form since doing so seems to cause unwanted aberrations. The current machinery sold to and used by opticians is only set up to grind lenses in minus cylinder form. This means even though ophthalmologists write prescriptions in plus cylinder format, the opticians must transpose (convert) the prescription to minus cylinder form and make the glasses in minus cylinder form. Plus (convergent) cylinder lenses are found only on instrumentation and tools these days.

In a plus cylinder, light rays that strike 90° away from the cylinder axis (axis meridian) are refracted as they pass through the lens. The refracted rays converge along a line corresponding to the cylinder axis, forming a real line focus. The convergent cylinder in figure 2–11 shows this.

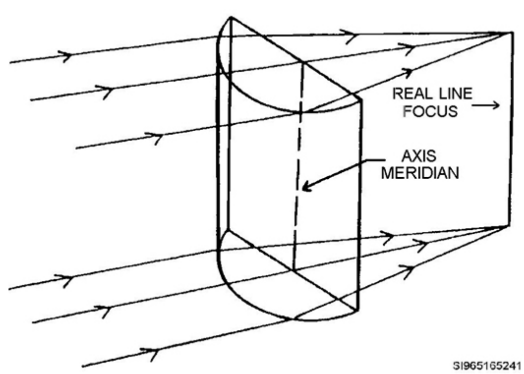


Figure 2–11. Positive cylinder forming a real line focus.

Minus (divergent) cylinders

Minus cylinders are used extensively in spectacles. A minus cylinder lens diverges light, but if an imaginary line were traced back from the divergent light rays, it would come to form a virtual line focus (fig. 2–12). Virtually all glasses with cylinder power in their prescription are ground in minus cylinder form. Optometrists write all their prescriptions in minus cylinder form and more ophthalmologists are doing the same.

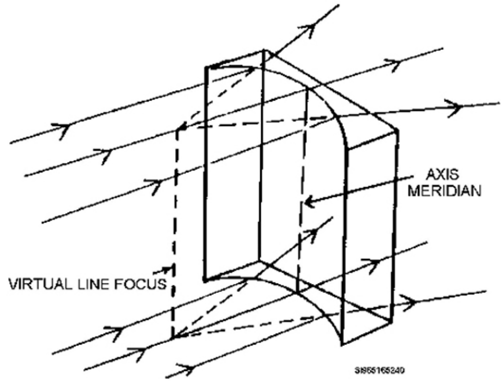


Figure 2–12. Negative cylinder forming a virtual line focus.

Another characteristic of cylindrical lenses is they have two curves on one side of the lens, and one curve on the other side. The key is one of the curves (on the side of the lens with two curves) is canceled out by the curve on the other side of the lens. Let's look at an example of a lens ground in minus cylinder form.

Say a lens has a curve of +3.00 on the front surface and curves of –3.00 in one meridian and –4.00 in the meridian 90° away on the back of the lens. The +3.00 front curve and the –3.00 back curve cancel each other out in one of the meridians. In the other meridian you still have a +3.00 curve on the front of the lens, but you have a –4.00 curve on the back of the lens in that meridian. Overall power in this meridian is –1.00 (+3.00 and –4.00 combined). You can see from this example you had zero power in one meridian and –1.00D of power in the meridian 90° away, the maximum power meridian.

Since a cylinder lens forms a line focus along the axis meridian, any prescription with cylinder power needs to specify the axis. The cylinder axis may be located anywhere between 001° and 180°. In many pictures, it's placed at the 090° or 180° positions to simplify the illustration only. The axis could be shown at the 049° position just as easily.

Since we are talking about axis meridians, remember the axis cannot be written as more than 180°. There is no such thing as a 185° meridian. Instead, we go to 180 (which is the same as 000) and start all over again at 001°. Therefore, if someone tells you the axis of a prescription is at 185°, you should realize the person really means an axis at the 005° meridian. Refer to figure 2–13 to visualize the location of the various axis meridians of a spectacles lens.

Here's a quick check to see if you understand what's being discussed. How close are the 165° and 005° meridians? If you said 160°, it would benefit you to review this section again. If, however, you answered 20°, you have the concept down.

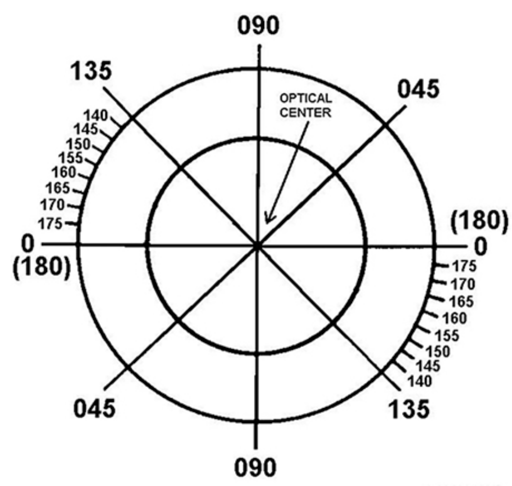


Figure 2–13. Location of meridians in a spectacles lens.

Let's see why the 165° and 005° meridians are only 20° apart. First, how far is it from 165° to 180°? 15°. How far is it from 180° (which can also be thought of as 000°) to 005°? The answer is 5°. 15° plus 5° equals 20°. So not that far apart.

Simple cylinder lenses (with no sphere power in them) are prescribed for patients who have normal vision with the exception of one meridian in their eye. They have simple astigmatism. They can be classified as having simple myopic astigmatism (SMA) or simple hyperopic astigmatism (SHA). A simple cylinder prescription would be written showing no sphere power (PL for plano), then the amount of cylinder power, and then the axis meridian location. Here is an example:

OD: PL –1.25 × 053
OS: PL –2.00 × 065

Here are the highlights of what we've discussed about cylinders so far:

- Cylinder lenses have zero power in one meridian (the axis meridian) and maximum power 90° away.
- The refracted light rays from a cylinder focus along the axis meridian, even though that meridian has no power.
- Cylinder lenses cause a line focus. Plus cylinders form a real line focus; minus cylinders form a virtual line focus.
- Cylinder power is used to correct astigmatism, or distortion of vision, in one particular meridian of an eye.

Spherocylinders (toric or compound lenses)

A spherocylindrical lens has maximum power in one meridian and minimum power in the meridian 90° away. The difference between a spherocylindrical lens and a cylinder lens is a spherocylindrical lens has maximum power in one meridian and minimum power in the one 90° away, not zero like a cylinder lens. The reason a spherocylinder lens has at least some power in all meridians is because it's a combination of a spherical lens and cylindrical lens. Just think about having a spherical lens and then gluing a cylindrical lens to it. A spherocylindrical lens is also called a toric or compound lens. Figure 2–14 shows the two different focal lengths a positive spherocylindrical lens forms by having a maximum power meridian (illustrated by the shorter HH focal length) and a minimum power meridian (shown by the longer VV focal length).

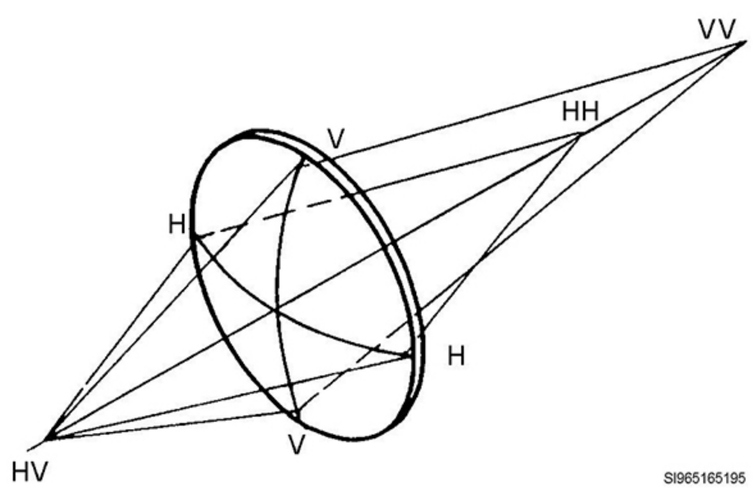


Figure 2–14. Refraction of light by a positive spherocylindrical lens.

A characteristic of spherocylindrical lenses is they have two curves on one side of the lens (the toric surface) and one curve on the other side of the lens. None of the curves are the same, front or back, so there is no canceling out of power in any meridian. With a spherocylindrical, there is at least some power in every meridian of the lens. An example of the curves on a spherocylindrical lens may be similar to this: a +6.00 curve on the front of the lens and curves on the back of the lens of –5.00 and 90° away –4.00. With these curves, you would get a meridian with a power of +1.00 (+6.00 and –5.00 combined) and a meridian with a power of +2.00 (+6.00 and –4.00 combined). You can see you do indeed have a meridian of maximum power (+2.00) and a meridian of minimum power (+1.00). This is what sets a spherocylindrical lens apart from sphere and cylinder lenses.

Spherocylindrical lenses form two-line foci, 090° away from each other, and at different distances from each other. This makes sense, as there are essentially two different power meridians within the lens. Each meridian has a slightly different focal length due to the different meridian powers. Since the meridians are 90° apart, there is a line focus in one meridian and another line focus in the meridian 90° away. The two-line focal points are also different distances from the lens due to the maximum power/minimum power relationship (fig. 2–15). Because of the difference in focal lengths between the maximum power axis and the minimum power axis, a spherocylindrical lens forms a figure known as Sturm's Conoid, or Interval of Sturm. It's characterized by two-line foci at right angles (090° apart) to each other, and a circle of least confusion (Sturm's Conoid) located between (at the midpoint) the two-line foci. Refer to figure 2–15 again to visualize this concept.

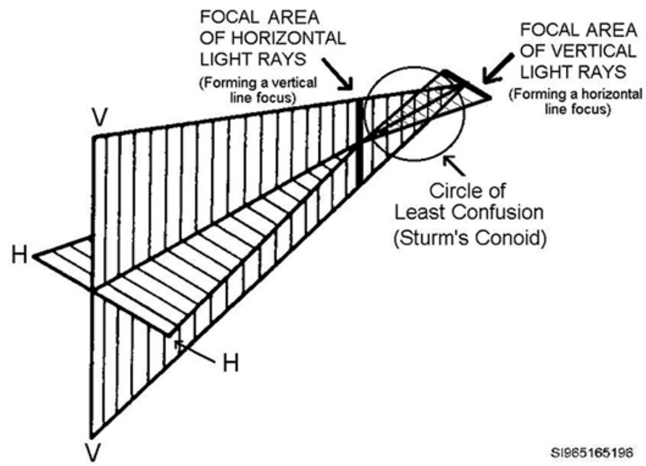


Figure 2–15. Illustration of two-line foci, 90° apart, and the Sturm's Conoid (circle of least confusion).

Since a spherocylindrical lens is a combination of a sphere and a cylinder, its prescription is denoted the same way. The first element is the sphere power in the lens, the second element is the cylinder power, and the third element is the orientation of the cylinder axis. An example would be:

OD: –1.25 –0.50 × 060
OS: –4.00 –1.00 × 070

Looking at the prescription in the left eye, you can interpret it like this: there is –4.00 diopters of sphere power. Remember, sphere power is everywhere. Now, the cylinder column of the prescription indicates there is an additional –1.00 diopter of power added to the lens. Notice what was just said. There is –4.00 diopters of power everywhere, then the cylinder portion of the prescription indicates there would be an additional –1.00 diopter of power somewhere in the lens, not that the one meridian would only have –1.00D of power. This is important to understand. Continuing on, the axis tells you the location of the cylinder's axis meridian. However, it is the flat or non-refracting meridian, remember? The –1.00 diopter of cylinder power actually shows up 90° away in the 160° meridian, not in the 070° meridian.

Sphere power is married to the axis. This means that at the 070° meridian of the lens you'll find –4.00 diopters of power. The cylinder power shows up 90° away, and is merely an addition to the sphere power everywhere else in the lens. Therefore, at the 160° meridian you would have –4.00D plus –1.00D, so a total power of –5.00 diopters at the 160° meridian.

Look at another example. You have a prescription of +2.00 –1.00 × 095. How much power is in the 095° meridian? The answer is +2.00D, because sphere power is married to the axis. How much power is in the meridian 90° away (005° meridian)? Sphere power (+2.00) added to the cylinder power

(–1.00) gives a power of +1.00D in the 005° meridian. Is this a spherocylindrical lens? Yes. You have maximum power, +2.00 in one meridian, and minimum power, +1.00, 90° away. If you said yes just because there was sphere power and cylinder power in the prescription, you made a common but wrong assumption. Let's continue on to see why.

Taking a prescription of +1.00 –1.00 × 025, a person might think it's a spherocylindrical prescription. It has sphere power, cylinder power, and an axis. Sounds logical but let's check it out. You have sphere power everywhere, but it is married to the axis, and we know that at the 025° meridian there is only +1.00D of power. Now, 90° away in the 115° meridian we would have the sphere power of +1.00, and the cylinder power of –1.00, combined. If you add +1.00 to –1.00, you end up with zero. We have a lens with maximum power in one meridian (+1.00 at 025°) and zero power 90° away (PL at 115°). Maximum power in one meridian and zero power in the meridian 90° away is the definition of a cylindrical lens, not a spherocylindrical lens. You just need to be careful when trying to decide if a prescription is for a spherocylindrical lens or a cylindrical lens. This concept of where the various lens powers of a prescription go is explored more thoroughly when you study how to diagram an optical cross later in this unit.

Spherocylindrical lenses are used to help patients who are nearsighted or farsighted and have astigmatism. Essentially, their cornea is shaped more like a football, having two different curves, whereas a person without corneal astigmatism would have a cornea with only one curve to it, like a basketball (fig. 2–16). A patient with myopia or hyperopia needs to have the myopia or hyperopia corrected by some sphere power. A patient without myopia or hyperopia but with astigmatism needs some cylinder power in one meridian to correct for the astigmatism. A patient with myopia or hyperopia and astigmatism needs both sphere power and cylinder power at the same time, and therefore, needs a spherocylindrical lens.

Patients with compound myopic astigmatism (CMA) who are nearsighted in one meridian and more nearsighted in the other meridian need spherocylindrical lenses. Patients who have compound hyperopic astigmatism (CHA) are farsighted in one meridian and even more farsighted in the other also need spherocylindrical lenses. Then there are patients who have mixed astigmatism (MA). They are farsighted in one meridian of the eye and nearsighted in the other. They, too, need spherocylindrical lenses to see clearly. In other words, if patients have astigmatism and myopia or hyperopia, they need a spherocylindrical lens to correct their vision.

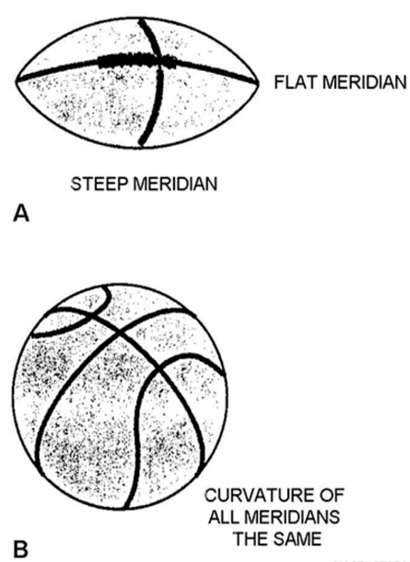


Figure 2–16. A. Football illustrating a surface with two different curves, like an astigmatic cornea would have. B. Basketball illustrating a surface with only one curve, like a spherical cornea would have.

Here are the highlights of what we've discussed about spherocylindrical (also called toric or compound) lenses:

- They have a meridian of maximum power and 90° away there is a meridian of minimum power.
- They have two curves on one lens surface and one curve on the other lens surface. None of the curves are the same, so they don't cancel each other out.
- They form two-line foci 90° apart and at different distances from the lens due to the different powers of the meridians. This separation of the two focal lines forms what is known as Sturm's Conoid (or Interval of Sturm). The exact point between the two-line foci is called the circle of least confusion.
- Spherocylindrical lenses (also called compound or toric lenses) are used for patients with CMA, CHA, and MA.

Prescriptions written in plus and minus cylinder forms

Prescriptions for spherical lenses do not contain cylinder power, so there is no plus cylinder form or minus cylinder form for spherical lens prescriptions; for example:

OD: +1.50 SPH
OS: +1.75 SPH

However, cylindrical and spherocylindrical lens prescriptions do have a cylinder power listed. Prescriptions where cylinder power is present can be written in plus cylinder form or minus cylinder form.

The way a prescription is written does not change the way the glasses are made or the overall lens power. The only reason for the difference is that some ophthalmologists like prescriptions in plus cylinder form and optometrists like prescriptions in minus cylinder form. Why the difference? As a surgeon operating on the eye, the ophthalmologist's work frequently affects the corneal curvature. Since the cornea has a convex (+) curve, it makes it easier to see changes in corneal curvature (cylinder axis changes and such) in convex, or plus, cylinder form.

It makes no visual difference how the prescription is written because the glasses are made with the correct powers in the correct meridians in either case. Let's say your patient, SSgt John Smith, saw ophthalmologist, Dr. Johnson, and was given a prescription for the right eye of **–1.00 +2.00 × 090.** Then, for some reason**,** SSgt Smith wanted a second opinion and went to see optometrist, Dr. Williams, and was given a prescription of **+1.00 –2.00 × 180** for the right eye. SSgt Smith was confused because the prescriptions look so different. However, if SSgt Smith had two pairs of glasses made, one with the plus cylinder prescription and one with the minus cylinder prescription, he would find his vision through the two pairs of glasses to be exactly the same. While the two prescriptions may look different, the actual powers in the 090° and 180° meridians of the prescriptions are exactly the same when the glasses are made.

Be aware that prescriptions can be written in either plus or minus cylinder form. One is not right over the other. They are just different. If you want to order glasses from one of the military fabrication labs though, you need to have the prescription in minus cylinder form or the lab will not accept it—it is just the lab's policy. You will learn how to transpose prescriptions from one cylinder form to another just a little further on in this unit.

Single vision and multifocal lenses

Spectacles come with either SV lenses or MF lenses. The type of lens prescribed depends on the patient's need for visual correction.

Single vision

These lenses generally are meant to help people at one particular focal distance. Single-vision lenses can be for distant, intermediate, or near vision, and can also be used to correct for astigmatism. The key concept is single-vision spectacles lenses have a prescription correcting for only one focal length or problem. There is no additional (“Add”) power put in the lens by means of a bifocal or trifocal segment, or by way of a progressively stronger lens power as in the no-line-type bifocals or trifocals.

Multifocal

Just as the name implies, a multifocal lens has two or three primary foci, or focal lengths. Essentially, MFs contain two or three prescriptions in one lens. They’re usually prescribed for people who have lost some or all of their ability to focus on near objects. Bifocals (BF) are simply described as being two single-vision lenses put together, each for a different focal length. Trifocals (TF) are simply described as three single-vision lenses put together, again each for a different focal length.

A traditional bifocal is usually a combination of a single vision distance lens with a single-vision near lens. The reason we use the term *traditional* is many doctors are now prescribing bifocals where the top portion of the lens is for intermediate vision (computer) and the lower portion is for near vision. This type of bifocal is popular with presbyopic computer users. A trifocal is usually a combination of a single-vision distance lens, a single-vision intermediate lens, and a single-vision near lens all rolled into one lens.

The multifocal additions to a basic lens are called segments. The segments in a multifocal lens have the same cylinder power and axis as the distant prescription portion of the lens. The only difference is the segments contain more positive sphere power. This additional plus sphere power shortens the focal length, making the segments suitable for viewing intermediate or near objects. Once the distant prescription has been established, it’s a relatively easy task to make glasses for intermediate or near work. One just needs to add the appropriate amount of additional positive sphere power to the original distance prescription. Let’s illustrate using this bifocal prescription:

OD **+1.00** –1.00 × 080
OS + 0.75 –0.50 × 085
Add +2.00 *OU*

Looking at the right eye, the distant prescription has **+1.00D** sphere power, –1.00D cylinder power (to correct astigmatism), and the axis meridian for the cylinder correction is at 080. To get a near vision prescription in the bifocal segment, the cylinder power and axis stay the same (i.e., –1.00 × 080). All that changes is an (**add**)itional **+2.00** diopters of sphere power needs to be added to the distant prescription sphere power of **+1.00**. That means the total power when looking through the bifocal segment of the right eye is actually: **+3.00** –1.00 × 080.

Trifocal notation is very similar to bifocal notation except the additional power for the intermediate segment is given as a percentage of the bifocal add power. For example:

OD: –1.00 –1.00 × 034
OS: –1.50 –1.00 × 144
Add +2.50 OU with 50% intermediate

This prescription shows the patient needs an additional +2.50D of sphere power added to the distance Rx’s sphere power in order to get the correct amount of refractive power needed in the bifocal segment. In the trifocal segment, 50% of the +2.50D (i.e., +1.25D) is added to the sphere power of the distance Rx to come up with the correct refractive power needed in the intermediate segment.

In essence, a multifocal lens has the same cylinder and axis throughout. The only change is the segments for intermediate and/or near vision simply have more plus (+) sphere power in them.

Now the question becomes, how does a multifocal lens get additional sphere power in the segments? You learned earlier that the two major factors influencing lens power were index of refraction and surface curvature. Thus, you have two ways to add more (positive) sphere power to the segment portion of a multifocal: increase the index of refraction (density) of the segment portion(s), or increase the steepness of the lens surface curvature (i.e., decrease the radius of curvature) in the segment portion(s). Those multifocals made by fusing in a segment of glass with a higher index of refraction than the rest of the lens are called fused multifocals (fig. 2–17).

Multifocals made by either cutting or molding in a steeper curvature (i.e., shortening the radius of curvature) to form the segment portion are called one-piece multifocals (fig. 2–18). They are one-piece because the same lens is used throughout; just the curvature is different (steeper) in the segment portion.

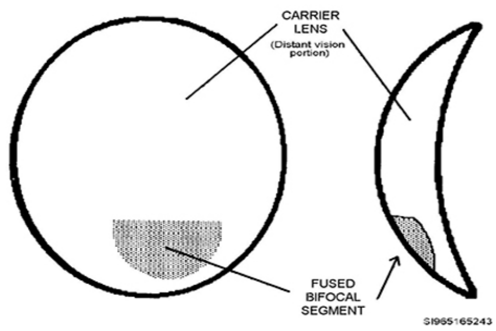


Figure 2–17. Fused multifocal (a bifocal in this illustration).

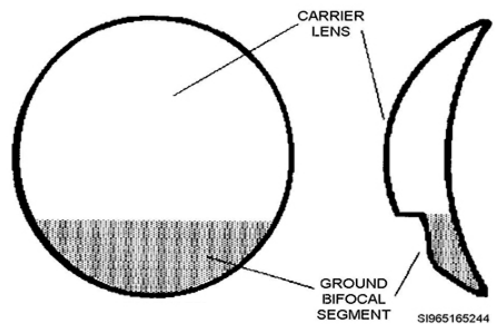


Figure 2–18. One-piece multifocal (a bifocal in this illustration).

To tell if a multifocal is fused or a one piece, you can simply run your fingernail over the top edge of the segment and the main lens. If you feel a ledge, it’s a one-piece. If it’s smooth (no ledge), it’s fused. Never make assumptions by just looking at a lens. Although it may look like it, not all D-style segments are fused. Some are molded to have a steeper curvature, which is why you can feel a ledge if you run you finger across it.

Lens aberrations

An aberration is a failure of the light rays from an object to form a perfect image after going through a lens. There are five inherent aberrations in ophthalmic lenses:

1. Chromatic.
2. Spherical.
3. Distortion.
4. Oblique astigmatism.
5. Curvature of field.

An explanation of each of these inherent lens faults shows which of them can be ignored, which can be compensated for, and which are just nuisances and cannot really be avoided.

Chromatic aberration

You have already learned prisms disperse, or break down, white light into its component colors (ROY G BIV). Since lenses are really just two prisms put together with the edges smoothed out, you can expect some dispersion from the lenses. This dispersion of light by prescription spectacle lenses cause chromatic aberration and is illustrated in figure 2–19.

This color aberration is not noticeable in most spectacles prescriptions and may be disregarded as a problem, except for those patients with very strong prescriptions. Patients experiencing chromatic aberrations complain images are fuzzy and have colored edges.

Chromatic means pertaining to color, so it’s easy to remember chromatic aberration as being the one causing people to see colors around objects.

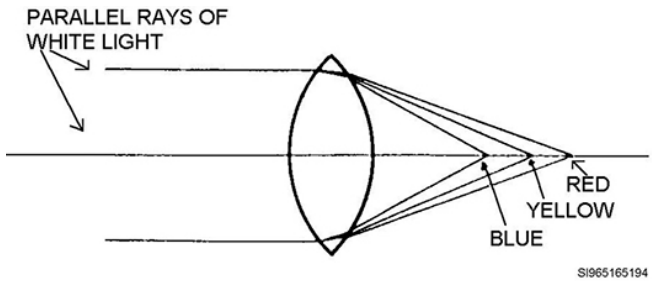


Figure 2–19. Chromatic aberration.

Spherical aberration

In theory, a spherical lens should focus all parallel light rays to a single point of focus. In reality, though, this does not always happen. Instead, the light rays passing closest to the edge of the lens, often called rim rays, are brought to a focus sooner than those rays passing closer to the optical center of the lens. This causes spherical aberration, as shown in figure 2–20.

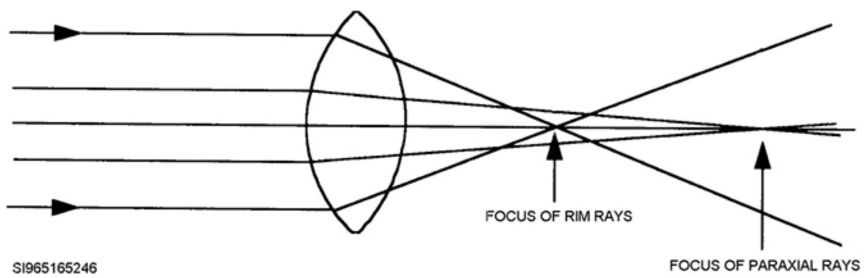


Figure 2–20. Spherical aberration.

As far as your patients are concerned, spherical aberration is not a problem. Grinding techniques have been developed eliminating this problem. Since those central rays are focusing just fine, there is no perceived visual problem for the spectacle wearer.

Distortion

When distortion is present, the image of the object being viewed either becomes more magnified (in plus lenses) or more minified (in minus lenses)—especially toward the periphery of the lens. This causes images to appear bowed. Distortion in plus lenses makes a square appear like a pincushion (think plus = pincushion). Distortion in minus lenses causes a square to look more like a barrel (fig. 2–21).

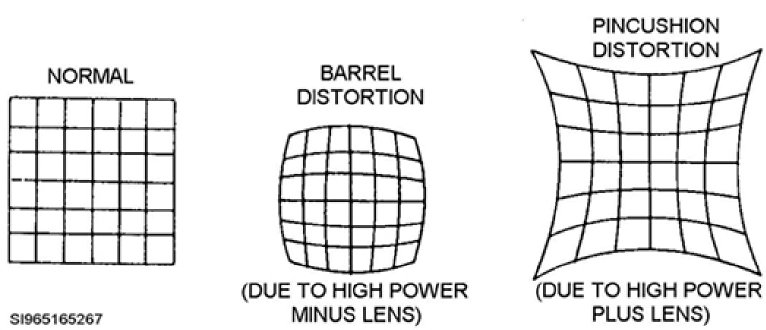


Figure 2–21. Distortion.

Distortion is usually overcome by using steeply curved lenses, high base curves, or aspheric lenses. However, with the vast majority of lens prescriptions, it's of no consequence, as the effects usually are minimal and the patient soon adjusts and doesn't notice the aberration. Patients wearing high-powered prescriptions can try different lenses with higher indices of refraction to minimize the lens curves, but the distortion may still be present to some extent. Another solution is to see if the patient can be fit with contact lenses. Contact lenses minimize or eliminate virtually all aberrations.

Oblique astigmatism

Oblique astigmatism (fig. 2–22), happens when light rays strike a spherical lens obliquely, or at an angle, and are refracted differently in the vertical plane than the horizontal plane. In essence, this aberration makes spherical lenses act as if they have cylinder power, and it makes cylindrical and spherocylindrical lenses act as if their axis meridian was in the wrong place or in two different places.

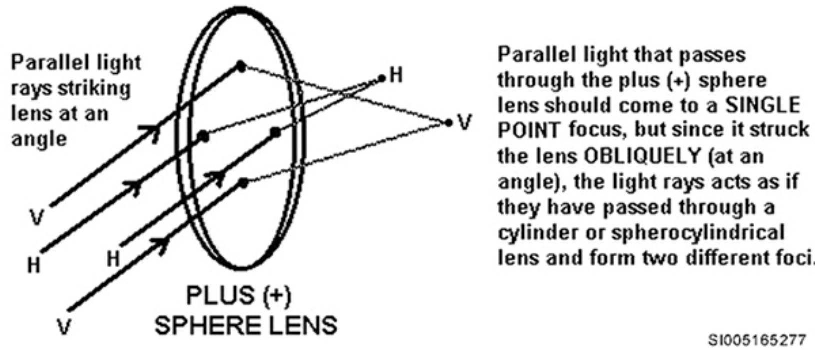


Figure 2–22. Oblique astigmatism.

By altering lens curvatures, lens designers may eliminate or significantly reduce oblique astigmatism. As a rule, less curve = less aberration. This modified lens is often called a *corrected curve lens*.

Oblique astigmatism is also called radial astigmatism, marginal astigmatism, marginal/oblique astigmatism, and astigmatism of oblique incidence. It's called oblique astigmatism here because it best describes the aberration: light striking obliquely (at an angle) acts as if it has passed through a lens meant to correct for astigmatism (a cylinder or spherocylinder). Oblique astigmatism is also very similar to another aberration you may hear of called coma aberration. The descriptions of the two are so similar there is no real reason to list coma as a separate type of aberration.

Curvature of field

Curvature of field is an aberration where a lens produces a curved image of a flat object. If a patient looks at a flat piece of paper and the edges seem to be curved upward, they are experiencing curvature of field problems. This is different from the aberration "distortion" as the edges are *not* bowed; they just appear to curve toward or away from the person. Curvature of field is shown in figure 2–23, which illustrates the concept with an arrow.

To correct for curvature of field aberrations, a corrected curve lens can be used. By modifying the front and rear surface curves, yet keeping the lens power the same, lens designers can usually eliminate curvature of field problems.

Did you ever think a lens could be so complex? This is why the ophthalmic career field is so challenging. The eye and everything associated with it are extremely complex and the technologies to help us see better are constantly changing.

You should now have a good understanding of how the eye works and of some things that help when problems arise. When those problems do occur, you now know the different types of lenses and prescriptions used to improve vision. Unfortunately, with every fix there seems to be side effects. Fortunately, our knowledge and technology continue to evolve and help minimize eye problems.

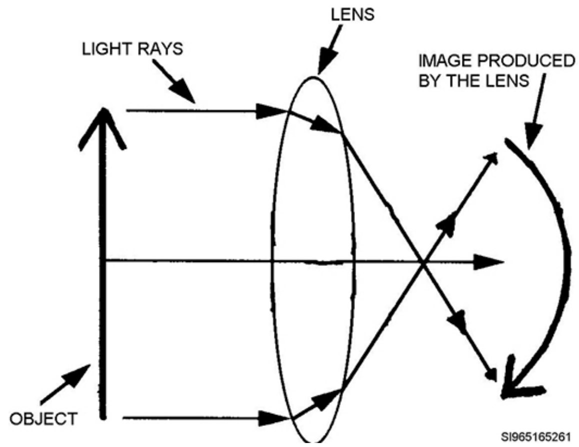


Figure 2–23. Curvature of field.

Now it is time to look at the spectacle script in more detail.

407. Lens and prescription calculations and conversions

It is now time to apply your knowledge about lens and spectacle prescriptions. In this lesson, you'll learn how to put a prescription on an optical cross and take a prescription off an optical cross. Building from there, you'll learn how to transpose an Rx from one cylinder form to another, how to calculate the spherical equivalent of a spherocylindrical Rx, and finally, how to convert a multifocal prescription to a single-vision Rx. Understanding how to perform these calculations definitely helps you on the job and is also useful throughout your career as an ophthalmic professional. The logical place to begin this lesson is with the optical cross.

Optical cross

An optical cross allows you to take a prescription and draw it on paper so you can see the total lens power in each major meridian of the Rx. You know cylinders and spherocylinders have two major meridians 90° apart. Optical cross is a method to diagram these two major meridians and label them with the power indicated in the prescription. Spherical lenses can also be diagrammed on an optical cross, but there's really no need to draw a picture to figure it out. Spherical lenses have the same power in all meridians.

An optical cross can be useful in calculating total lens power in the various meridians, which could be an issue when ordering certain frames. The optical cross can help you decide if the lens is cylindrical (maximum power in one meridian and zero power 90° away) or spherocylindrical (maximum power in one meridian and minimum power 90° away). The optical cross can help you figure out what a patient's visual classification would be (i.e., SM, SH, SMA, SHA, CMA, CHA, or MA). Finally, an optical cross is also useful in finding out how much power is in the 180° meridian of a lens, which is important if you want to calculate prismatic effect using the math formula Prentice Rule. The optical cross is a valuable tool, so let's learn how to draw and label one.

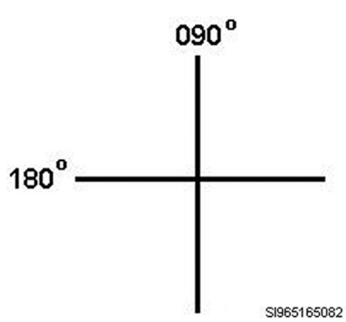


Figure 2–24. Optical cross with meridians labeled.

Putting a prescription on the optical cross

Start your diagram by drawing a cross. Label one line with the axis (meridian) from the prescription. Label the other line with an axis 90 degrees away. Keep in mind though, you can't go over 180 degrees. If you have an axis of 095, the other meridian cannot be labeled 185; it would be 005 instead. Let's do an example of a simple prescription like +1.00 –2.00 × 180. The cross is drawn and the meridians (lines) are labeled as shown in figure 2–24.

Now, put the power of the Rx (+1.00 –2.00 × 180) on the cross. Start with sphere power. There are two rules about sphere power. Rule one is *sphere power goes everywhere*.

This means there is +1.00D power in all meridians so label each meridian with the sphere power as shown in figure 2–25.

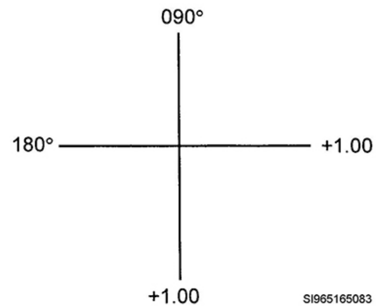


Figure 2–25. Optical cross with sphere power shown.

The second rule of sphere power is the *sphere power is married to the axis of the prescription*. What this means is the sphere power and the prescription axis (meridian) are married and nothing else can go on this meridian. So on the 180° meridian (line) of your cross, you'll have nothing but the sphere power. This being the case, it leaves only one place for the cylinder power to go: on the meridian 90° away, which, in this case, would be the 090° meridian. That means on the 090° meridian, you should have the sphere power (+1.00) and the cylinder power (–2.00) shown (fig. 2–26).

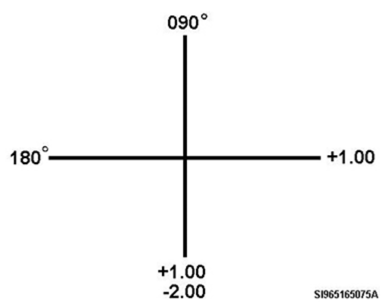


Figure 2–26. Optical cross with sphere power and cylinder power shown.

Now with the optical cross-labeled correctly, you can easily find the overall power in each meridian. The 180° meridian (in this example) is simple. It only has the sphere power of +1.00. Therefore, the total power in the 180° meridian is +1.00. To find the total power in the 90° meridian (in this example), algebraically add the sphere power and cylinder power; your answer is the total power in the 90° meridian. +1.00 algebraically added to –2.00 leaves –1.00, so the total power in the 090° meridian is –1.00D. One meridian has +1.00D of power and the other has –1.00D of power (fig. 2–27). You can now see, you have a spherocylindrical lens (maximum power in one meridian; minimum power 90° away). Also note, the patient has MA. The person is farsighted in one meridian (+1.00) and nearsighted in the other (–1.00). You could now use the Prentice rule to calculate prism if needed, since you now know how much power is in the 180° meridian. Quite a lot of information to gain for doing something as easy as an optical cross, isn't it?

To diagram an optical cross, remember:

- Your meridians are 90° apart. The axis of the prescription is one meridian. To get the other meridian, just add 90 (if Rx axis is 090° or less) or subtract 90 (if the Rx axis is 091° or more). Remember, there is no axis larger than 180°!
- Sphere power goes everywhere (both meridians).

- Sphere power is “married” to the Rx axis (meridian), and nothing else goes on this meridian.
- Cylinder power goes on the meridian 90° from the axis (the one not shown in the written prescription). Then algebraically add the sphere power and cylinder power to find the total power for this meridian.

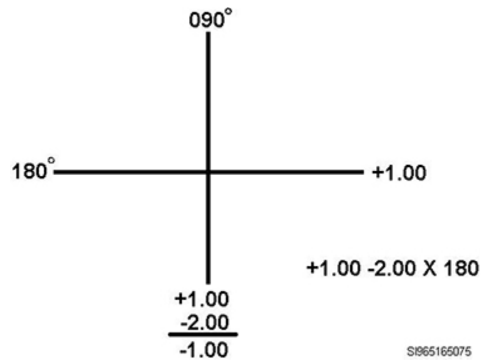


Figure 2–27. Completed optical cross with total power of each meridian shown.

To illustrate further, study the completed diagrams in the examples below. The ability to diagram an optical cross can be useful in many ways.

Example 1 (fig. 2–28):

+1.00 + 1.50 × 135

You can see this is a spherocylindrical lens and it would be for a patient with CHA.

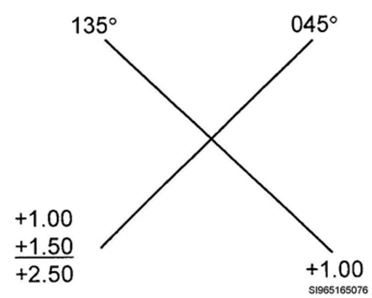


Figure 2–28. Illustration of the Rx: +1.00 +1.50 × 135, on an optical cross.

Example 2 (fig. 2–29):

PL –1.25 × 027

This is a cylindrical lens because one meridian has zero power (PL). This prescription would be for a patient with SMA.

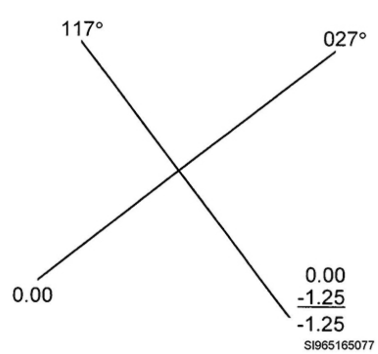


Figure 2–29. Illustration of the Rx: PL –1.25 × 027, on an optical cross.

Example 3 (fig. 2–30):

–4.75 +2.25 × 155

This is a spherocylindrical lens would be for a patient with CMA.

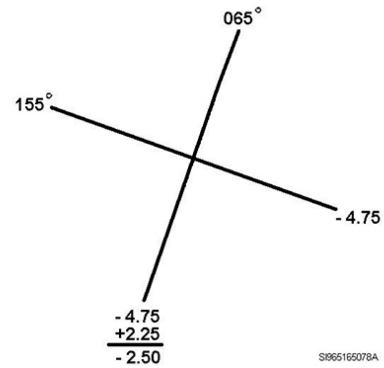


Figure 2–30. Illustration of the Rx: –4.75 +2.25 × 155, on an optical cross.

Taking a prescription off the optical cross

You now know how to put a prescription on an optical cross, but what if someone handed you a picture of an optical cross with the total powers already shown in each meridian? Would you be able to take the prescription off the optical cross? You should be able to do so after you read this section. You should even be able to take the numbers off the optical cross in such a way you can write the prescription correctly in either plus or minus cylinder form.

Observe in figure 2–31 that only the total power is shown in each meridian of the optical cross. To obtain the actual prescription, you'll need to select one of the powers, from one of the meridians, and make it your sphere power. You could choose the dioptric power from either meridian to figure out the Rx. However, if you want to get the Rx specifically in **(-)** cylinder form or **(+)** cylinder form, you'll have to be more picky about the number you choose to be your sphere power.

Remember these two rules when you are taking a prescription off the optical cross:

1. To get the Rx in (–) cylinder form, take the most plus number as your sphere power.
2. To get the Rx in (+) cylinder form, take the most minus number to be your sphere power.

In our example, using figure 2–31, the most plus number in this case is +1.25 and the most minus number is +0.50 (since +0.50 is closer to being minus than +1.25). If you are having trouble visualizing this concept, place these powers on a number line and you can see the correlation.

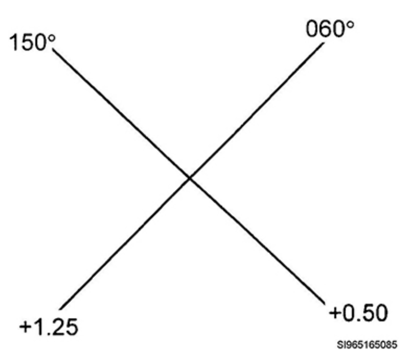


Figure 2–31. Completed optical cross showing only the total power of each meridian.

In this example, you want the final Rx in (–) cylinder form. The rule states take the most plus number and make it your sphere power. So use +1.25 as the sphere power and you're already one third of the way to the answer! Now, what do you know about sphere power? It's married to the axis and as you look across from your sphere power, you see the axis for the prescription. In this case, +1.25 is directly across on the 060° meridian, so 060° is the axis. Two thirds of the way there now! Your prescription is now: +1.25 _____ × 060.

The last thing you need to do now is figure out the cylinder power. This is where people tend to make errors. The cylinder power is *not* the number left (on the 150° meridian) (i.e., +0.50 is *not* the cylinder power). *The cylinder power is determined by the direction and distance traveled. In this case, you travel from your sphere power of +1.25 to the* *meridian 90° away, which has a power of +0.50.* Traveling from +1.25 to +0.50 gives you the actual cylinder power. To get from +1.25 to +0.50, you have to move in the minus (negative) direction. You traveled 0.75D in the negative or minus direction. So, your cylinder power is actually **–0.75**.

Remember, cylinder power is the direction and distance traveled. That is the key to doing cylinder power correctly.

Now you have finished, your Rx is **+1.25 –0.75** × **060**. It's that easy. Just remember the cylinder power is distance and direction traveled, which, as previously stated, is the part many people tend to forget.

Look at figure 2–31 again. Since you just found the Rx in minus (-) cylinder form, now figure out the Rx in plus (+) cylinder form. The first rule says to get an Rx in (+) cylinder form, you must start with the most minus number as your sphere power. In this example, +0.50 is the most minus when compared with +1.25. The sphere is married to the axis, so which meridian is +0.50 sitting on? The 150° meridian. So this makes 150° the axis of this prescription. The last step is determining your cylinder power. Remember, cylinder power is determined by the distance traveled and the direction from the sphere power to the meridian 90° away. In this case you go from +0.50 (your sphere power) to +1.25. You headed in the plus (positive) direction and traveled +0.75D. Your final Rx in plus cylinder form is **+0.50 +0.75** × **150**.

Review the rules before you move on:

- Decide if you want the prescription in plus or minus cylinder form. If you want the Rx in minus cylinder form, take the most plus number from the cross to be your sphere power. If you want the Rx in plus cylinder form, take the most minus number from the cross to be your sphere power.
- Axis is determined by the sphere number you chose, as the axis is married to the sphere power. Whatever meridian your sphere number was on, is now your prescription axis.
- Determine cylinder power. Decide which direction (+ or –) and how far you would travel to get from your sphere power number to the number still on the optical cross.

That's all there is to taking an Rx off an optical cross. Now you're ready to move on to mathematical transposition of prescriptions.

Transposition

Transposition is a great thing. It's one of those truly basic and valuable skills every ophthalmic technician should know. Transposition is simply *converting a prescription from one cylinder form to another*. You've probably been handed a prescription from a patient written in plus cylinder form. If so, you had to transpose the Rx before sending to a military fabrication lab. Remember, military labs do not fill orders written in plus cylinder form.

You could transpose a prescription by putting it on the optical cross and then taking it off the cross in the form desired. This would be a slow process. The clinic is a busy place and time is valuable. There is a much quicker way involving three very easy steps. However, it's important you *do the steps in order*. If you do the steps out of sequence, your results will be wrong.

Here are the steps to transpose an Rx from one cylinder form to the other:

1. Algebraically add the cylinder to the sphere; this becomes your new sphere power.
2. Change the sign of the cylinder. If it is plus, make it minus, and vice versa.
3. Rotate the axis by 90°. The result is your new axis. (Remember, the axis can go from 001° to 180°. You cannot have an axis more than 180°. An axis of 000° is written as 180°.)

Let's do an example together. Transpose –0.50 +2.00 X 175 to minus cylinder form.

1. Algebraically add the cylinder to the sphere to get the new sphere power, so +2.00 added to –0.50 leaves +1.50. Your new sphere power is **+1.50**.
2. Change the sign of the cylinder. It's +2.00, so make it **–2.00.**
3. Rotate the axis by 90°. It is 175, so subtract 90 from 175 and you end up with **085** as our new axis. (You wouldn't want to add 90° to 175 since you would end up with an axis of 265°, which is outside our range of 1° to 180°.)

So, –0.50 +2.00 × 175 transposed into minus cylinder form becomes **+1.50 –2.00 X 085**.

Here are some more examples for you to review; see if you can work them out to match the answers shown.

Example 1:

Transpose **+1.50 –2.00** × **090** into plus cylinder form.

(**Answer**: –0.50 +2.00 ×180)

Example 2:

Transpose **+1.25 +1.00** × **035** into minus cylinder form.

(**Answer**: +2.25 –1.00 × 125)

Example 3:

Transpose **–4.75 –1.25** × **105** into plus cylinder form.

(**Answer**: –6.00 +1.25 × 015)

One final point should be made: transposing a bifocal or trifocal has no effect on the "Add" power whatsoever. Once you have transposed the main part of the prescription, just leave the "Add" as it was. That's it for transposition. Keep it simple and just follow the three rules in order. You can't go wrong.

Spherical equivalent

A spherical equivalent is a spherical lens approximately equivalent in power to a person's spherocylindrical prescription. A spherocylindrical lens forms two separate focal lengths with one meridian focusing sooner than the other meridian. When figuring a person's spherical equivalent, you are finding what spherical power lens focuses the light at a point halfway between the two separate focal lengths formed in a spherocylindrical lens (fig. 2–32). Essentially, a spherical equivalent Rx is the average of the powers in the two major meridians of a spherocylinder Rx.

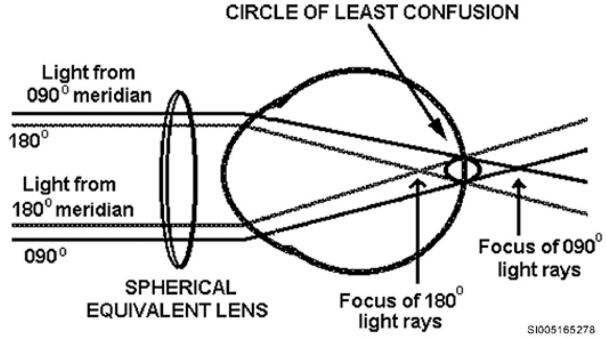


Figure 2–32. Spherical equivalent lens bringing the circle of least confusion to focus on the retina.

Knowing a person's spherical equivalent can be useful when:

- Fitting spherical contacts on a person with an Rx of –1.00D or less cylinder power.
- Calculating temporary spherical replacement lenses for someone who has lost or damaged his or her spherocylindrical glasses.

Knowing how to figure out a spherical equivalent is important. It's a simple process; there are only two steps involved:

1. Take half of the cylinder power and add it algebraically to the sphere power. This is the new sphere power.
2. Drop the cylinder and axis from the prescription and replace them with SPH.

That's it. Let's do an example together. Say the patient had an Rx in the right eye (OD) of +4.00 –1.00 X 070.

Step 1: Take half the cylinder power (half of –1.00 is –0.50) and add algebraically to the sphere power (+4.00). So –0.50 added to +4.00 is **+3.50**. This is the new sphere power.

Step 2: Drop the cylinder and axis and replace them with SPH. The spherical equivalent of +4.00 –1.00 × 070 is **+3.50 SPH**.

Here are some more examples. Calculate the spherical equivalent yourself and then check to be sure that you were able to get the correct answer.

Current Rx	Spherical Equivalent Rx
+3.25 –0.50 × 099	+3.00 SPH
–7.75 +2.50 × 101	–6.50 SPH
PL –2.00 × 023	–1.00 SPH
–4.00 +8.00 × 075	PL SPH
+5.50 SPH	+5.50 SPH

What happens when you don't have a cylinder power you can divide in half evenly, such as 1.25 or 2.75? The answer: cut it in half and round off to the nearest *quarter diopter in the more minus direction*. Generally, a bit more minus is easier to tolerate than a bit more plus.

Using this rule, take an example of the following Rx: **PL -3.25 × 100**. Dividing the cylinder power of –3.25 in half leaves you with –1.62; rounding toward the more minus direction would be –1.75. In this case, you would have a spherical equivalent of **–1.75 SPH**.

Here are some more examples of these types of cylinder powers.

1. Rx is: **+1.75 –1.75 × 087**, the spherical equivalent is: **+0.75 SPH**.

   Reasoning: Half of –1.75 is –0.87 and rounding toward the more minus direction gives you –1.00. Algebraically adding -1.00 to the sphere power of +1.75 gives you the spherical equivalent of +0.75 SPH.
2. Rx is: –**6.00 +1.25 × 065**, the spherical equivalent is: **–5.50 SPH.**

   Reasoning: Half of +1.25 is +0.62, rounding toward the more minus direction gives you +0.50. Algebraically adding +0.50 to the sphere power of –6.00 results in a spherical equivalent of –5.50 SPH.
3. Rx is: +**4.25 –2.25 × 140**, the spherical equivalent is: **+3.00 SPH.**

   Reasoning: Half of –2.25 is –1.12 and rounding toward the more minus direction gives you –1.25. Algebraically adding –1.25 to the sphere power of +4.25 gives you the spherical equivalent of +3.00 SPH.

You should now be able to calculate spherical equivalents quickly and accurately.

Converting a multifocal Rx to a single vision Rx

Virtually every person needs glasses eventually. It's the built-in job security nature has provided our career field! Some people start needing glasses at a young age, while others don't need lenses until affected by presbyopia, usually occurring around ages 40 to 45.

With presbyopia comes reading glasses, bifocals, or trifocals. Some people are prescribed a bifocal or a trifocal so they can wear one set of glasses to correct their vision in all distances, although some people may not like that. They'd rather have a pair of glasses for distant vision, a pair of glasses for reading, and maybe even a pair of glasses for those intermediate distances, such as computer work.

If a patient wants a single vision Rx, your job is to convert a multifocal prescription into a single-vision prescription for the distance, intermediate, or near ranges. This part of your lesson will help you convert the Rx. You'll start with how to convert a bifocal Rx to a near vision only (NVO) Rx.

Converting a bifocal Rx to a near vision only Rx

Understand a bifocal is really two types of glasses. The top portion of the lens is usually for distance vision and the lower segment is for near vision. To convert a person's bifocal Rx to a distance prescription or to a near prescription is very easy.

Take the following Rx as an example:

OD: –1.00 –0.50 × 050
OS: –0.75 –0.75 × 130
Add +2.00 OU

A prescription written in this manner means the following:

OD: –1.00 –0.50 × 050 = Distance Rx in right eye.
OS: –0.75 –0.75 × 130 = Distance Rx in left eye.
Add +2.00 OU = additional spherical power needed to make the distance Rx good for near vision.

So to make this a distant vision only (DVO) Rx would be as simple as dropping the "Add +2.00 OU" from the prescription leaving you with:

OD: –1.00 –0.50 × 050
OS: –0.75 –0.75 × 130

The only possible "wrinkle" occurs when the prescription is written in plus cylinder form. Then you would need to transpose the Rx before you could order glasses.

To make our example bifocal prescription a NVO Rx, take the +2.00 "Add" power and algebraically add it to the sphere power of each eye's Rx. The cylinder power and axis do not change. So +2.00 added to the –1.00 sphere power of the right eye (OD) Rx leaves a sphere power of +1.00; so the **NVO Rx** for the OD would read: **+1.00 –0.50 × 050**. Notice there is no "Add" power at the end of the prescription. The "Add" is gone because you used it up to make the Rx NVO. Now, convert the OS Rx to NVO. "Add" +2.00 to the sphere power of –0.75. This leaves you with an NVO sphere power of +1.25, so your **NVO Rx** for the OS would read: **+1.25 –0.75 × 130**. Again, note the cylinder power and axis do not change. The NVO Rx for both eyes would be:

OD: +1.00 –0.50 × 050
OS: +1.25 –0.75 × 130

Again, note the "Add" power is gone. Think of it as having been used up. You actually added it in when you converted the distance portion of the Rx to near vision only.

Remember, the only "wrinkle" would be if the Rx was in plus cylinder form, then you would need to transpose it to minus cylinder form.

Does it matter if you transpose before converting your Rx to NVO? No. Whether you do it before or after, doesn't affect the results. Just don't try to do it during your conversion from multifocal to single vision—it'll just complicate a simple process.

So, a quick review:

- To convert a BF to a DVO prescription, just drop the “Add” power off.
- To convert a BF to a NVO prescription, add (algebraically) the “Add” power to the sphere powers of the distance Rx. Leave the cylinder and axis the same. Drop the “Add” power from your new NVO Rx, as it was used up in the conversion process.
- If necessary, transpose the final Rx to get it into minus cylinder form.

Here are some more examples of converting bifocal Rxs into NVO Rxs. Look them over and make sure you can visualize what was done, as you’ll be doing some conversion when you get to your self-test questions.

Example 1:

BF Rx is:

OD: +1.75 –1.00 × 150

OS: +1.50 –0.50 × 130

Add +1.25 OU

Converted to NVO:

OD: +3.00 –1.00 × 150

OS: +2.75 –0.50 × 130

Example 2:

BF Rx is:

OD: –3.00 SPH

OS: –4.25 –0.25 × 099

Add +3.00 OU

Converted to NVO:

OD: PL SPH

OS: –1.25 –0.25 × 099

Example 3:

BF Rx is:

OD: –1.00 +2.50 × 145

OS: –2.00 +2.25 × 140

Add +2.50 OU

Converted to NVO:

OD: +1.50 +2.50 × 145 **Transposed → OD: +4.00 –2.50 × 055**

OS: +0.50 +2.25 × 140 **Transposed → OS: +2.75 –2.25 × 050**

Now you should have a good grasp on how to convert a BF Rx into a NVO Rx.

Converting a trifocal Rx to NVO or IVO

Converting a TF Rx to DVO is the same as before. Just drop the “Add” portion and the “w/50% int.” portion from the prescription and you are done.

Converting a TF Rx to a NVO Rx is performed in the exact same manner as the conversion of a BF to NVO. The **“**Add**”** power is (algebraically) combined to the sphere power of the distance Rx, and then the “Add” and *w/ 50% int.* portion is dropped. You don’t do anything with the *w/50% int.* portion. It is not needed. To reiterate, converting a TF to an NVO is no different than converting a BF to an NVO. You just throw away the *w/50% int.* part, because it has no role in what you are doing. Here’s a quick example:

Trifocal (TF) Rx:

OD: –1.75 –1.25 × 145

OS: +2.00 SPH

Add +2.50 OU w/ 50% int.

To obtain the near Rx “Add” **+2.50** to both sphere powers. The result is the NVO sphere power. The cylinder and axis remain the same. Now, the “Add +2.50 OU w/50% int.” portion is thrown away. Your new **NVO Rx** would be:

OD: +0.75 –1.25 × 145

OS: +4.50 SPH

Converting a TF to an intermediate vision only (IVO) Rx is a little more complex, but not much. To get an Rx for NVO, you added all the “Add” power to the distant sphere powers. However, for an IVO Rx, you only add half (50%) of the “Add” power to the distant sphere powers. The result becomes your IVO Rx sphere power. The cylinder and axis do not change, and once again, after the conversion is done, the “Add ____ w/50% int.” portion is thrown away. Very similar to what you have been doing. Do a few examples to help visualize the process.

Convert the following trifocal (TF) Rx to IVO:

OD: –1.00 –0.75 × 001
OS: –1.25 –1.25 × 005
Add +2.50 w/50% int.

Take 50% of +2.50, which is +1.25. Add (algebraically) to the sphere powers of the prescription. The result is your new IVO sphere power. Leave the cylinder and axis the same, and drop the “Add +2.50 w/50% int.” Your IVO Rx is:

OD: +0.25 –0.75 × 001
OS: PL –1.25 × 005

We’re going to show you a few more examples just to be sure you are comfortable with converting a TF Rx to an IVO Rx. Just a reminder: if the final Rx is in plus cylinder form, you have to transpose it before you can order glasses from a military lab. Here are some examples of TF to IVO:

Example 1:

TF Rx:

OD: PL –0.25 × 179
OS: –0.50 –0.50 × 003
Add +1.50 w/50% int.

IVO Rx:

OD: +0.75 –0.25 × 179
OS: +0.25 –0.50 × 003

Example 2:

TF Rx:

OD: +1.50 –1.50 × 088
OS: +2.75 –1.00 × 077
Add +2.00

IVO Rx:

OD: +2.50 –1.50 × 088
OS: +3.75 –1.00 × 077

Example 3:

TF Rx:

OD: –0.50 +1.25 × 090
OS: –0.25 +2.00 × 067
Add +3.00 w/50% int.

IVO Rx:

OD: +1.00 +1.25 × 090 **Transposed → OD: +2.25 –1.25 × 180**
OS: +1.25 +2.00 × 067 **Transposed → OS: +3.25 –2.00 × 157**

When you’re converting a TF Rx to an IVO Rx, there are times when the “Add” does not divide into 50% evenly (e.g., +2.25 or +2.75). Do you round up or round down? You’ll need to talk to the patient to find out. If the patient’s need for intermediate glasses is for working distances of 30 inches and closer, you would round up to the more plus number; if the patient is working at 30 inches and farther, round down to the more minus number. Look at the following example TF Rx:

OD: +2.00 SPH
OS: +2.00 SPH
Add +2.25 w/50% int.

IVO Rx (for 30” *and closer*):

OD: +3.25 SPH
OS: +3.25 SPH

IVO Rx (for 30” *and farther*):

OD: +3.00 SPH
OS: +3.00 SPH

In this lesson, you covered the various types of lenses available and their refractive qualities including aberrations and their corrections. Then you learned how to put a prescription on an optical cross and take a prescription off an optical cross. Once the basics were covered, you then learned how to transpose Rxs from one cylinder form to another, calculate spherical equivalents, and convert multifocal Rxs.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

406. Types and characteristics of lenses

1. What is the most common variety (shape) of ophthalmic lenses?

2. List the three basic ophthalmic lens types.

3. What type of lens has the same power in all meridians and has only one curve on the front surface and one curve on the back surface?

4. What type of focus does a spherical lens form?

5. A cylindrical lens has maximum power in one meridian. What kind of power does it have in the meridian 90° away?

6. What type of focus does a cylindrical lens form?

7. How much power does the axis meridian of a cylinder have?

8. What are other names for a spherocylindrical lens?

9. How many curves does a toric lens surface have?

10. What kind of a focus does a spherocylindrical lens form?

11. What unique figure, or characteristic, does a spherocylindrical lens form?

12. In the following spherocylindrical prescription, describe what the first, second, and last set of numbers represent: –1.00 –2.00 × 090.

13. What kind of patient will a spherocylindrical lens help?

14. Which form of spectacles lenses has two or three primary foci?

15. What is the only difference in prescription (power) between the distance portion of a multifocal lens and the segment?

16. What are the two ways of modifying a lens to get more sphere power in the multifocal segment?

17. List the five types of lens aberrations.

18. If a person wearing spectacles complains distortion is causing the image of a square to appear as a pincushion shape, what kind of lenses would you logically presume were in the glasses?

19. Which two aberrations can be corrected with a corrected curve lens?

407. Lens and prescription calculations and conversions

1. Place the following lens prescriptions on an optical cross:

    a. +4.00 –4.75 × 150.

    b. –0.25 –0.25 × 064.

c. –3.75 +1.25 × 001.

d. –7.25 +6.00 × 090.

e. +2.75 –2.75 × 088.

2. Take the prescriptions off the optical cross in the cylinder form indicated:

a. Minus cylinder form.

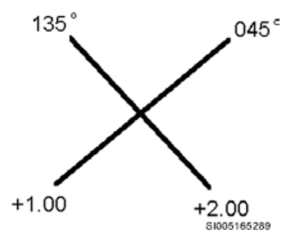


Figure 2-33. Optical Cross.

b. Minus cylinder form.

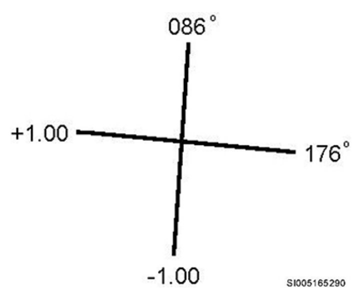


Figure 2-34. Optical Cross.

c. Plus cylinder form.

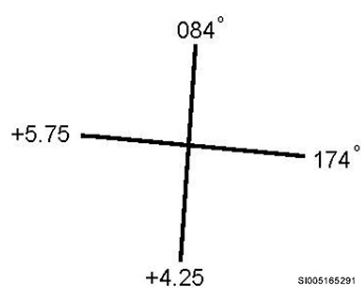


Figure 2-35. Optical Cross.

d. Minus cylinder form.

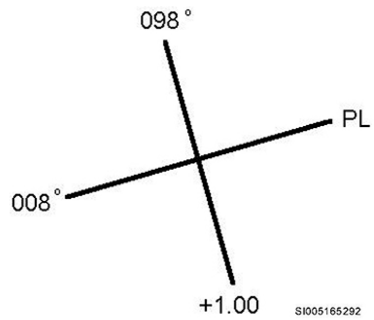


Figure 2-36. Optical Cross.

e. Plus cylinder form.

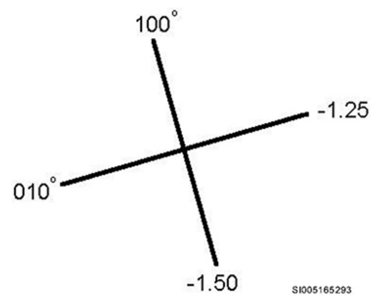


Figure 2-37. Optical Cross.

3. Transpose the following prescriptions to the opposite cylinder form:

   a. +1.00 –1.25 × 090.

   b. +2.25 +2.00 × 180.

   c. –3.00 –2.00 × 070.

   d. –3.25 +2.25 × 160.

   e. +2.75 –3.25 × 135.

   f. +1.25 +3.00 × 172.

   g. –2.25 –3.00 × 172.

h. –2.25 +3.25 × 045.

i. +0.75 –3.50 × 117.

j. +0.50 +0.50 × 132.

4. Compute the spherical equivalent of the following prescriptions:

a. +4.00 –1.00 × 045.

b. –3.00 –2.50 × 033.

c. +3.50 +2.50 × 165.

d. +1.00 –3.00 × 180.

e. –2.00 +4.00 × 006.

f. –3.25 – 3.50 × 014.

g. PL –2.75 × 180.

h. +1.00 –1.25 × 095.

i. +7.00 –7.00 × 140.

j. PL +1.50 × 131.

5. Convert the following multifocal prescriptions as indicated. All final answers must be in minus cylinder form, so transpose as necessary.

   a. Derive the NVO Rx.
   OD: –3.00 SPH
   OS: –2.50 SPH
   Add +1.75 OU

   b. Derive the NVO Rx.
   OD: +1.25 SPH
   OS: +0.75 SPH
   Add +2.50 OU w/50% int.

   c. Derive the NVO Rx.
   OD: +0.50 –1.00 × 085
   OS: +0.25 –0.75 × 100
   Add +1.50 OU

   d. Derive the NVO Rx.
   OD: –4.75 –2.25 × 035
   OS: –5.25 –2.00 × 140
   Add +1.25 OU

   e. Derive the NVO Rx.
   OD: PL SPH
   OS: PL –0.75 × 180
   Add +2.00 OU w/50% int.

   f. Derive the NVO Rx.
   OD: –3.00 +2.50 × 075
   OS: –1.50 +4.00 × 025
   Add +1.75 OU

   g. Derive the NVO Rx.
   OD: –2.00 SPH
   OS: –3.00 SPH
   Add +2.00 OU w/50% int.

   h. Derive the IVO Rx.
   OD: +5.00 –2.00 × 180
   OS: +4.50 –1.25 × 180
   Add +1.50 OU w/50% int.

   i. Derive the IVO Rx.
   OD: PL +1.25 × 130
   OS: –2.00 +1.00 × 180
   Add +2.50 OU w/50% int.

j. Derive the IVO Rx.
OD: +3.75 –1.50 × 135
OS: +2.50 –1.00 × 147
Add +3.00 OU w/50% int.

2–2. Lenses, Tints, Coatings and Frames Available from Military Labs

Military prescription eyewear is a huge part of your job. You deal with patients virtually every day and they will ask about what lenses they can get and what tints or coatings are available on them. As an ophthalmic technician, you need to be ready to answer their questions and know the proper justifications for any special orders. You also need to know how to take an accurate pupillary distance measurement so your patient doesn't experience unwanted prismatic effect from the glasses you order. Let's begin this section by first learning about the lenses available from the military optical labs.

408. Lenses, tints, and coatings available

Before you can order military prescription eyewear, you need to know what is available in terms of lenses, lens materials, frames, eyewear measurements required, and justifications needed. The Naval Ophthalmic Support and Training Activity (NOSTRA) website is where you can find the most up-to-date information on the availability of these items. NOSTRA is the premier manufacturing facility for the Optical Fabrication Enterprise (OFE). Occasionally, NOSTRA offers a new frame or discontinues an old one. Again, for the most up-to-date information on what's available, always check the NOSTRA website. At the time of this writing, the link can be found at: http://www.med.navy.mil/sites/nostra/Pages/default.aspx.

Lenses available

Unfortunately, due to funding and time constraints, military labs cannot offer every lens option that a civilian, for-profit, fabrication lab can offer. Even so, there are still many different lenses available. For you to be able to place orders for standard spectacles, you'll need to know what lenses you can order and how to justify them.

Lens material

The standard lens material used by the military optical labs today is CR–39 plastic. It is not an impact resistant material, but is about half the weight of an equivalent glass lens. There are other lighter lens materials, however CR–39 is inexpensive and breaks less frequently during manufacture. It doesn't need to be heat or chemically treated either which makes it an easy lens material for optical fabrication labs to use. There is a disadvantage to CR–39 plastic, however; it scratches more easily than a glass lens. Because of this, remind patients to be careful when handling spectacles with plastic lenses.

An impact resistant lens material available on a special order basis is a polycarbonate lens. A finished polycarbonate lens is extremely resistant to breakage. For this reason, most civilian optical centers present this option as a good choice for children and teenagers. You could literally hit a finished and edged polycarbonate lens with a hammer and it wouldn't break. It simply flexes and bounces back when struck. Polycarbonate lenses are about twice the cost of CR-39 and are only authorized under special circumstances (e.g., for pilots who must wear night vision goggles [NVG] or for monocular patients—those who have only one functional eye and, therefore, need to protect it). Polycarbonate lenses can be ordered for total powers between +5.00 and -8.00 on single vision jobs and +/-5.00 on multifocal jobs. All other powers need to be justified. An example of the justification required to get polycarbonate lenses for a pilot who wears NVGs would be, "Poly required since member is a flyer who wears NVGs." The justification required to get polycarbonate lenses for a monocular patient would be, "Poly required for monocular patient." A sample justification to get polycarbonate lenses if the doctor authorizes it would be, "Poly required due to doctor's orders." Keep in mind that while the polycarbonate lens material has many advantages, such as being lightweight and impact resistance, it also has a downside—it scratches easily and is costly.

Another material available on a special order basis is a high-index lens. High-index lens material reduces lens thickness, resulting in greater comfort and a better appearance. High-index lenses are authorized if the total power is greater than or equal to +/- 6.00 in any meridian. A justification is required to order high-index for powers less than this range or if a doctor specifically requests it. An example of the justification required to would be, "High-index required due to doctor's orders."

Single-vision lenses

SV lenses do not contain a segment like bifocals or trifocals. They are designed for one particular focal length, such as distant vision, intermediate vision, or near vision.

Multifocal lenses

As you should recall, we previously discussed the two different types of MFs—fused and one-piece. Most plastic multifocal lenses are of the one-piece type. The straight top (ST)-style segments are just molded into the main lens with a steeper curvature. You can feel a ledge at the top of the segment, verifying the lens is, in fact, a one-piece multifocal.

There are MFs that look as if they are SV lenses because the segments are not visible. They are called progressive add lenses (PAL) or no-line multifocals. Although the military labs do not offer these as an option to the general military population, these types of MFs are hugely popular. Therefore, you will have patients who purchase PAL through a civilian lab that present to your clinic wearing them, and at times, complaining of their vision through them. The segments are not visible in these lenses because they are blended in and gain their extra plus sphere power through mild increases to the index of refraction and surface curvature. To do this, the peripheral portions of the lower half of the lens has to be distorted somewhat. In essence, the patient has a channel of lens to view near and intermediate objects (fig. 2–38), but if the patient looks through the periphery of the lower portion of the lens, the view will be blurry and distorted. Patient complaints can arise because it takes a little bit of work for a new wearer to find the "sweet spot" for their best near/intermediate distance.

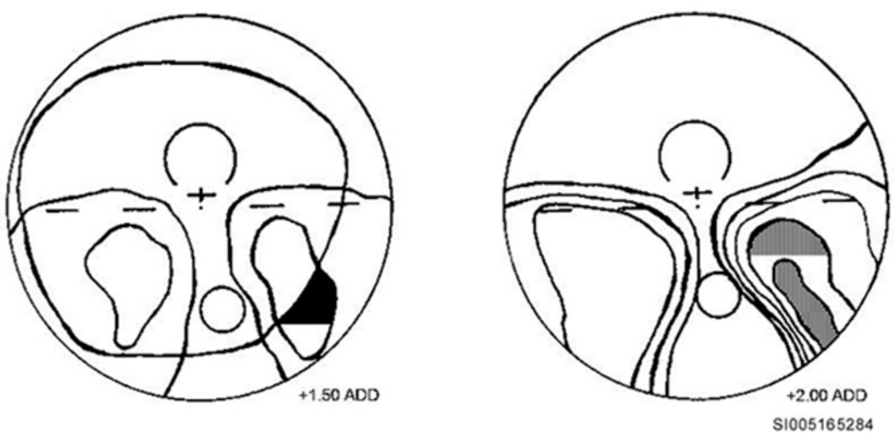


Figure 2–38. PAL or no-line multifocal.

Be aware that a technician fitting a patient with a no-line multifocal has to take accurate measurements if the patient is to be satisfied with these types of lenses. Again, our military labs do not currently offer this type of MF lens, but you do still need to realize this lens exists and that a patient who has a pair may walk into your clinic and need help from you someday.

NOTE: Wounded Warriors with mild to severe traumatic brain injury (TBI) are authorized frame of choice (FOC) to include PAL. The prescribing doctor determines which lens option or combination of options best meets the patient's needs. You need to contact your assigned military fabrication lab or NOSTRA to coordinate production.

Bifocals

Figure 2–39 shows different types of bifocals that you may encounter from patients who purchase their glasses through a civilian fabrication lab. Of those shown, only a few styles are available through the military fabrication labs. The most common style in the military is the ST, which is frequently referred to as the D style, since it looks like a D tilted to the right 90°. The sizes of ST (D) style bifocals available are ST–28 (D–28), and ST–35 (D–35). The number merely indicates the width, in millimeters, of the segment at its widest point. Another type of bifocal available through the military lab is the double D type. It's only available to active duty personnel and only for specific occupational needs.

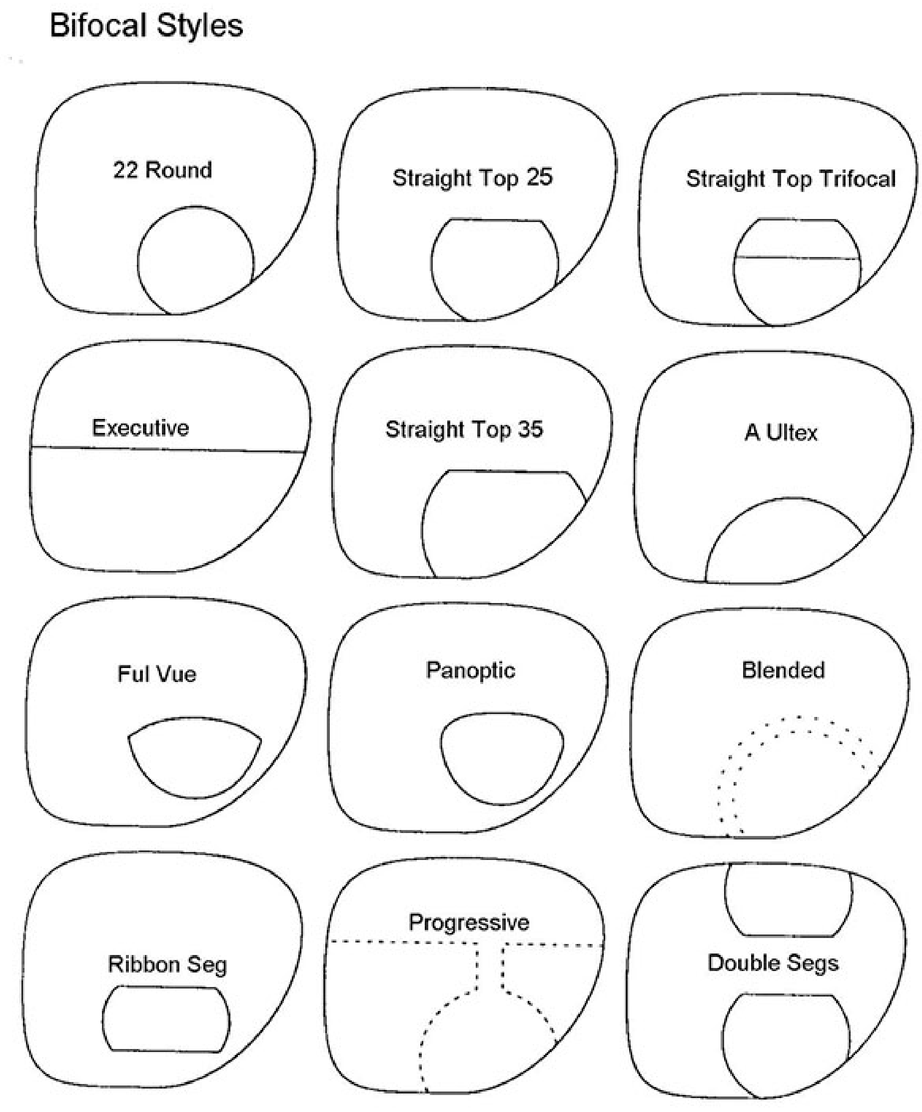


Figure 2–39. Many types of bifocal styles being made commercially.

For any bifocal order going to a military lab, the minimum (weakest) “Add” power you can request is **+ 0.75D**.

Example 1:

A prescription of:

OD: +2.50 –1.00 × 090

OS: +2.00 –1.25 × 091

Add +0.75 OU

is acceptable.

Example 2:

Whereas, a prescription of

OD: +2.50 –1.00 X 090

OS: +2.00 –1.25 X 091

Add +0.50 OU

is *not* acceptable.

A patient who only needs an additional +0.50D of “Add” power to read can do without bifocals for now. The patient just has to hold his or her reading materials out another 2½ inches or so and can do just fine. It’s not worth the money and work of making the bifocals until the “Add” gets up to at least +0.75D.

An order for a ST–28 bifocal does not require any special justification. It is considered the standard issue for military bifocals (fig. 2–40).

An order for the ST–35 bifocal requires a justification. This bifocal has a larger segment (fig. 2–41) and costs more money. To justify the additional expense, the lab needs a valid reason why the ST–28 will not suffice. The most common justification is, “Patient requires a wide field of view (FOV) at near.” Military labs used to offer a lens called the executive style lens, where the near/intermediate segments were ground all the way across the lens. If a patient happens to come into your clinic with this discontinued style of lens, the ST–35 bifocal is the proper replacement, as it offers as wide a field of vision as possible.

Figure 2–40. ST-28 bifocal lens.

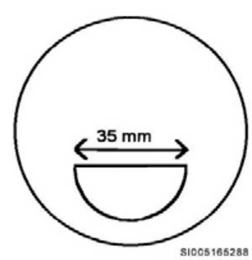


Figure 2–41. ST-35 bifocal lens.

The double D bifocal lens is a specialty order lens and can only be ordered from the military labs for active duty members. It is considered an occupational bifocal, and since retirees are no longer performing mission-related tasks for the military, they cannot get this type of bifocal. The double D bifocal has two near vision segments: one segment is in the normal position in the lower portion of the lens and the other segment is on the upper portion of the lens (fig. 2–42).

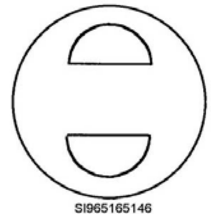


Figure 2–42. Double D bifocal.

It is especially useful to those active duty members who need clear near vision above and below the normal line of sight. Think about pilots and navigators who have instruments and gauges above and below their heads. They must see near objects clearly both above and below without moving their heads much. The double D bifocal is unusual, but invaluable to patients who need clear vision both above and below their line of sight. You would justify an order for double D bifocals by stating on the order, “Patient’s occupational need for double D bifocals has been verified.”

Trifocals

Trifocals also come in many styles and shapes, but again, the military has settled on the ST style because of its functionality and cost. TFs have two segments. The first segment below the main lens (distant vision lens) is the intermediate viewing area. This segment brings objects about 30 inches away into focus for the wearer. The lowest segment is for objects about 16 inches away.

Trifocal lens designation is a little different from bifocals. In the military, you can order a 7 × 28 TF, or an 8 × 35 TF. The first number indicates the height of the intermediate segment. Meaning the “7” in 7 × 28 indicates the intermediate segment extends 7 mm above the bifocal segment (i.e., is 7 mm tall). The “8” in 8 × 35 indicates the TF segment is 8 mm tall. The second number, such as the “28” in 7 × 28 is referring to the width of the segments at their widest point. So, 7 × 28 is 28 mm wide, and 8 × 35 is 35 mm wide. The minimum “Add” power required for a trifocal order is **+1.50D**. This makes sense, since **+1.50D** is twice as much as what is required for a bifocal.

Ordering a 7 × 28 TF (fig. 2–43) does not require any special justification. However, the 8 × 35 trifocal (fig. 2–44) does require one. A common justification is “Patient requires a wide FOV at near and intermediate distances.” The 8 × 35 is the appropriate substitute for patients who had been getting the executive-style trifocal in the past.

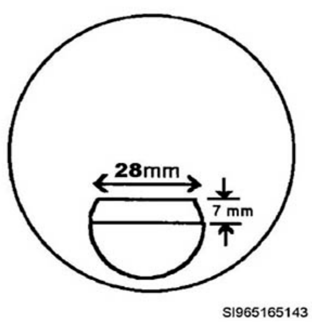


Figure 2–43. 7 × 28 trifocal lens.

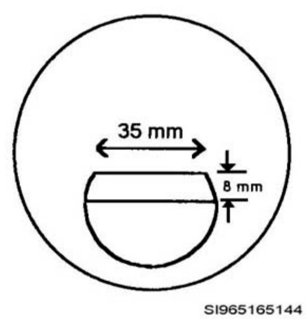


Figure 2–44. 8 × 35 trifocal lens.

Additional lenses available

In addition to the lenses described above, the military labs also are able to fabricate a variety of other special purpose lenses.

Glass lenses

Fabrication labs predominately use plastic lenses because glass lenses are twice as heavy, more expensive, and not as safe. However, no lens material provides a clearer, cleaner, or better functioning material than glass. In addition, glass is a harder material than plastic and therefore, not as easily scratched. If a doctor feels glass lenses are more appropriate for a patient, they can be special ordered. Glass lenses are an option for quadrifocal lenses and for laser eye protection (KG–3). As a special order, a justification is required in the comments section for these items. An appropriate statement would be, “Patient has a medical need for glass lenses due to _____ medical condition,” with you filling in the applicable diagnosis, or, "Patient is a surgeon and requires KG–3 laser lenses due to continuous work with lasers," with you altering the statement as needed for the patient's profession.

Other lenses

When required, specialty lenses such as Myodisc, Lenticular, or Slab-off can be fabricated. You need to contact your assigned military fabrication lab or NOSTRA for additional information and to coordinate production.

Tints and coatings available

When we refer to a tinted lens, we are speaking of a lens with some coloration to it. Tints and coatings can be ordered for the lenses of standard military eyewear. As such, you need to be familiar with the available tints and coatings, their applications, and justifications required to order them.

Lens tints

The CR–39 plastic or polycarbonate lenses used today are tinted easily using a dye process done at the lab. Dying a lens is a lot like coloring Easter eggs. The lens gets dunked in the appropriate colored dye, absorbs the dye, and takes on a new color. The longer the lens is left in the dye, the more color it absorbs. In a dyed lens, the outer surface absorbs the color into the lens, but the dye does not go all the way through. Most military lenses are dyed either gray (for sunglasses) or pink (for computer glasses or patients who are sensitive to fluorescent lighting).

The advantage of dying a lens as opposed to manufacturing it with tint is the thickness of the lens has no effect on the darkness of the tint. Therefore, lenses can be dyed to the same gradient of tint even if the patient's prescription is significantly different in each eye. An additional benefit of a dyed lens is it can be bleached clear again if the tint is not needed or needs to be redone.

Gray tint (N–15 or 31 tint)

The military standard tints for sunglasses are N-15 and N-31. The "N" stands for a neutral density gray tint. A huge advantage of this tint is colors seen through the tint do not change (i.e., blues are still blue, reds still red, and greens will still be green). The "15" or "31" represents the amount of light the tint allows to pass through. In the case of the N-15, 15 percent of the available light passes through the lenses. 85 percent of the light striking the lens is reflected off or absorbed and converted to thermal energy (heat). It is also good to know the N-15 tint in military sunglasses also effectively reduces transmitted infrared and ultraviolet light to the wearer.

The standard gray tint is the N-15. However, patients may request either the N-15 or N-31 tints for the standard issue eyewear (5A) or Air Force flight frames (Air Force dress [AFD] frame, Air Force flight [AFF] frame, and the Air Force Joint Service [AFJS] frame). Which one is more appropriate depends on the patient's needs and wants. If the patient wants a lighter tint, you should order the N-31. If the patient wants a darker tint, order the N-15.

There is no special justification needed to get the tint in the 5A or AFF frame (we'll use this designation to indicate *all* flight frames) for active duty. The verification the person receiving the glasses is on active flying status suffices for the AFF frame. Active duty members are authorized one pair of tinted 5As along with two clear pairs. Retirees who have had cataract surgery are authorized one pair of N–15 5As. You need to provide a justification for ordering tinted frames for retirees; an example would be, "Patient has a medical need for sunglasses due to post-op cataract surgery."

Pink tint (SL1 or SL2 tint)

Another tint you can order is the pink tint, which has also been called the rose or soft-light tint. This tint is not ordered very often, but it is useful for patients who are sensitive to fluorescent lighting or have eyestrain from a lot of computer work and is only available in the 5A frame.

Pink tint comes in two gradients: SL1 (a light tint), and SL2 (a medium tint. When in doubt, SL1 is the best choice.

Acceptable justifications for ordering pink tint would be statements like, “Patient is sensitive to fluorescent lighting” or “Patient works continuously on computers.” Choose the justification to match the patient. If the patient works continuously on computers, you are claiming an occupational need.

Lens coatings

A coating only covers the outer lens surface. It penetrates very little into the lens material. It can be scratched or rubbed off much easier than a dye. The coatings available through the military labs are an anti-reflective (AR) coating and an ultraviolet protective coating called U400.

Anti-reflective coating

An AR coating is very useful in some aviation jobs and can make a significant difference in the elimination of reflection and glare from lenses (fig. 2–45). AR-coated glasses are ordered on a case-by-case basis for authorized aircrew members. They must be on active flying status, and the justification should state the AR coating is needed during the performance of flight duties. A statement such as, “Patient requires anti-reflective coating for performance of flight duties” will suffice. You should place an order for two pair. Therefore, when AR glasses are ordered, they take the place of the two clear flight frames typically ordered for those on flying status.

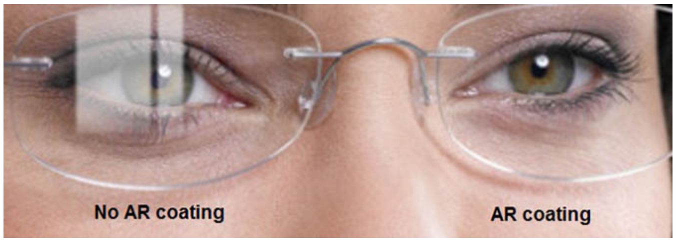


Figure 2-45. Example of an AR coated lens versus a normal lens.

UV400

The UV400 coating is a clear coating blocking out ultraviolet (UV) rays shorter than 400 nm. The UV400 coating is not visible to the naked eye. Sometimes when comparing a UV400 coated lens to an uncoated lens you see the coated lens has a slight yellow tinge to it, but not always. Another clue to its presence would be to rub a tissue over a UV400 coated lens and then a noncoated lens. The coated lens is smoother and has a more slippery feeling. Beyond those two methods, you would need a device to actually measure the transmission or blockage of UV light to know whether a lens had been coated or not.

The UV400 coating is justified for certain medical needs and patients who perform a lot of computer work (occupational need). Cataract surgery patients, patients with a pterygium, or patients with macular degeneration are medically justified to have the coating. There could also be other ocular (medical) conditions that the doctor feels would warrant the addition of UV400 coating. The justification used would be similar to, “Patient has a medical need for UV coating due to (list the condition here).” A justification for an occupational need might read, “Patient works continuously on computers.” Remember, only an active duty member can receive the coating for an occupational need. Lenses other than plastic have UV protection built in by the manufacturer.

Justification for special-purpose items

If an item requires a justification, it’s considered a special-purpose order. If not justified correctly, the order could be rejected, causing frustration and delays. Most importantly, delays can negatively impact the mission.

Keep in mind, however, that an order for a special-purpose item needs to be warranted. When you enter a justification, you are certifying you have questioned the patient or doctor and verified the request is authorized and based on a legitimate need. The labs are counting on your integrity to avoid abuse of the system. The justification needs to be written in the "Special Comments/Justification" block of the DD Form 771, Eyewear Prescription, (fig. 2-46) or put in the comments section of the Spectacle Request Transmission System (SRTS) order (discussed in a later section).

(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - Use DD Form 2005.)

EYEWEAR PRESCRIPTION	DATE 1 Jun 2017	ACCOUNT NUMBER 001234	ORDER NUMBER 1001

TO: (Lab) NOSTRA

FROM: 123 AMDS/SGPE (Ophthalmic Clinic)
12 Your Clinic St.
Base, State 12345

NAME (Last, First)	SSN Last 4 only	GRADE
Smith, John	1234	E5

ADDRESS/UNIT	PHONE
123 AMDS/SGPE (Ophthalmic Clinic)	(123) 123-1234

ADDRESS CONTINUED: 12 Your Clinic St. — SHIP TO: ✓ CLINIC ☐ PATIENT

CITY, STATE, ZIP: Base, State 12345

AD	RES	NG	RET	OTHER*	A	N	AF	MC	CG	PHS	OTHER*
✓							✓				

FRAME	EYE	BRIDGE	TEMPLE	COLOR
5A Small	48	22	145	Black

PD DIST	NEAR	LENS	TINT	MATERIAL	PAIR	CASE
62	/	Single Vision	UV Coat	POLY	1	1

	SPHERE	CYLINDER	AXIS	DECENTER	H PRISM	H BASE	V PRISM	V BASE
R	-5.25	DS						
L	-1.25	-0.75	053					

MULTIVISION

	NEAR ADD	SEG HT	TOTAL DECENTER
R			
L			

LAB USE: EMAIL ADDRESS

PRIORITY: Routine — TECH INITIALS: AMD

SPECIAL COMMENTS/JUSTIFICATION (*Use this space to specify blocks marked "Other.")
Poly required for monocular patient

PRESCRIBING OFFICER/AUTHORITY — SIGNATURE

DISTRIBUTION: ORIGINAL - Retained by Lab. COPY 1 - Returned with eyewear. COPY 2 - Entered in health record.

DD FORM 771, JUL 96 — PREVIOUS EDITION IS OBSOLETE.

Highlighted fields are mandatory — Clear Form — Email Form

Figure 2–46. Sample DD Form 771.

409. Frames available

This lesson covers basic frame nomenclature and the types of frames available through the military fabrication labs. Frame availability is constantly changing as new frames are authorized and others are discontinued. For the most up-to-date information on frame options available, check the NOSTRA website. At the time of this writing, the link can be found at: http://www.med.navy.mil/sites/nostra/Pages/default.aspx.

Frame nomenclature

A spectacle frame consists of three basic parts: frame front and two temples (fig. 2–47). The frame front consists of the eyewire, bridge bar, nose pads (fixed or adjustable), end-piece, lens groove, hinge, and, in some frames, a (hinge) shield (fig. 2–48). The size of a frame front is determined by the horizontal width of the eyewire and the distance between the lenses (DBL). The DBL often is referred to as the *bridge size*. These measurements are given in millimeters. As an example, a "48–22" 5A frame has a 48 mm eye size and a 22 mm bridge size.

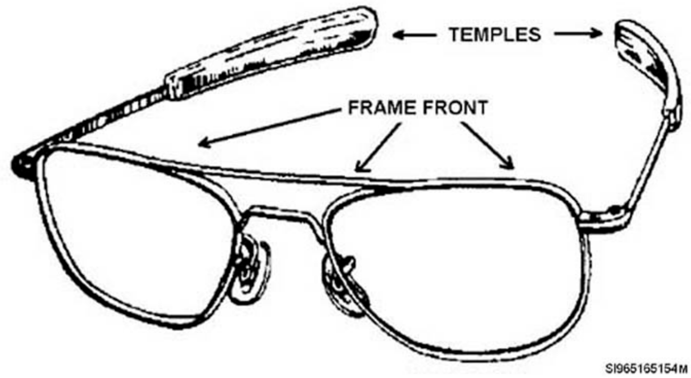


Figure 2–47. Basic frame parts—frame front and temples.

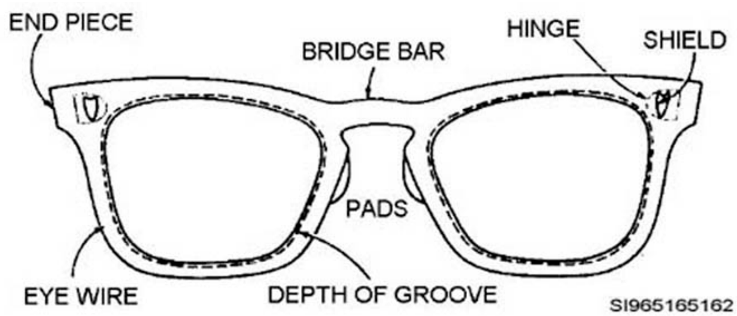


Figure 2–48. Components and landmarks of a typical frame front.

Often, you hear the term *frame PD* being used by the people who make glasses. FPD refers to the distance from the geometrical center of one lens to the geometrical center of the other lens when they are mounted in a particular frame. This is not the same as the distance from the optical center of one lens to the OC of the other, though many people confuse the two.

FPD is determined easily for a frame; just add the eye size and bridge size together. In our earlier example, we had a 5A frame with a 48 mm eye size and 22 mm bridge size. The FPD for this frame would be 70 mm (48 + 22 = 70).

FPD may not mean much to you as an eye technician, but it is a very important figure for opticians. They use the difference between the FPD and a patient's PD (PPD) to determine a measurement called *decentration*. Their goal is to line up the optical centers of the lenses with the pupils of the patients' eyes. If done correctly, patients are more comfortable with their glasses. This concept of decentration is covered again in the next lesson when PD measurements are covered.

Now let's look at temples. Temples come in a variety of styles, the most common ones being the skull temple, straight back temple, and comfort cable temple (fig. 2–49). The majority of the spectacles make use of one of these temple styles.

Temple measurements are given in millimeters. Look again at figure 2–49. For the skull-type temples, the length is based on the distance from the butt to the bend. For the straight back and comfort-cable-style temple, the length is determined by the distance from the butt to the tip.

Assume you are given frame data of "50–24-150." What does this mean? The horizontal width of the eye size is 50 mm. The bridge size or the DBL is 24 mm; and, the temple length is 150 mm.

Figure 2–49. Skull, straight back, and comfort cable temples.

Nose pads are available in two basic styles: (1) molded-into-the-bridge fixed style (similar to those in fig. 2–47) and (2) those mounted-on-guard arms, an adjustable style (fig. 2–50). Fixed nose pads do not allow for any adjustment of the bridge fit and are best suited to patients with relatively straight noses and slightly elevated facial bridges. They are not the best choice for a person who's had a broken nose that healed crooked or for patients with relatively flat facial bridges. In these cases, adjustable nose pads would allow more flexibility to get the glasses to sit comfortably on the face.

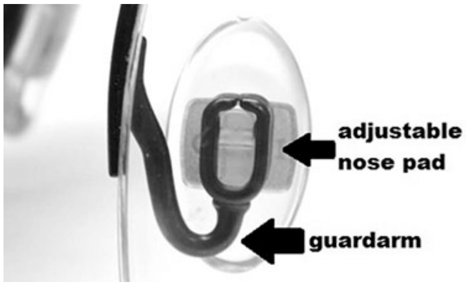


Figure 2–50. Adjustable nose pads.

Standard issue eyewear

Standard issue eyewear comprises the majority of the orders sent to military optical labs. Standard issue eyewear consists of the 5A frame, the 5AM frame, and the half-eye frame.

The 5A frame

The 5A frame is the standard issue military plastic frame. It is only available in black. Virtually any type of lens can be ordered in the 5A frame: DVO, IVO, NVO, BFs, TFs, gray tinted, pink tinted, UV400 coated, polycarbonate, and high-index lenses. It is available with (fig 2–51) and without nosepads (fig. 2–52).

Figure 2–51. 5A frame with nose pads.

Figure 2–52. 5A frame without nose pads.

The 5A frame comes in a small or large designation. Within those designations is a range of sizes suitable for most patients' needs. The 46 and 48 mm eye sizes make up the 5A small, whereas the 50, 52, and 54 mm eye sizes make up the 5A large. The following table shows the various combinations of sizes available.

5A Frame Options													
Frame	**Eye Size (mm)**	**Bridge Size (mm)**						**Temple Size (mm)**					
		16	**18**	**20**	**22**	**24**	**26**	**135**	**140**	**145**	**150**	**155**	**160**
5A Small *without* nosepads	46	X	X	X	X			X	X	X	X		
	48	X	X	X	X			X	X	X	X	X	
5A Small *with* nosepads	46	X		X				X	X	X	X		
	48		X		X			X	X	X	X	X	
5A Large *without* nosepads	50		X	X	X	X	X	X	X	X	X	X	X
	52		X	X	X	X	X	X	X	X	X	X	X
	54			X	X	X	X		X	X	X	X	X
5A Large *with* nosepads	50				X	X		X	X	X	X	X	X
	52				X	X		X	X	X	X	X	X
NOTE: An "X" indicates the bridge size/temple size available for that eye size.													

The 5AM frame

The 5AM is also only available in black. This frame, however, is strictly for bifocal and trifocal Rxs. In addition, it is only available without nosepads (fig. 2–53).

Figure 2–53. 5AM frame without nose pads.

The 5AM is *not available* for single vision Rxs. The frame has a deeper vertical measurement, which is why it is allocated for bifocal and trifocal lenses only. The following table shows the various combinations of sizes available for the 5AM frame.

5AM Frame Options								
Frame	**Eye Size (mm)**	**Bridge Size (mm)**				**Temple Size (mm)**		
		20	**22**	**24**	**26**	**140**	**145**	**150**
5AM *without* nosepads	48	X	X			X	X	
	50	X		X		X	X	X
	52	X	X	X		X	X	X
	54	X	X	X	X	X	X	X

The half-eye frame

The plastic half-eye frame is so named because the lenses are about half the vertical size of standard lenses (fig. 2–54). The reason for the rather small vertical size of the lenses is the glasses are meant to correct near vision only. The wearer can look down through the lenses to read and then look up over the top of the lenses to see across the room.

Figure 2–54. Half-eye frame.

The half-eye frame is available in either brown or gray. If a member is eligible for the frame, it can be issued instead of one pair of SV lenses or one pair of BF lenses in the standard issue frame. It's intended for patients who only need their near vision corrected. If a patient is a moderately high myope and/or has a lot of astigmatism, half-eyes cannot be ordered. These glasses cannot be filled for an Rx with a myopic correction over -3.00D or astigmatic correction greater than 0.75D. When ordering half-eyes with a (-) minus sphere power (-3.00D or less), NOSTRA suggests adding a justification such as, “NVO verified” to prevent the lab from possibly rejecting the order. Since most near vision prescriptions have a (+) sphere power, this lets the lab know you are vouching for the validity of the half-eye prescription.

The following table shows the various combinations of sizes available for the half-eye frame.

Half-eye frame options					
Frame	**Eye Size (mm)**	**Bridge size (mm)**		**Temple size (mm)**	
		20	**22**	**145**	**150**
Half-eye (brown or gray)	46	X		X	X
	48	X		X	X
	50		X	X	X

Flight frames

The flight frames are metal frames designed primarily for use by personnel on flying status. Aircrew members who are on active flight status are authorized two pairs of flight frames with clear lenses and two pairs with tinted lenses. As discussed previously, if members require NVGs, you can order their frames with clear polycarbonate lenses.

Personnel on inactive flight status are authorized one pair of clear flight frames per year. Pilot trainees are also authorized flight frames, but the glasses are not provided until the trainee is ready to report to the flying phase of their training. Pilot trainees are authorized one clear and one tinted pair of flight frames.

While we tend to think of the flight frame as being for flyers only, other personnel are authorized. The following is a fairly complete list of nonflying status personnel who are authorized to receive flight frames:

- Nonflying physiological training personnel required to perform chamber duties (one clear pair).
- Nonflying team members of the Navy’s Blue Angels and the Air Force Thunderbirds (one clear and one tinted pair).
- Missile propellant transfer personnel required to wear rocket fuel handler clothing while performing missile fuel transfer and inspection duties (two pairs clear with comfort cables).
- High altitude/low opening (HALO) and high altitude airdrop mission support personnel (two clear pairs and two tinted pairs).
- Deployable members of the US Navy Navigation Aids Support Unit (one clear and one tinted pair).
- Navy parachute riggers who are required to perform parachute testing (one tinted pair).
- Navy aviators, Navy flight line, and Navy flight deck personnel (authorized the gold AFF frames).
- Air Force air traffic controllers (one clear and one tinted pair).

Standard flight frames are ordered so frequently that, though a justification was originally supposed to be provided; the lab does not typically require one. Do not take this trust for granted. Should you want to enter a justification, a simple statement of, “Flight status verified” or, “Eligibility verified” will work. Rarer orders, such as the gold AFF frame for eligible Navy personnel, need a justification similar to, "Patient is an active duty Navy _____ —eligibility verified." To complete the justification, simply fill in their position with the applicable title. For all other personnel listed above, use the justification, "_____—eligibility verified" filled in with the specifics of what they do that qualifies them (e.g., HALO personnel, team member of the Air Force Thunderbirds, Air Force air traffic controller, etc.).

Fraud is a violation of the Uniform Code of Military Justice (UCMJ) and punishable by court martial. You do not want to be an accomplice to such an act. If you are unsure of a member's flight status, you may be able to verify his or her status by reviewing the medical record—either the paper record or the electronic version in the Armed Forces Health Longitudinal Technology Application (AHLTA) (discussed in unit 2 of volume 2). Typically, members on flight status are enrolled with the Flight Medicine Clinic, and as such in AHLTA, will have a black airplane icon on the top right hand corner of their electronic record. For Air Force personnel, you can also look in the Aeromedical Services Information Management System (ASIMS) (discussed in unit 2 of volume 1) to verify a member's status. For others, you may need them to provide a leave and earnings statement (LES) showing they are receiving flight pay.

NOTE: Military fabrication labs do not issue plano sunglasses. Current aircrew who require nonRx sunglasses obtain them through their Aircrew Flight Equipment (AFE) section using their unit's funds. AFE is the same section responsible for issuing items such as the member's flight suit.

Air Force flight frame

The AFF frame (fig. 2–55) is considered the operational flight frame and is available to only Air Force members. It's available in either gold or black.

Figure 2–55. AFF frame.

The following table shows the various combinations of sizes available for the AFF, as well as the AFD frame, which we'll discuss in the next section. The size options are identical for the two frames.

AFF and AFD Frame Options									
Frame	**Eye Size (mm)**	**Bridge Size (mm)**	**Temple Size (mm)**						
		18	**140 straight back**	**140 skull**	**145 skull**	**150 skull**	**155 comfort cables**	**160 comfort cables**	**165 comfort cables**
AFF and AFD	52	X	X	X	X	X	X	X	X
	55	X	X	X	X	X	X	X	X
	58	X	X	X	X	X	X	X	X

Air force dress frame

The AFD frame (fig. 2–56) is considered the dress flight frame and is available only to Air Force members. As a dress frame, it has a narrower frame front, but retains all other AFF safety frame characteristics. It is also available in either gold or black. (The table above shows the combinations of sizes available for the AFD frame.)

Figure 2–56. AFD frame.

Other flight frame styles

There are additional flight frame styles available (fig. 2–57), but they are ordered less frequently than the frames previously discussed.

Figure 2–57. Air Force Joint Service, Apache Helicopter, Flight Goggle Gold, and Flight Goggle Silver frames.

Therefore, on the following chart we will not go into further detail other than to list them and the available sizes so you are aware of the options for your patients.

Other Flight Frame Options

Frame	Eligibility	Eye Size (mm)	Bridge Size (mm)		Temple Size (mm)					
			20	22	130 straight back	135 skull	140 straight back	140 skull	145 skull	160 comfort cables
Air Force Joint Service Frame (AFJS)	Air Force only	49		X	X					
		52		X	X					
		55		X	X					
Apache Helicopter (AH-64)	Army and Army National Guard (NG) only	52	X				X			X
Flight Goggle Gold (FGG)	Navy, Marine Corps, and Coast Guard	52	X			X	X	X	X	X
		55	X			X	X	X	X	X
		58	X			X	X	X	X	X
Flight Goggle Silver (FGS)	Army and Coast Guard only	52	X				X	X		X
		55	X				X	X		X
		58	X				X	X		X

Gas mask inserts

Gas mask inserts (GMI) (fig. 2–58) are considered a special-purpose frame, and as such, you can only order them for eligible personnel. According to Air Force Instruction (AFI) 44–117, *Ophthalmic Services*, a GMI is required if:

- Unaided visual acuity in each eye is worse than 20/20 for military vehicle operators, flight personnel, and enlisted personnel with Profile I occupational requirements.
- Unaided binocular visual acuity is worse than 20/40 for all other personnel.
- Bifocal correction is required to perform assigned duties satisfactorily.
- Medical or employment requirements necessitate wearing spectacle inserts although the binocular visual acuity is not worse than 20/40.

Figure 2–58. Gas mask inserts.

The following table shows the GMI options; which branch of service is eligible for them; and the various combinations of sizes available. Be aware that although these inserts are currently available, all branches of service are working toward making the M–50 insert the standard.

Military labs are able to issue the inserts listed above because they stock those particular inserts. However, some members are required to wear inserts for industrial protective masks (i.e., firefighter respirator) that are not among those stocked by the military labs. In these cases, the member's unit purchases the actual insert and has the member provide the insert to the ophthalmic clinic. The ophthalmic clinic then forwards the insert, along with a completed DD Form 771, to the appropriate military lab for lens fabrication. (Reference AFI 44−117 for an inclusive list of personnel eligible to receive a GMI.)

Gas Mask Insert Options

Frame	Eligibility	Eye Size (mm)	Bridge Size (mm)							Temple Size (mm)				
			18	20	22	23	24	25	36	Small	Med	Large	175	180
MCU-2P	Only for Navy training and Army “jumpers”	46			X			X		No temple				
		48			X			X		No temple				
		50			X			X		No temple				
M-40	Army only	50					X			No temple				
A1000[1]	Coast Guard only	45				X				No temple				
MSOI[2]	Navy only	48			X					X	X	X		
M-50[3]	All branches	54			X					No temple				
M-45	Not widely used	38							X	No temple				
EAB-17	Navy sub-mariners	43	X										X	
		47		X										X

NOTES:
[1] Ordered only when the MCU-2P does not make a proper seal.
[2] Replacement for the MCU-2P.
[3] Used for the M-50 or M-53 gas masks.

Ballistic protective eyewear

The fabrication labs at NOSTRA only manufacture ballistic protective optical inserts for eyewear meeting or exceeding military ballistic standards (MIL PRF–31013 for spectacles and MIL STD–662 for goggles).

The military ballistic standard is a standard for lenses only. Spectacles are tested with a 0.15 caliber projectile and must be able to withstand impact at a velocity of 650 feet per second (ft/sec). This translates to 5.43 foot pounds (ft/lbs) of energy, which is greater than 6X the American National Standards Institute (ANSI) Z87.1 standards for civilian eyewear. Goggles are tested with a 0.22 caliber projectile and must be able to withstand impact at a velocity of 560 ft/sec. This translates to 5.60 ft/lbs of energy, which is greater than 5X the ANSI Z87.1 standards for civilian goggles. A spectacle/goggle system may meet this standard but still be unacceptable due to safety concerns found during ballistic testing.

Unit costs

For deploying members who require vision correction, only the insert itself is available through the NOSTRA. NOSTRA supplies the insert but each individual unit supplies the ballistic protective eyewear (BPE). BPE are commercially available products with national stock numbers purchased with unit funds. Cost for the individual unit would be the cost of providing BPE to each deploying Airman, depending upon mission requirements.

Program guidance

All Airmen deploying to an area of responsibility (AOR) should have BPE. It's up to the individual unit deployment manager (UDM) to determine what's ordered for the unit. The UDM needs to be aware that not all BPE is insert-compatible. This is where it becomes important to educate the UDMs on your base. For members that require vision correction, there are specific BPE on the approved Authorized Protective Eyewear List (APEL) that are insert-compatible. It is typically easier for UDMs to order the same style BPE for everyone in their unit, so you want to make sure they order a style that the military labs are capable of supporting.

Deploying Airmen who do not require vision correction and do not need an insert are able to wear any BPE on the APEL, depending upon mission requirements. At the time of this writing, the link can be found at: http://www.peosoldier.army.mil/equipment/eyewear/.

Universal protective lens carrier insert

The universal protective lens carrier (UPLC) insert (fig. 2–59) is now the universal insert for all insert-compatible BPE. It is available in a 42-24 eye/bridge size. It attaches to the BPE at the nosepiece, and as such, does not have a temple. Since polycarbonate is an impact-resistance material, all UPLC orders are fabricated using this protective material.

UPLC

Figure 2–59. UPLC.

Aircrew laser eye protection

Aircrew laser eye protection (ALEP) inserts can be ordered for aircrew members who require vision correction. ALEP devices are issued and worn when there is any risk of a laser exposure. The wear policy is based on risk assessment, threat environment, and is at the local commander's discretion. Similar to the BPE program, military labs only provide the ALEP insert. With the ALEP, however, it is the AFE section that provides the actual ALEP eyewear and is responsible for fitting, periodic inspection, and routine maintenance of the device. To order the correct eyewear size, AFE requires a PD measurement. AFE personnel are not trained ophthalmic technicians, so be prepared to assist them with these measurements should the need arise. The member's PD determines the ALEP eyewear size that AFE orders, which then corresponds to the ALEP insert size your clinic orders: small, medium, or large.

Frame of choice

Although the FOC program provides active duty members a wide variety of frames to choose from, the FOCs are not intended as a replacement for the standard issue (5A or flight) frames. A FOC with proper corrective lenses may be considered an asset toward fulfilling the two-pair requirement. Members not on flying status are still required to have at least one pair of standard issue frames along with the one pair of FOC. Those members on flying status must still maintain the full complement of flight frames.

To be eligible for a FOC, members must be on active duty for greater than 30 consecutive days. This means Guard or Reserve personnel placed on active duty status may need to furnish a copy of their orders to prove they are eligible for a FOC. Military retirees, to include retired generals and/or flag officers, are *not* eligible for the FOC program.

When dispensing FOC to those members on flight status, ensure you notify them the FOC is not intended to be worn while performing their flight duties—this is why they are issued flight frames.

Flight Frames	
At the time of this writing, NOSTRA indicates active duty, in any branch of service, are eligible for the following complement of glasses:	Military retirees are eligible for:
• 1 pair of clear lenses in a FOC (if active duty for greater than 30 consecutive days). • 1 pair of clear lenses in a 5A or 5AM frame. • 1 pair of sunglasses in the 5A or 5AM frame. • BPE inserts (if required). • GMI (if required).	• 1 pair of clear or tinted lenses (but not both) in the 5A or 5AM frame.
NOTE: AFI 44–117 further defines additional eligibility categories.	

Personnel who damage their FOC or need an Rx change may return the FOC for repair or replacement, and personnel who lose their FOC may request an exact replacement if the following criteria are met:

- The Rx meets the required timeframe.
- The Chief of Optometry/Ophthalmology feels the patient has acted cautiously.
- Replacing the glasses ensures the best standard of care.

FOC glasses come with clear lenses. An exception to this is any Wounded Warrior with a diagnosis of TBI. These members are authorized tinted lenses in their FOC. You must add a justification such as, “Tint requested due to TBI diagnosis” to the comments section of the order. Additional members authorized tinted FOC lenses include active duty very important persons (VIP) (O-7 and above), or specific job authorizations (i.e., Criminal Investigation Division). Again, a justification must be provided.

NOTE: Wounded Warriors are also authorized photochromatic lenses. These lenses darken on exposure to specific types of light, most commonly UV radiation. Photochromatic lenses for Wounded Warriors may be ordered clear or with a base tint. The prescribing doctor determines which lens option or combination of options best meets the patient’s needs. You need to contact your assigned military fabrication lab or NOSTRA to coordinate production.

The FOC program has gone through many changes since it was implemented in February 2000. New frames are frequently being released, while others are discontinued. As such, we will not list them individually here. You can find further information on the frames currently available through the NOSTRA website at: http://www.med.navy.mil/sites/nostra/FramesLenses/Pages/FrameofChoice.aspx, or by looking at the latest version of SRTS.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

408. Lenses, tints, and coatings available

1. What is the standard lens material used by optical fabrication labs?

2. Besides it being half the weight of an equivalent glass lens, what are two other advantages of a CR–39 plastic lens?

3. What is the main disadvantage of plastic lenses compared to glass lenses?

4. Give two examples of patients who can get polycarbonate lenses regardless of their prescription powers?

5. List the advantages of a high-index lens.

6. High-index lenses are authorized if the total power is greater than or equal to what range?

7. How can you verify if a lens is a one-piece multifocal?

8. Which multifocals can look like single-vision lenses?

9. If it is deemed necessary by their doctor, who is authorized PAL in their FOC glasses?

10. What does the “28” stand for in ST–28?

11. What is the *minimum* (weakest) “Add” power you can request for a bifocal?

12. What is the most popular justification used to order the ST–35 bifocal?

13. Can you order a double D bifocal for a retiree?

14. How many segments does a trifocal have?

15. For what viewing distance is the (middle) intermediate segment of a trifocal appropriate?

16. What does the “8” stand for when a trifocal is described as being 8×35?

17. What is the *minimum* “Add” power that must be requested to order a trifocal?

18. What method does the optical lab use to tint plastic lenses?

19. What colors are used most when tinting military spectacle lenses?

20. What is the military standard tint for sunglasses? What does the “N” stand for?

21. How much light is reflected or absorbed by an N-15 tinted lens?

22. Which tint is useful for patients who are sensitive to fluorescent lighting or have eyestrain from a lot of computer work?

23. Who is authorized anti-reflective-coated lenses?

24. UV400 coating is justified in cases of medical need. When else is it justified?

409. Frames available

1. List the three basic parts of a spectacle frame.

2. What does DBL stand for?

3. What is frame PD (FPD)?

4. What is the FPD for a 50-22-145 frame?

5. What measurement is FPD and PPD used to determine?

6. The length of which temple style is based on the distance from the butt to the bend?

7. Can you order a 5A frame with polycarbonate lenses?

8. What three eye sizes make up the 5A large designation?

9. You have a patient who likes his SV glasses with as large a lens as possible and is asking if you can order the large 5AM frame for him. Are you able to place this order? Why or why not?

10. The half-eye frame is intended for which type of patients?

11. What eye sizes does the half-eye come in? What bridge sizes?

12. How many flight frames are aircrew members on active flight status authorized?

13. How many flight frames is an Air Force air traffic controller authorized?

14. You have an aircrew member on active flight status that does not require an Rx but needs to order sunglasses. Are you able to place this order? Why or why not?

15. Does the need for a bifocal qualify or disqualify a person for a GMI?

16. Which GMI is becoming the standard for *all* branches of service?

17. Does NOSTRA issue the actual BPE?

18. Where can a UDM find a list of all approved BPE?

19. What is the universal insert for all BPE?

20. How long must members be on active duty status to be eligible for the FOC program?

21. Can members on flight status wear their FOC while performing their flight duties?

22. You have patient who has a documented TBI. Your doctor has determined the patient would benefit from having photochromatic lenses in the FOC so that the eyewear can be used both indoors and out. Are you able to place this order? Why or why not?

2–3. Frame Selection

Selecting the right frame for a patient is something a good technician takes sufficient time to do. A frame complementing a patient’s facial features, requiring minimal adjustments, and holding the lenses securely benefits the patient the most. It pays off in greater patient comfort and satisfaction with the eyewear received from your clinic. This reflects well on you and the hospital, so it’s worth the effort to do a good job. You’ll be executing the core value of excellence in all you do.

410. Selecting frame size

One of the first things you need to beware of is the lens. A high minus lens is thicker near the edges of the lens and thinner near the center. If the Rx also calls for moderate to high cylinder correction, the lens becomes even thicker. It might benefit the patient, therefore, to go for a smaller, rounder frame. This results in the lenses being as thin as possible. Selecting a large angular style frame would cause the lenses to be much thicker and heavier and, as such, might not stay put on the patient’s nose.

The next step is determining which of the seven facial shape categories your patient has. Figure 2–60 shows these basic facial shapes.

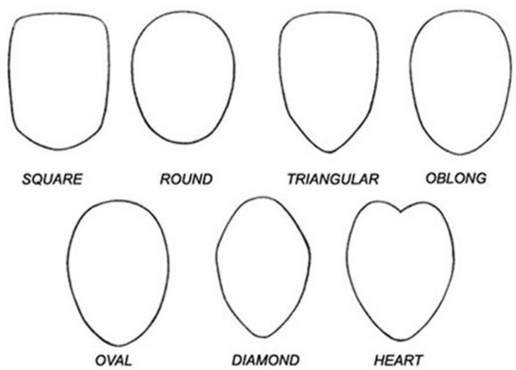


Figure 2–60. Facial shapes.

Evaluating the shape of someone's face can be difficult. It requires good observation and some trial and error as patients may have a combination of several shapes. Basically, you want to select a frame the opposite of the patient's facial shape. This allows for a balanced look for the wearer and highlights positive features. Choosing a frame shape the same as the patient's facial shape emphasizes the shape of the face. If you were to select an oval frame for an oval face, the frame would accentuate the roundness of the face. However, the face can appear less round by selecting an angular shaped frame. Oval faces look good in almost any shape frame. Rounded faces tend to look best with angular frames. Oval shape frames work best with those who have square faces (avoid angles). Oblong facial shapes look more balanced when frames have a short vertical measurement (makes the face look shorter). Diamond and the triangular shaped faces are very angular and have a softer appearance when fitted with oval or rounded frames. Regardless of the facial shape, the patient's frames should complement them. The frames should not detract from the patient. The goal of frame selection is to enhance the patient's overall appearance and meet or exceed their visual expectations.

For the flight frames, we'll discuss the AFF since that is the most commonly ordered. You only have three eye sizes and one bridge size available. It is as simple as looking at the patient's face to determine if they need a small, medium, or large eye size. Ask their preference for the temple style, they may have an occupational need for one over another. Once the style has been determined, it is just a matter of looking at their face to judge if a small, medium, or large temple size is needed.

Ordering the right size half-eye is also a simple process. Again, you only have three eye sizes and two bridge/temple sizes from which to choose. Look at the patient's features to determine if small, medium, or large sizes would work best.

Both the M–50 GMI and the UPLC BPE insert only have one size option, which makes ordering those items error-proof. As for the ALEP insert, as previously discussed, the member's PD measurement determines the ALEP eyewear ordered, which then corresponds to the ALEP insert ordered. Three frame sizes are available depending on the PD measurement: small (53−61 mm), medium (59−67 mm), and large (65−73 mm).

Since the 5A and 5AM are the standard issue frames, we'll go into further detail when discussing how to determine a proper fit those styles (we will use "5A" to refer to both). To fit a patient, the first thing you must do is visually assess the patient's face and head. Facial shapes are important, but unfortunately, the 5As only come in one shape for all faces. When fitting a 5A, guess the frame size by judging the width of the patient's head and nose. From there, you can pick a trial frame in the "ballpark" of the correct size. Once you have picked a trial frame and placed it on the patient, assess if the eye size, bridge, and temples are correct based on your judgment and adjust as necessary to get the proper fit.

Selecting the correct bridge size

Once you have made your initial guess of which frame to try on the patient, work on refining the bridge size. You want the glasses to sit at a height where the eyes are centered or just a bit above the halfway point in the frame. If you need to make adjustments, a wider bridge lowers the frames and a narrower bridge raises them. You do not want a large gap between the bridge bar and the nose. This would indicate the bridge size selected is too narrow. You also do not want the bridge bar of the frame resting on the nose. This would indicate the bridge size selected is too wide. Your goal is to choose a bridge size allowing the bridge bar of the frame to sit on the nose with a slight gap between the two (fig. 2–61).

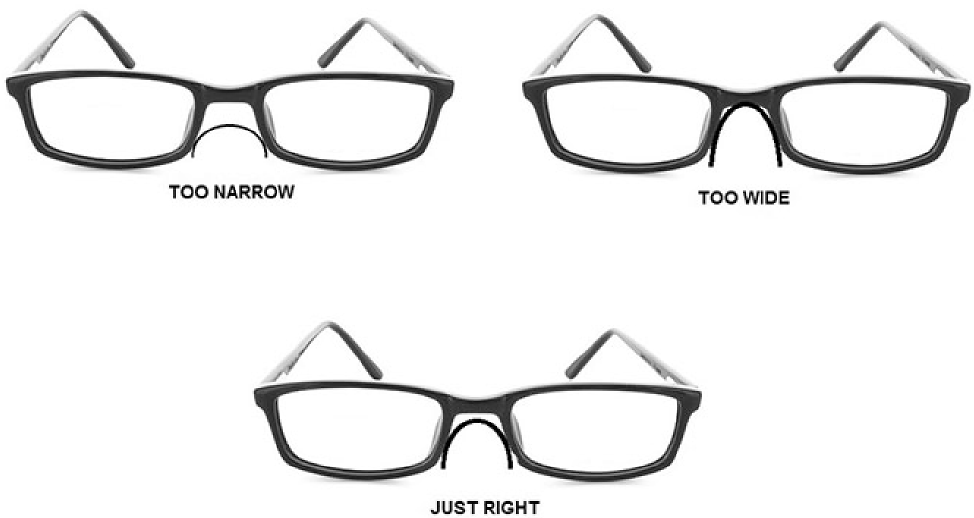


Figure 2–61. Selecting the correct bridge size.

Most men tend to be well fit by a 20 or 22 mm bridge. Occasionally, you may find a patient really needs a 24 mm bridge, but it's extremely rare to ever find someone who needs a 26 mm bridge. Stick with the 20 to 22 mm range for most of your male patients and you should do fine. You may find patients with a flat bridge are actually easier fit with a wider bridge. This actually allows more of the bridge to come in contact with the patient's face.

Most female patients have narrow noses, and they tend to fit in the 18 to 20 mm bridge sizes. Occasionally, you may find a woman who needs a 22 mm bridge, but anything larger is rarely required.

Selecting the correct eye size

Once you have determined the right bridge size, you are ready to move on to the eye size. Make sure at this point you have the patient wearing a frame with the correct bridge size, and the earlier guessed eye size. Ideally, you would like to find an eye size having the eyes fairly well centered, side to side, in the frame. This may not always be possible due to facial variations. Some people have very narrow set eyes and attempts to fit them with a smaller eye size can cause the frame selected to squeeze on the sides of their head. This leads to the glasses continually pushing forward off the patients face, frustrating the patient.

An easy way to judge eye size is to seat the patient with the trial frame on and then stand above them. While the patient looks straight ahead, look down on the patient's head from above to determine if the temples are running parallel along the head (good), appearing loose and tapering in toward the head (eye size is too wide), or looking flared out away from the head (eye size is too narrow).

Figure 2–62 shows good examples each.

Figure 2–62. Selecting the correct eye size.

For men, you really can't go wrong starting with a 50 mm eye size frame. It seems to be right for about 50 percent of the patients. If it isn't quite right, going down to the 48 mm eye size or up to the 52 mm eye size usually gets you to the correct frame and you'll be ready to move on to temple length.

For fitting female patients, it is best to start with a 48 mm eye size. This seems to be right about 75 percent of the time. If the 48 mm does not seem quite right, try going down to a 46 mm or up to a 50 mm eye size to get you on target.

If you are unsure about which eye size to select, go with the smaller size. This is especially important for patients with high power prescriptions because the smaller the eye size, the less chance of noticeable aberrations. In addition, smaller lenses mean lighter spectacles. Additionally, it's easier to adjust a narrow frame than to adjust a wide frame. Once you have sorted out the eye size, you are close to being done. All that's left is to decide which temple length fits best.

Selecting the correct temple length

At this point, you should have a trial frame on the patient with the correct bridge and eye size. Now look at the side of the patient's head and determine the correct temple length. You want the bend of the temple to be right at the top of the ear so the end of the temple curves downward following the contours of the back of the ear (within $^1/_8$ of an inch of touching the ear) (fig. 2–63).

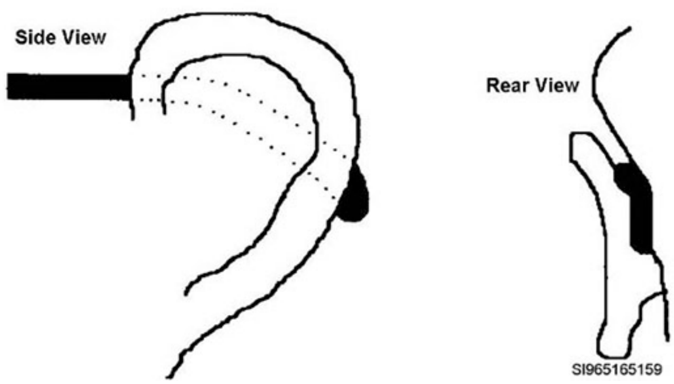


Figure 2–63. Selecting the correct temple size.

Pay attention to the size of the temple on the trial frame you select. Once it is on the patient, all you need to do then is measure how much longer or shorter the temple needs to be to get the bend at the top of the ear. After you measure this a few times with a ruler, you get to a point where you can just "eyeball" it correctly, speeding up your fittings.

Do not overlook this step and get into the bad habit of routinely ordering the same temple size for every patient. The 145 mm skull does not work for everyone. This is unprofessional and shows a weak work ethic. You need to look at how the temple of the trial frame fits. Ordering the correct temple from the start eliminates replacing or adjusting a poorly fitted temple later.

Selecting fixed or adjustable nose pads

The 5A comes with either a molded-in, fixed nose pad or an adjustable nose pad. This gives you some flexibility in fitting the frame to the patient when the fixed bridge design does not seem to fit well. Experience says you should only order the adjustable nose pads in cases where there is just no way to get a good fit with the fixed type. Adjustable pads can be difficult to adjust, can break off easily if adjusted more than a few times, and can require you to make adjustments to the bridge size and temple length before you order.

However, adjustable nose pads can be of help when dealing with patients who wear a multifocal. The adjustable nose pads allow some adjustment of the segments in relation to the patient's eyes. If the adjustable nose pads are spread further out, the glasses sit lower on the face, effectively lowering the segment placement. If the adjustable nose pads are moved closer together, the glasses sit higher on the face, effectively raising the segment placement.

This same concept can be applied to fixed nose pad frames, to some degree. If a person is wearing a 50−24 frame, and you need to move the segments of the glasses higher, you could put the lenses into a 50−22 or a 50−20 frame. If you need to lower the segments, you could put the lenses into a 50−26 frame. This is not a perfect solution and can cause its own fitting and decentration problems, but it might work. At least you can see how pads, whether fixed or adjustable, can have a sizable effect on the adjustability and comfort of a frame.

Example:

Let's say you are fitting a patient with a 5A frame and the one fitting the best is the 52−22 with a 145 mm temple. Problem is the patient's nose was broken when he was a kid, and the bridge fit is just not very good. You decide to go with adjustable nose pads. In order to have room for the adjustable nose pads to be adjusted, you'll need to order one bridge size larger than the one that came closest to fitting. In this example, you'll have to order a 52−24 frame. Then, you need to take into account the adjustable nose pads are going to push the glasses out farther from the patient's face. This is going to require you to order the next larger temple length than what fit the patient with the fixed nose pad frame. In this case, the 145 mm temple needs to be replaced with a 150mm temple. Your final frame choice, therefore, would be the 52−24 with a 150 mm temple and adjustable nose pads.

To recap, when ordering adjustable nose pads, order the bridge one size larger and the next larger temple size than what seemed to fit the patient in the fixed nose pad frame. In addition, be careful when tweaking the adjustable nose pads to avoid breaking them.

411. Taking measurements for ordering eyewear

Knowing what lenses and frames are available and authorized is important when ordering through military fabrication labs. However, this is not the only information you'll need to place valid orders. As previously mentioned, you'll need the patient's PD for all orders, as well as a segment height for multifocal orders. This lesson is intended to teach you how to take these measurements.

Pupillary distance measurement

PD is the distance from the center of one pupil to the center of the other pupil. It's measured in millimeters using a simple plastic, metal, or wooden ruler referred to as a PD ruler. It's normal to measure a patient's distant and near PD.

Importance of measuring PD

The PD measurement is needed by the lab to determine decentration of the lenses when making spectacles. Ideally, a person wearing prescription eyewear should be looking directly through the OCs of the lenses (fig. 2–64). This means the OC of each lens should be right in front of the patient's pupils.

If you recall from your earlier reading and your three-level training, the optical center is the point on a lens where light passes straight through without deviating. Remember, corrective lenses can be thought of as nothing more than two prisms put together. The point where the two prisms touch is the optical center. Get away from the optical center and, technically, you're looking through a prism.

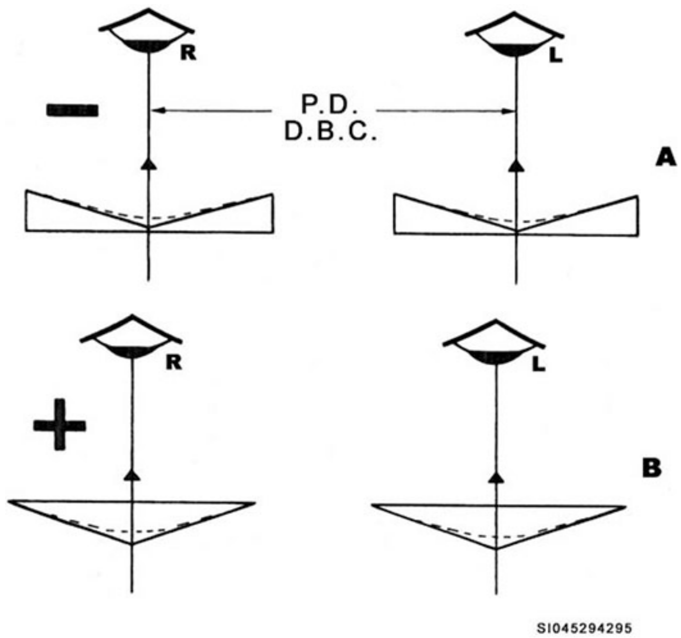


Figure 2–64. Example of correct PD alignment.

If the labs were to make glasses without any attempt to line up the OCs of the lenses to the patient's pupils, the patient would experience eyestrain, headaches, and even double vision (diplopia). This happens because the patient is looking through the prism portion of a lens, and not the OC. The patient would experience what is termed "induced prismatic effect," which could easily be called "unwanted prismatic effect" in this case.

PD and decentration

The fabrication labs use the FPD and patient's PD to calculate the amount of decentration required to line up the OCs of the lenses with the pupils of the patient. Look at an example. Assume you have selected a 50-20 5A frame for a patient who has an Rx for DVO. You measure the patient's distant PD and find it to be **64 mm**. You send the information into the lab (with the Rx, of course) and lab personnel go to work. First, they figure out the FPD, which is 70 mm in this example (50 plus 20 = 70). Then, they look at the patient's distant PD, which is 64 mm. They can see there is a 6 mm difference between the two figures. This represents the total amount of decentration required to line up the OCs of the lenses with the patient's eyes.

The lab is going to have to displace the OCs within the frame so they line up with the patient's eyes. Which way do the lenses need to be decentered to line up correctly? Let's see, the FPD was 70 mm and the patient's PD was 64 mm. To get the lenses to line up to the patient's eyes in this case, the lenses have to be decentered inward, since this is where the patient's eyes are in relation to the FPD. The total decentration needed is 6 mm in. Since there are two eyes the lab divides the 6 mm total by two. The reason—there are two eyes and this allows each lens to be decentered equally. Each lens in this example is then decentered in 3 mm for a total of 6 mm.

This was just an example. The labs can decenter in or out as needed, depending on the FPD and patient's PD. Their goal is to line the OCs of the lenses up with the pupils of the patient's eyes so the patient doesn't experience any (unwanted) prismatic effect.

Consequences of a poorly measured PD

What does this means to you? You must be accurate in your measurement of the patient's PD. If your measurement is inaccurate, you'll order glasses using the wrong PD, causing the lab's calculations and decentration to be wrong (fig. 2–65). Consequently, the patient experiences unwanted prismatic effect leading to eyestrain, headaches, and, potentially, diplopia. The patient may be miserable, and you'll end up spending a lot of time troubleshooting the glasses. Eventually, you'll find the problem was a poorly measured PD.

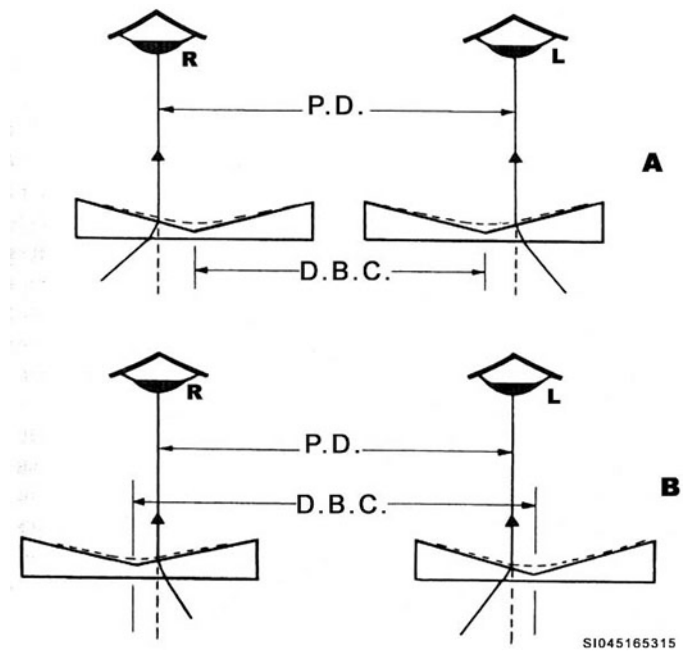


Figure 2–65. Poor decentration inducing unwanted prism.

Now the glasses have to be reordered. The patient has to wait another 4 to 6 weeks for new glasses. Wasted time, effort, and money, as the lab has to grind new lenses, then box, label, and mail the corrected spectacles back to your clinic. You'll have to repeat the process of checking in the glasses in SRTS, notifying the patient the glasses are in, and refitting the new glasses to the patient.

You can see an inaccurate PD measurement causes visual problems, inconvenience, frustration, and wasted time, resources, and money. It's important to take the time to measure a PD correctly. The amount of time and effort involved is a drop-in-the-bucket compared to the time and money involved in fixing the problems of incorrect measurements. We know you want to do a good job, so let's look at how to measure a PD accurately.

Manual PD measurement on orthophoric and heterophoric patients

For a patient who is orthophoric or heterophoric (i.e., does not have strabismus), taking a PD measurement is not complicated. Since you have to touch the patient's face, first wash your hands. Then, clean the PD ruler with an alcohol pad. Ideally, you and the patient are seated so both are comfortable and steady. You must be eye level with the patient, or the accuracy of the reading is questionable.

Always explain to the patient what you'll be doing. Follow these steps for PD measurements:

1. Position yourself 16 inches (40 cm) from the patient. (This is theoretically the correct distance. You may find with practice and experience your measurements may come out more accurately if you are just a little farther away.)
2. Place the PD ruler on the bridge of the patient's nose so the "0" mark is to your left. Tilt the top of the ruler toward the patient so it lies flush with the nose. The ruler should be positioned

so its top edge is at the halfway point of the eyes (i.e., cutting the pupils in half). *Do not touch the patient's eyes with the ruler*. Just place the ruler as close to the eyes as the bridge of the nose allows. This increases the accuracy of your measurement. For best results, hold the ruler with your thumb and pointer finger and then touch the patient's temple area with your other three fingers to help stabilize your hand. You need to be as steady as possible. Touching the patient helps, if the patient moves, your hand moves with him or her and it won't throw off your measurement.

3. Measure from the patient's RIGHT TEMPORAL LIMBUS (zero mark lined up here) to the patient's LEFT NASAL LIMBUS (actual reading taken here). This is shown in figure 2–66. To do this:

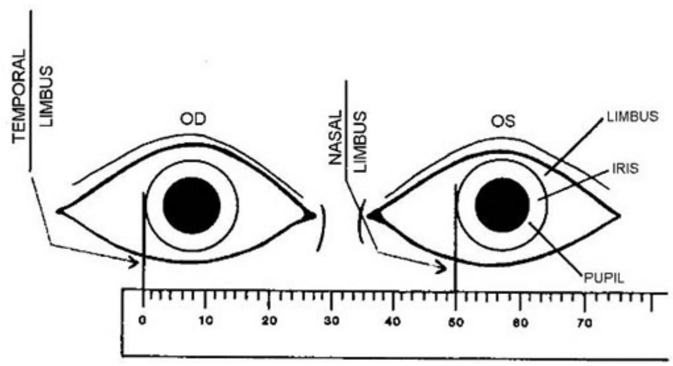


Figure 2–66. Location of where the zero mark alignment is made (patient's right temporal limbus) and where the actual PD reading is taken (patient's left nasal limbus).

a) Have the patient look at the center of your left eye.

b) Close or cover your right eye.

c) Line up the zero mark of your ruler with the patient's right temporal limbus (fig. 2–67). Be careful to keep the ruler parallel with the patient's face. Once the zero mark has been lined up, DO NOT MOVE THE RULER.

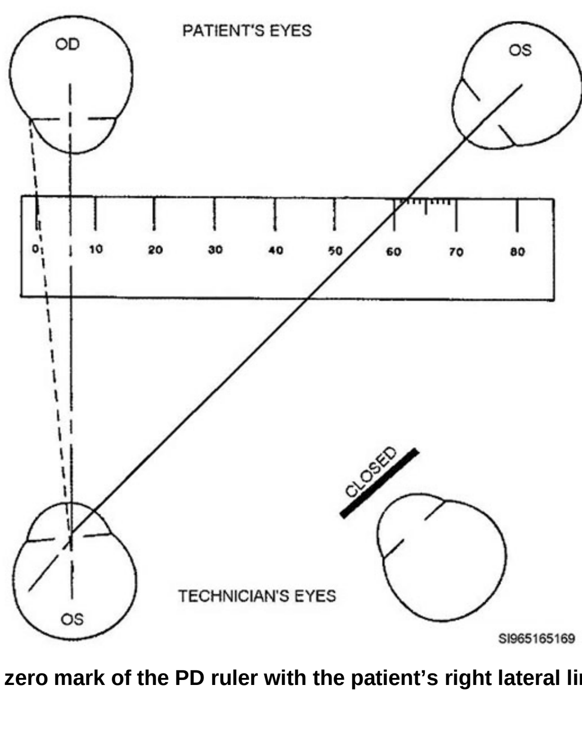


Figure 2–67. Lining up the zero mark of the PD ruler with the patient's right lateral limbus (using your left eye).

4. You want to get the *near PD* measurement. With the patient still looking at your left eye, and without moving the ruler or opening your right eye, look across the patient's face to his or her left eye and observe where the left nasal limbus is lining up on the PD ruler (fig. 2–68), and in this example, the reading happens to be 63. Whatever reading you get, just keep it in your head for now. You're not done yet. You've only gotten the near PD so far. Again, DO NOT MOVE THE RULER.

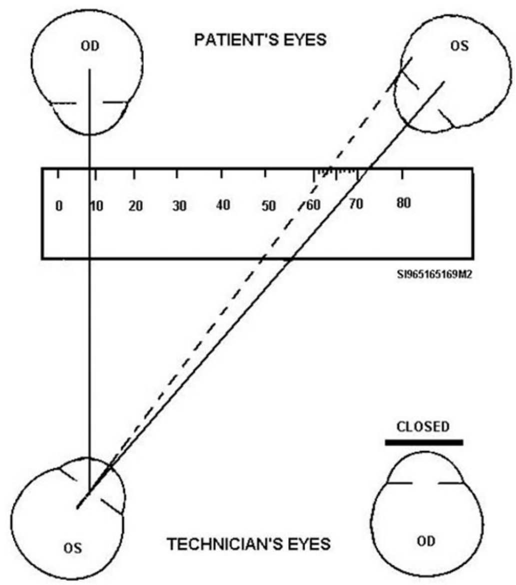


Figure 2–68. Taking the near PD reading from the patient's left nasal limbus (using your left eye).

5. Get the *distant PD* measurement. Open (or uncover) your right eye and close or cover your left eye. Tell the patient to now look in the center of your right eye. DO NOT MOVE THE RULER. Look at the patient's left eye (using your right eye) to see where the patient's nasal limbus lines up on the ruler now. The reading in the example in figure 2–69 is 66 mm. This makes sense, as the reading should be about 3 mm larger than before, since the patient's left eye shifted to the left when they switched their gaze to your right eye.

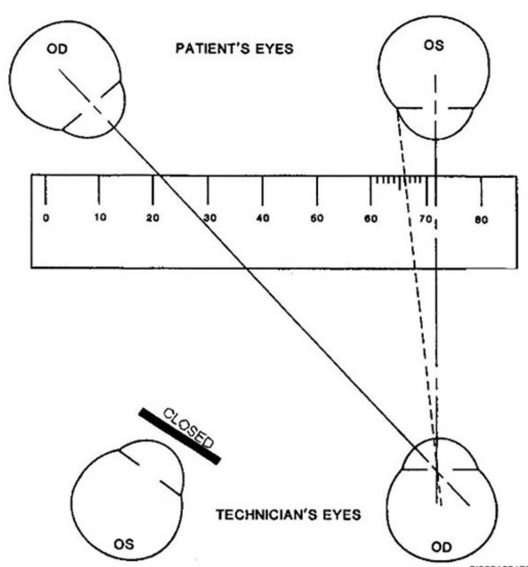


Figure 2–69. Taking the distant PD reading from the patient's left nasal limbus (using your right eye).

Now, write down the measurements you have. In the ophthalmic world of doing things, you always list the distant PD first, then a slash (/), and then the near PD. In our example, based on the illustrations used, it would look like this: 66/63.

That's it. Recheck the PD once or twice more, just to be sure, but essentially, you are done at this point. The most common errors made are as follows:

- Misreading the ruler.
- Moving the ruler after the initial alignment of the zero mark is made.
- Tilting the ruler so one side is closer to the patient's face than the other is.
- Not "cutting the eyes in half" properly, leading to measurements taken too low on the eyes.
- Trying to measure from the edge, or center, of the pupil instead of the limbus.

Being aware of common errors can help you avoid them. Remember you are trying to be accurate to within ± 0.5 mm and it is tough to do if you have a flaw in your technique. Do not try to measure from the center of one pupil to the center of the other, even though this is what you are technically doing. It's too tough to accurately judge the centers of the pupils to get a correct reading. It's much easier and more accurate to measure from the very distinct landmarks of the patient's right temporal limbus to the left nasal limbus.

Manual PD measurement on heterotropic patients

If the patient has a heterotropia (strabismus), performing the PD measurement as described above gives false readings. A strabismic patient can only fixate on a target with one eye or the other, but not with both eyes at the same time. This doesn't work with the PD measurement steps just described. You need a certain consistency of alignment and fixation to get accurate measurements. With a strabismic patient, you'll have to change your method a little bit.

The eye level, 16 inches (40 cm) from the patient, ruler-on-the-nose stuff, and so forth, all remain the same. The first step is still to get your zero mark lined up. To do this accurately on a strabismic patient, you'll have to follow these slightly modified instructions (as shown below in bold). As before, try to visualize what is being described:

1. Close your right eye.
2. Have the patient close or cover their left eye.
3. Have the patient look into your left eye using their right eye.
4. Line up the zero mark of the ruler as before.
5. WITHOUT MOVING THE RULER, *have the patient open (or uncover) his or her left eye and close (or cover) his or her right eye*. Continue to have the patient look into your left eye.
6. Look across the patient's face (with your left eye) and take the measurement of where the patient's left nasal limbus is on the ruler, just like before. You have just taken the near PD. Note the reading.

You're done. To calculate the distant PD, just take the near PD measurement and add 3 mm to it.

Let's say you followed the procedures just given and came up with a near PD of 58 mm. Adding 3 mm would give you 61 mm. You would record the PD as: 61/58.

That's it. It's not perfect, but adding the three millimeters to get the distance PD is going to be good enough for these patients. They do not use both eyes at the same time, so you are trying to get as close as possible to what their PD would be if their eyes did align correctly.

Automated PD measurement with a pupillometer

If you have a pupillometer in your clinic, a PD can be determined using this automated method. These instruments allow you to quickly and accurately measure the patient's PD.

Most pupillometers are handheld and have similar design features. Some of the more common features are listed:

- Forehead rest for the patient’s forehead.
- Nose rest for the patient’s nose.
- Finder for the examiner to measure PD.
- PD lever (R) measures the PD for the right eye (OD).
- PD lever (L) measures the PD for the left eye (OS).
- Target distance set lever allows distance, intermediate, and near PD to be calculated.
- Fixation target−a target inside the instrument used by the patient.

As with the design features, the steps involved in measuring a patient’s PD are also similar. For more specific guidance, refer to the instruction manual provided by the manufacturer of your specific instrument. The following steps provide a rough guide for using any pupillometer:

1. Turn the target distance set lever to the desired setting. For distance PD measurement, this is usually optical infinity.
2. If automated, turn the instrument power on. (Most pupillometers have a light source operated by batteries.)
3. Have the patient look into the instrument, making sure to place the forehead and nose rest in a comfortable position.
4. Direct the patient’s attention to the fixation target.
5. Look into the finder to view the patient’s eyes. (If your pupillometer is equipped with a light source, you’ll see the light reflecting on the patient’s pupil.)
6. Move the PD levers (the right lever for OD and the left lever for OS) and match the marks with the appropriate landmarks on the patient’s pupils (usually the reflected light).
7. If your pupillometer has a digital display, read the values shown on the display. Otherwise, measurements are given on a sliding scale for each eye. If the total PD is not given in the display, simply add the two monocular PDs together.

One of the major advantages of measuring a patient’s PD with a pupillometer is the ability to determine a patient’s monocular PD. This is particularly useful in the civilian sector for ordering PAL bifocals.

Measuring multifocal segment heights

Whenever you are ordering a MF lens for a patient, you must include a segment height on the order. The lab needs to know how high you want the BF or TF segments placed in the lenses.

To measure a segment height, you must use the correct size frame (use the steps discussed in the previous lesson to determine the proper frame size). Make sure it is level on the patient’s face so your measurements are accurate. Also, ensure the frame has 8 to 10° of pantoscopic tilt, as this too can affect your readings. Have a PD ruler handy for the measurement. It’s best if you and the patient are seated so you’ll both be steady during your measurement. You need to be eye level with your patient to get correct readings. Finally, the patient needs to look straight ahead, without tilting his or her head back or lowering the chin. The patient should be looking right between your eyes with his or her head in a normal position.

Measuring for bifocal segment height

To measure for a bifocal height, measure from the top edge of the lower eyewire to the lower limbus of the patient (fig. 2–70). If the lower lid covers the lower limbus, measure to the top edge of the lower lid. Whatever reading you get, add 1 mm to it so you’ll account for the depth of the eyewire groove in the frame. For instance, if you get a reading of 17 mm, then add 1 mm to account for the groove. Your final bifocal height measurements are 18 mm, and this is what you order.

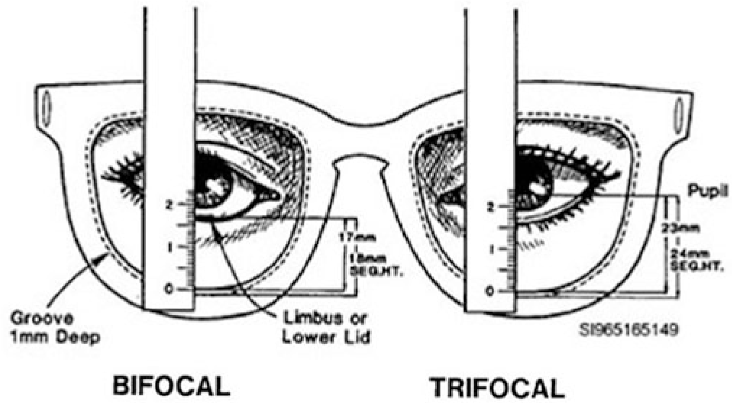


Figure 2–70. Measuring bifocal and trifocal segment heights.

To take a segment height measurement for a double D segment, you measure just as you would for a regular bifocal. You do not have to take any measurements for the upper segment but you do have to be more critical about the frame selected. The patient's eyes need to be well centered in the eyewires of the frame front to ensure the upper bifocal does not get in the patient's way.

Measuring for trifocal segment height

To measure for a trifocal segment height, measure from the top edge of the lower eyewire to the bottom edge of the patient's pupil. Again, add 1 mm to your measurement to account for the depth of the eyewire groove in the frame (fig. 2–70).

Since the trifocal height is measured from the bottom edge of the pupil, be aware pupil sizes vary with room lighting, so measure in a room with normal reading light. There should be no bright lamps shining toward the patient, no dim eyelanes; just normal lighting so the patient has normal size pupils. Another factor to consider is the pupils may be slightly constricted from focusing on a near object (you!). This can affect your measurements by 1 to 2 millimeters. Some people like to subtract a millimeter or two from their measurements to account for this accommodative constriction of the pupil. Judge for yourself if you think it's a factor worthy of consideration.

Measuring for multifocal segment height with NVGs

There are no hard fast rules for determining the segment height when it comes to NVGs. However, there are a couple of methods used to allow the pilot to see properly at all distances. Have pilots come in with their helmets and NVGs. You may need a few pairs of AFF frames of varying sizes with plano lenses or you can use the pilot's own spectacles.

After the pilot has put on the glasses, helmet, and has the NVGs in place you can use a yellow sticky or sharpie to mark where the segment heights should go. Have the patient sit in a configuration resembling his or her cockpit and look back and forth between the NVGs and a near objects placed in a similar fashion to the aircraft's layout. Once the lenses have been marked, measure the distance from the top edge of the frame to the mark you made. Do this three or four times to ensure consistency. Use this measurement for ordering the spectacles with the appropriate segment height.

Points to consider and common errors

Some things you should keep in mind when measuring multifocal segment heights:

- Cut the eye in half with the ruler, so to speak, so you know you are measuring right through the middle of the eye. This gives the most accurate reading (fig. 2–70).
- Always measure the segment height for both eyes. If they are coming out different, re-check the frame ensuring it is level and try again. If they still measure different, but the difference is 1 mm or less, just order both lenses with the same segment height, using the *smaller* of the two measurements taken. If the difference is 2 mm or more, order each lens with the actual

segment height measured. When you do this, let the lab know you are aware you have ordered unequal segment heights, by putting the comment “seg. ht’s verified” in the comments section of your order.

Finally, do *not* try to compensate for a first time wearer by putting the segment height 1 mm lower than it should be. You may have heard some people advocating this practice since they feel it helps the first time wearer adapt to the multifocals easier. Maybe so, but we would like to discourage this philosophy. The problem with ordering the glasses with the segments lower than they should be is the patient gets use to them in this lower than normal position. Then, when the patient gets his or her next multifocal Rx with the segment height at the correct position (instead of 1 mm lower), the patient has to adapt all over again.

Common errors to watch for and avoid:

- Inadvertently pushing the frame farther up the patient’s face with the ruler while taking the segment height measurement. If a patient complains the segment seems too low in his or her new glasses, you may be guilty of having done this.
- Unknowingly resting a finger on the frame when taking the segment height measurement, causing the front to tilt or sit lower than it should. If the segment heights seem too high when the patient puts the glasses on, you may have caused the problem.
- Not measuring down the middle of the eye. If your segment height measurements seem inconsistent—sometimes good, sometimes high, and sometimes low, you may be guilty.

This unit dealt primarily with understanding prescriptions, military frame options and measurements required to order eyewear. As stated earlier, frame availability can frequently change and the NOSTRA website is your best bet to get the most up-to-date frame options. The website also provides brief guidance on how to take PD and segment height measurements. With so much information available, it wouldn’t be a bad idea to add the NOSTRA website to your favorites list. Again, at the time of this writing, the address is: http://www.med.navy.mil/SITES/NOSTRA/Pages/default.aspx.

Self-Test Questions

410. Selecting frame size

1. What type of frame might benefit a patient with moderate to high cylinder correction?

2. How many bridge sizes are available on the AFF frame?

3. How do you determine which size insert to order for the M–50 gas mask or UPLC BPE?

4. How do you determine which size ALEP insert to order?

5. You have a patient try on a 5A trial frame and notice gaps between the bridge and the nose, and that the frame is resting on the nose. What is the problem?

6. While checking the eye size of a 5A frame, you notice the temples seem to be flaring out away from the head. What does this indicate?

7. A patient has a high dioptric power prescription. You're not sure whether to go with the 48- or 50-mm eye size, as they both seem to fit well. Which eye size should you choose and why?

8. Describe a proper temple fit.

9. When fitting a pair of frames with adjustable nose pads, what is the effect on the fit if you spread the adjustable nose pads further apart?

10. A patient is wearing a 50-22 frame. The segment height of their multifocal is too low. Besides going to a frame with adjustable nose pads, how could you effectively raise the segments in relation to the patient's eyes?

411. Taking measurements for ordering eyewear

1. What is the PD measurement?

2. Ideally, a person wearing prescription eyewear should be looking directly through what part of the lenses?

3. What problems might the patient experience if the lab does not line the OCs up to match the patient's PD?

4. If you ordered a 48−24 frame and the patient's PD is 60 mm, how much decentration is required in each lens and in which direction?

5. What can happen if you poorly measure a patient's PD and then order the glasses using the wrong PD measurement?

6. When taking a patient's PD, who should be sitting higher, you or the patient?

7. Theoretically, how close to the patient should you be when taking a PD?

8. When you are lining up the zero mark of your PD ruler, at which one of your eyes should the patient be looking?

9. When taking the *near* PD measurement (on an orthophoric or heterophoric patient), at which one of your eyes should the patient be looking? Which one of your eyes do you use to take the measurement?

10. When taking the *distant* PD measurement (on an orthophoric or heterophoric patient), at which one of your eyes should the patient be looking? Which one of your eyes do you use to take the measurement?

11. You found the patient’s near PD was 61 mm and his or her distant PD was 64 mm. How would you record the measurements?

12. List the most common errors made when taking a PD.

13. To take the near PD measurement on a strabismic patient (after you have gotten the zero mark lined up correctly), what does the patient need to do besides look into your left eye?

14. How do you calculate the distant PD for a strabismic patient?

15. Why is the ability to determine a patient’s monocular PD considered one of the major advantages of a pupillometer?

16. From which two points is a bifocal segment height measured?

17. How many millimeters, if any, do you add to your segment height measurement to account for the depth of the eyewire groove?

18. From which two points is a trifocal segment height measured?

19. What should the room lighting be when measuring a trifocal segment height (i.e., bright, normal, or dim)?

20. Assuming you've checked the frame is level, what should you do if the segment heights you measured for each lens differ by 1 mm or less? What if the measurements differ by 2 mm or more?

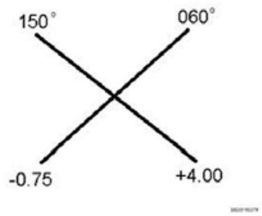
Answers to Self-Test Questions

406

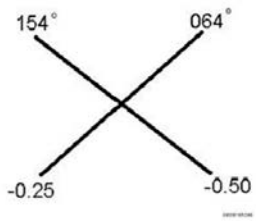
1. Meniscus.
2. (1) Spheres.
   (2) Cylinders.
   (3) Spherocylinders.
3. Spherical.
4. A point focus.
5. Zero (no power).
6. A line focus.
7. None (zero).
8. Toric or compound.
9. Two.
10. Two-line foci, 090° away from each other, and at different distances from each other.
11. Sturm's Conoid (or Interval of Sturm).
12. –1.00D sphere power, –2.00D cylinder power, with the axis meridian located at 090°.
13. One who is nearsighted or farsighted and has astigmatism.
14. Multifocals.
15. The segment portion contains more positive (+) sphere power.
16. (1) Increase the index of refraction (density) of the segment portion(s).
    (2) Increase the steepness of the lens curvature (i.e., decrease the radius of curvature).
17. (1) Chromatic.
    (2) Spherical.
    (3) Distortion.
    (4) Oblique astigmatism.
    (5) Curvature of field.
18. Plus lenses.
19. (1) Oblique astigmatism.
    (2) Curvature of field.

407

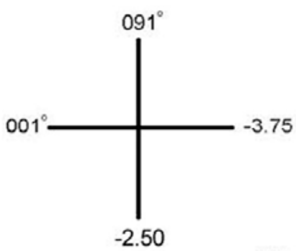
1. a. T2−1. Optical Cross.



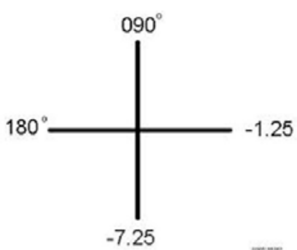
b. T2−2. Optical Cross.



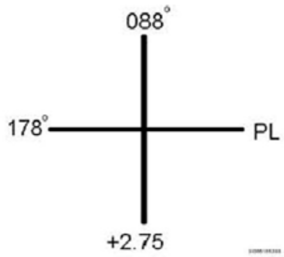
c. T2−3. Optical Cross.



d. T2−4. Optical Cross.



e. T2−5. Optical Cross.



2. a. +2.00 –1.00 × 135.
   b. +1.00 –2.00 × 176.
   c. +4.25 +1.50 × 084.
   d. +1.00 –1.00 × 098.
   e. –1.50 +0.25 × 100.
3. a. -0.25. +1.25 × 180.
   b. +4.25 –2.00 × 090.
   c. –5.00 +2.00 × 160.
   d. –1.00 –2.25 × 070.
   e. –0.50 +3.25 × 045.
   f. +4.25 –3.00 × 082.
   g. –5.25 +3.00 × 082.
   h. +1.00 –3.25 × 135.
   i. –2.75 +3.50 × 027.
   j. +1.00 –0.50 × 042.

4 a. +3.50 SPH.
   b. –4.25 SPH.
   c. +4.75 SPH.
   d. –0.50 SPH.
   e. PL SPH.
   f. –5.00 SPH.
   g. –1.50 SPH.
   h. +0.25 SPH.
   i. +3.50 SPH.
   j. +0.75 SPH.

5 a. OD: –1.25 SPH.
   OS: –0.75 SPH.
   b. OD: +3.75 SPH.
   OS: +3.25 SPH.
   c. OD: +2.00 – 1.00 × 085.
   OS: +1.75 – 0.75 × 100.
   d. OD: –3.50 –2.25 × 035.
   OS: –4.00 –2.00 × 140.
   e. OD: +2.00 SPH.
   OS: +2.00 –0.75 × 180.

f. OD: –1.25 +2.50 × 075 Transposed → OD: +1.25 –2.50 X 165.
OS: +0.25 +4.00 × 025 Transposed → OS: +4.25 –4.00 X 115.

g. OD: PL SPH.
OS: –1.00 SPH.

h. OD: +5.75 –2.00 × 180.
OS: +5.25 –1.25 × 180.

i. OD: +1.25 +1.25 × 130 Transposed →OD: +2.50 –1.25 × 040.
OS: –0.75 +1.00 × 180 Transposed → OS: +0.25 –1.00 × 090.

j. OD: +5.25 –1.50 × 135.
OS: +4.00 –1.00 × 147.

408

1. CR–39 plastic.
2. It is inexpensive and breaks less frequently during manufacture.
3. They scratch more easily.
4. Pilots who must wear NVGs and monocular patients.
5. Reduced lens thickness, greater comfort, and better appearance.
6. +/-6.00 in any meridian.
7. By feeling the top edge of the segment portion. If you feel a ledge, it's a one-piece.
8. PAL or no-line multifocals.
9. Wounded Warriors with mild to severe TBI.
10. The width of the bifocal segment is 28 mm at its widest point.
11. +0.75D.
12. "Patient requires a wide FOV at near."
13. No, it's considered an occupational bifocal, and since retirees are no longer performing mission-related tasks for the military, they cannot get this type of bifocal.
14. Two.
15. 30 inches.
16. The height of the intermediate segment (i.e., how tall it is).
17. +1.50D.
18. A dye process.
19. Gray and pink.
20. N-15 and N-31; neutral density gray tint.
21. 85 percent.
22. Pink tint (also called rose or soft-light tint).
23. Authorized aircrew members.
24. When patients perform a lot of computer work (occupational need).

409

1. Frame front and two temples.
2. Distance between lenses.
3. The distance from the geometrical center of one lens to the geometrical center of the other lens when they are mounted in a particular frame.
4. 72 mm.
5. Decentration.
6. Skull.
7. Yes; virtually any type of lens can be ordered in the 5A frame: DVO, IVO, NVO, bifocals, trifocals, gray tinted, pink tinted, UV400 coated, polycarbonate, and high-index lenses.

8. 50, 52, and 54 mm.
9. No; this frame is strictly for bifocal and trifocal Rxs.
10. Patients who only need their near vision corrected.
11. 46, 48, and 50 mm eye sizes; 20 and 22 mm bridge sizes.
12. Two clear and two tinted pairs of flight frames.
13. One clear and one tinted pair of flight frames.
14. No; military fabrication labs do not issue plano sunglasses. Current aircrew who require non-Rx sunglasses obtain them through their AFE section using their unit's funds.
15. Qualifies the person.
16. M–50.
17. No; NOSTRA supplies the insert but each individual unit supplies the BPE.
18. On the approved APEL found at http://www.peosoldier.army.mil/equipment/eyewear/.
19. The UPLC insert.
20. Greater than 30 consecutive days.
21. No, this is why they are issued flight frames.
22. Yes; Wounded Warriors are also authorized photochromatic lenses. You would need to contact your assigned military fabrication lab or NOSTRA to coordinate production.

410

1. A smaller, rounder frame.
2. One bridge size.
3. There is only one size option.
4. The member's PD measurement determines the ALEP eyewear ordered, which then corresponds to the ALEP insert ordered.
5. The bridge size selected is too wide.
6. The eye size is too narrow.
7. Go with the smaller size, in this case the 48 mm eye size; it has less chance of noticeable aberrations, weighs less, and it's easier to adjust a narrow frame than a wide frame.
8. You want the bend of the temple to be right at the top of the ear so the end of the temple curves downward following the contours of the back of the ear (within $^1/_8$ of an inch of touching the ear).
9. The glasses sit lower on the face, effectively lowering the segment placement.
10. By putting the lenses into a frame with a more narrow bridge size; in this case, a 50-20 frame size.

411

1. The distance from the center of one pupil to the center of the other pupil.
2. The optical centers.
3. Eyestrain, headaches, and double vision (diplopia) from induced prismatic effect.
4. 6 mm IN for each lens.
5. The lab's calculations and decentration will be wrong and the patient experiences unwanted prismatic effect. This leads to eyestrain, headaches, and, potentially, even diplopia.
6. Neither. You and the patient should be at eye level with each other.
7. 16 inches (40 cm).
8. Your left eye.
9. Your left eye. You'll also take the measurement with your left eye.
10. Your right eye. You'll also take the measurement with your right eye.
11. 64/61.
12. (1) Misreading the ruler.
    (2) Moving the ruler after the initial alignment of the zero mark is made.
    (3) Tilting the ruler so one side is closer to the patient's face than the other is.

(4) Not “cutting the eyes in half” properly, which leads to taking the measurement too low on the eyes.

(5) Trying to measure from the edge or center of the pupils instead of from the limbus.

13. Open (or uncover) his or her left eye and close (or cover) his or her right eye.
14. Add 3 mm to the patient’s near PD measurement.
15. Because this is particularly useful in the civilian sector for ordering PAL bifocals.
16. From the top edge of the lower eyewire to the lower limbus (or top edge of the lower lid if it is covering the lower limbus).
17. 1 mm.
18. From the top edge of the lower eyewire to the bottom edge of the patient’s pupil.
19. Normal room lighting.
20. Order each lens with the same segment height, using the smaller of the two measurements. If the difference is 2 mm or more, order each lens with the segment height measured in that eye.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the AFCDA.

39. (406) The point of a lens where light passes through without being refracted is the
    a. meridian.
    b. datum point.
    c. optical center.
    d. geometrical center.

40. (406) The most common lenses used in spectacles are
    a. spherical.
    b. biconvex.
    c. meniscus.
    d. biconcave.

41. (406) Which lens forms a point focus?
    a. Sphere.
    b. Cylinder.
    c. Compound.
    d. Spherocylinder.

42. (406) What type of focus do cylinder lenses form?
    a. Line.
    b. Point.
    c. Two lines.
    d. Two points.

43. (406) At their closest point, how far is the 172 degrees (°) meridian from the 022° meridian in a spectacle lens?
    a. 30°.
    b. 52°.
    c. 150°.
    d. 194°.

44. (406) Which lens has maximum power in one meridian and minimum power in the meridian 90 degrees (°) away?
    a. Sphere.
    b. Cylinder.
    c. Spherocylinder.
    d. Compound sphere.

45. (406) Which lens type would form a figure called Sturm's Conoid?
    a. Sphere.
    b. Cylinder.
    c. Spherocylinder.
    d. Compound plano.

46. (406) Which refractive error would a toric lens correct?
    a. Simple myopia (SM).
    b. Simple hyperopia (SH).
    c. Mixed astigmatism (MA).
    d. Simple hyperopic astigmatism (SHA).

47. (406) A lens with two or three primary foci, or focal lengths, best describes
    a. a multifocal lens.
    b. an aspherical lens.
    c. a single vision lens.
    d. an astigmatic correcting lens.

48. (406) Which type of bifocal increases the (positive) sphere power in the segment portion by increasing the index of refraction (“n”)?
    a. Single lens.
    b. One-piece.
    c. Executive.
    d. Fused.

49. (406) Which type of aberration will cause no perceived visual problem for the spectacle wearer?
    a. Spherical.
    b. Chromatic.
    c. Curvature of field.
    d. Oblique astigmatism.

50. (407) Where is the sphere power written when diagramming a prescription on an optical cross?
    a. 090 degrees (°) meridian.
    b. 180 degrees (°) meridian.
    c. On both meridians.
    d. Only on the axis meridian.

51. (407) Determine the total power in the 060 degrees (°) meridian for the prescription: –1.00 – 1.00 × 150.
    a. Plano.
    b. –1.00.
    c. –1.50.
    d. –2.00.

52. (407) Use figure T–2, take the prescription off the optical cross in plus cylinder form.
    a. –3.00 + 6.00 × 005.
    b. – 3.00 + 3.00 × 005.
    c. + 3.00 + 6.00 × 095.
    d. + 3.00 + 3.00 × 095.

53. (407) Convert the *right* lens of the following *multifocal* prescription to *near vision only* (NVO).
    OD + 1.75 – 2.00 × 123
    OS + 2.00 – 1.25 × 023
    Add + 2.50 with 50 percent (%) intermediate both eyes (OU).
    a. +2.25 – 2.00 × 123.
    b. +2.50 + 2.00 × 033.
    c. +3.25 – 2.00 × 033.
    d. +4.25 – 2.00 × 123.

54. (407) Convert the *left* lens of the following *multifocal* to *intermediate vision only* (IVO):
    OD Plano (PL) – 1.00 X 008
    OS – 0.25 – 2.50 X 010
    Add +3.00 with 50 percent (%) intermediate both eyes (OU).
    a. PL sphere (SPH).
    b. PL – 1.25 × 100.
    c. + 1.25 – 2.50 × 010.
    d. + 2.75 – 2.50 × 010.

55. (407) Convert the *right* lens of the following *multifocal* to *intermediate vision only* (IVO). Ensure your answer is in *minus cylinder form*. (**NOTE**: The patient will be using the glasses at a distance of 30 inches and farther.)
    OD – 1.00 + 2.50 × 090
    OS – 1.25 + 1.25 × 091
    Add + 2.75 with 50 percent (%) intermediate both eyes (OU).
    a. +0.50 –2.50 × 090.
    b. +1.75 –2.50 × 180.
    c. +2.75 –2.50 × 180.
    d. +3.00 –2.50 × 090.

56. (408) “Patient requires a wide field of view (FOV) at near and intermediate distances” would be the justification for which lens?
    a. Executive trifocal (TF).
    b. 8 × 35.
    c. 7 × 28.
    d. Straight top (ST)–35.

57. (408) The military standard tints for sunglasses are N–15 and
    a. N–21.
    b. N–30.
    c. N–31.
    d. N–40.

58. (408) Who is eligible to order anti-reflective coating on their lenses?
    a. Any authorized active duty member who needs them for occupational duties.
    b. Any authorized aircrew member who needs them for flight duties.
    c. Any active duty or retired member.
    d. Any active duty member.

59. (409) Which temple style has its length measured from the butt to the bend?
    a. Skull.
    b. Riding bow.
    c. Comfort cable.
    d. Straight library.

60. (409) Which lens prescription *can* be ordered in a half-eye frame?
    a. + 0.75 – 0.50 × 073.
    b. +2.00 – 1.25 × 179.
    c. – 1.25 – 1.75 × 084.
    d. – 3.50 sphere (SPH).

61. (409) Which is *not* an eye size option for the Air Force Flight (AFF) frame or the Air Force Dress (AFD) frame?
    a. 50.
    b. 52.
    c. 55.
    d. 58.

62. (409) Which gas mask insert (GMI) will be the standard for *all* branches of service?
    a. MCU–2P.
    b. A1000.
    c. M–40.
    d. M–50.

63. (409) What measurement determines the size of the aircrew laser eye protection (ALEP) insert the ophthalmic clinic orders?
    a. Eye size.
    b. Flight helmet size.
    c. Segment height (SH).
    d. Pupillary distance (PD).

64. (410) The aircrew laser eye protection (ALEP) comes in what size designations?
    a. Medium only.
    b. Small and large.
    c. Medium and large.
    d. Small, medium, and large.

65. (410) Which eye size, in the standard issue (5A) frame, fits about 75 percent of your *female* patients?
    a. 46 millimeters (mm).
    b. 48 millimeters (mm).
    c. 50 millimeters (mm).
    d. 52 millimeters (mm).

66. (410) A patient wears flight frames with bifocal lenses. If you move the adjustable nose pads closer together the
    a. bifocal segments would sit higher on the patient’s face.
    b. bifocal segments would sit lower on the patient’s face.
    c. optical centers of the lenses would be closer together.
    d. optical centers of the lenses would be farther apart.

67. (411) What is the frame pupillary distance (FPD) of a 52–26–150 millimeter (mm) frame?
    a. 26 mm.
    b. 78 mm.
    c. 176 mm.
    d. 202 mm.

68. (411) The lab has received a spectacle order requesting a 46–18–140 millimeter (mm) frame for a patient with a pupillary distance (PD) of 66 mm. How much decentration will be required for each lens, and in which direction?
    a. 1 mm IN.
    b. 1 mm OUT.
    c. 2 mm IN.
    d. 2 mm OUT.

69. (411) Essentially, the difference between taking a pupillary distance (PD) on a heterophoric patient and a heterotropic patient is a
    a. heterotropic patient needs to close (or cover) one eye to be accurately measured.
    b. heterophoric patient only has their distant PD checked. No near PD is taken.
    c. heterophoric patient will always have a PD between 60 and 69 millimeters (mm).
    d. heterotropic patient gets measured from pupil to pupil.

70. (411) To accurately measure a segment height, you place the correct frame on the patient, and then
    a. make sure the frame is level.
    b. ensure the frame has 3 to 7 degrees (°) of retroscopic tilt.
    c. slide your pupillary distance (PD) ruler just inside the frame, so it is close to the eye, but not touching it.
    d. push ever so gently down on the frame to position it like it would be if it had the weight of lenses in it.

Please read the unit menu for unit 3 and continue ➔

Unit 3. Spectacle Procedures

ORDERING SPECTACLES is a day-to-day activity and can encompass a significant portion of your job. It, therefore, is important you do it correctly the first time. Another significant portion of your day can be spent neutralizing spectacles, whether for a routine exam or prescription verification. While automated machines have simplified the task dramatically, you still need to know how to operate a manual machine for those, albeit rare, cases when it is necessary. If you go on any humanitarian missions, you may only have a manual lensmeter available. When verifying lenses, knowing the applicable standards established by the American National Standards Institute (ANSI) allows you to determine if the lab did a good job manufacturing the glasses. Finally, you have to be able to repair and adjust spectacles if you are to take care of your customers properly. You are the “expert,” and they trust you to do a good job. The information here should help you accomplish just that.

3–1. Ordering Spectacles

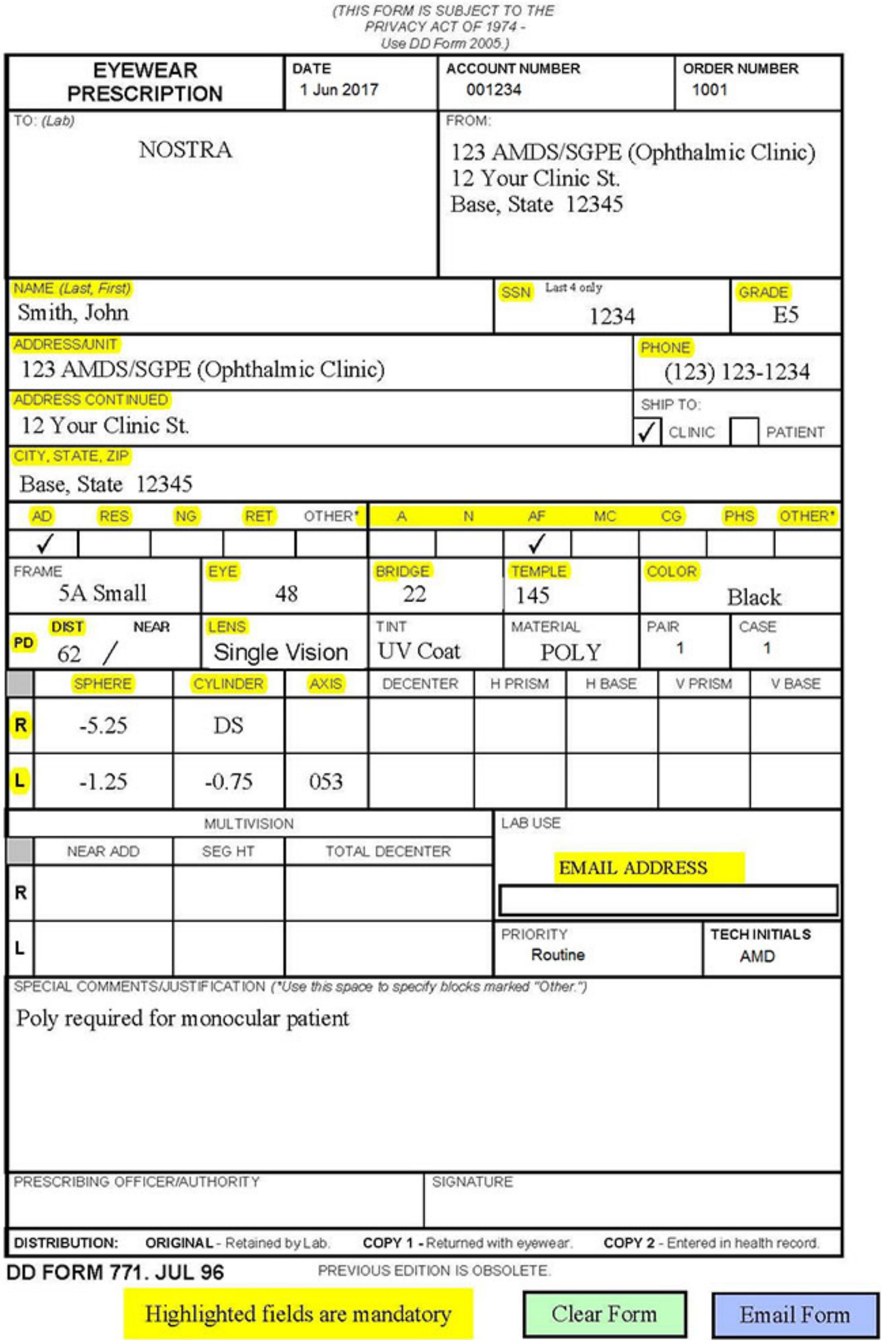
According to Air Force Instruction (AFI) 44−117, *Ophthalmic Services*, all military personnel are given an eye examination as soon as possible upon entering the military. If eyewear is required, it is ordered promptly. This ensures that members start their military career with any vision correction they need. With routine eye care and periodic health assessments, they are able maintain good eye care. This enhances the mission by improving readiness and reducing surges in fabrication prior to deployments and mobilizations. To support this effort, you need to know how to order, measure, and adjust military eyewear.

412. Ordering spectacles manually

You may be wondering why you need to know how to manually order glasses when SRTSweb exists and orders can be processed electronically. It is the same as manual lensometry mentioned above; there are certain tasks you need to know how to do in case you do not have access to the easier, automated versions. We all have experienced computer crashes and power outages. If a prolonged issue were to occur, we cannot allow it to disrupt our mission. In a deployed or war environment, we do not know what equipment or processes will be available to us. For circumstances such as these, it is important to know how to fill out DD Form 771 (fig. 3–1) and submit spectacle orders manually. It is not difficult and you should not have to do it often. Still, you need to be ready for those occasions when you do.

Using DD Form 771 to order spectacles

When completing a DD Form 771, make sure all information is complete, accurate, and legible. Check your orders carefully to ensure all necessary data is present. Take special care to ensure all prescription (Rx) information, decimal points, and power signs (+ and –) are written clearly and correctly. After reading and studying the following information, you should have no trouble completing a manual order form correctly.



(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - Use DD Form 2005.)

EYEWEAR PRESCRIPTION	DATE 1 Jun 2017	ACCOUNT NUMBER 001234	ORDER NUMBER 1001
TO: (Lab) NOSTRA		FROM: 123 AMDS/SGPE (Ophthalmic Clinic) 12 Your Clinic St. Base, State 12345	

NAME (Last, First)	SSN Last 4 only	GRADE
Smith, John	1234	E5

ADDRESS/UNIT	PHONE
123 AMDS/SGPE (Ophthalmic Clinic)	(123) 123-1234
ADDRESS CONTINUED: 12 Your Clinic St.	SHIP TO: ✓ CLINIC ☐ PATIENT
CITY, STATE, ZIP: Base, State 12345	

AD	RES	NG	RET	OTHER*	A	N	AF	MC	CG	PHS	OTHER*
✓							✓				

FRAME	EYE	BRIDGE	TEMPLE	COLOR
5A Small	48	22	145	Black

PD DIST / NEAR	LENS	TINT	MATERIAL	PAIR	CASE
62 /	Single Vision	UV Coat	POLY	1	1

	SPHERE	CYLINDER	AXIS	DECENTER	H PRISM	H BASE	V PRISM	V BASE
R	-5.25	DS						
L	-1.25	-0.75	053					

MULTIVISION	NEAR ADD	SEG HT	TOTAL DECENTER
R			
L			

LAB USE

EMAIL ADDRESS

PRIORITY: Routine

TECH INITIALS: AMD

SPECIAL COMMENTS/JUSTIFICATION (*Use this space to specify blocks marked "Other.")

Poly required for monocular patient

PRESCRIBING OFFICER/AUTHORITY

SIGNATURE

DISTRIBUTION: ORIGINAL - Retained by Lab. COPY 1 - Returned with eyewear. COPY 2 - Entered in health record.

DD FORM 771, JUL 96 PREVIOUS EDITION IS OBSOLETE.

Highlighted fields are mandatory

Clear Form

Email Form

Figure 3–1. Sample DD Form 771.

The prescription decimal points

We cannot overemphasize the importance of correctly placing the decimal points in the Rx. Errors here lead to confusion and wasted time and resources. Be sure you always place a zero before the decimal point if the Rx power is *less* than a whole diopter. In addition, write Rxs to *two places after the decimal point*. Shown here are examples of the correct and incorrect use of decimal points:

Correct	Incorrect
+ 0.50	+ .50
+ 1.50	+ 1.5

Rx power signs

It is also important the appropriate Rx power signs (+ and –) be put before the dioptric power of the Rx. If the plus or minus sign is left off, the order is rejected automatically by the fabrication lab. Even if a number is a positive power, a (+) plus sign is still required. Though all Rxs sent to the lab must be in minus cylinder form, they still require a (-) minus sign. The lab assumes nothing and to the lab, no plus or minus sign means no spectacles. Right or wrong, this is how it is. Check out the following examples for the correct and incorrect ways of writing a prescription.

Correct	Incorrect
OD + 2.00 – 2.00 × 090	OD 2.00 – 2.00 × 90
OS + 2.00 – 2.00 × 135	OS 2.00 – 2.00 × 135
OD – 1.00 – 1.00 × 140	OD – 1.00 1.00 × 140
OS – 1.25 – 1.25 × 145	OS – 1.25 1.25 × 145

Leading and trailing zeros in the axis

As for the axis of the prescription, the leading zero is essential to accuracy. The axis amount must occupy three numerical places. If it does not, something is wrong. An axis written as "10" could easily be an error in writing "100." Since the lab cannot be sure, they kick back the order. If you do it right the first time, ordering spectacles goes much smoother. If you want an axis of 10, then write "010." If you want an axis of 15, then write "015."

Transposition

If a patient brings in a prescription written in plus (+) cylinder form, or you work with an ophthalmologist who writes prescriptions in plus cylinder form, you have to transpose the Rx before you can place an order with the lab. This is why we covered transposition in detail in the previous unit. Refer to unit 2 should you need a refresher.

Completing the DD Form 771

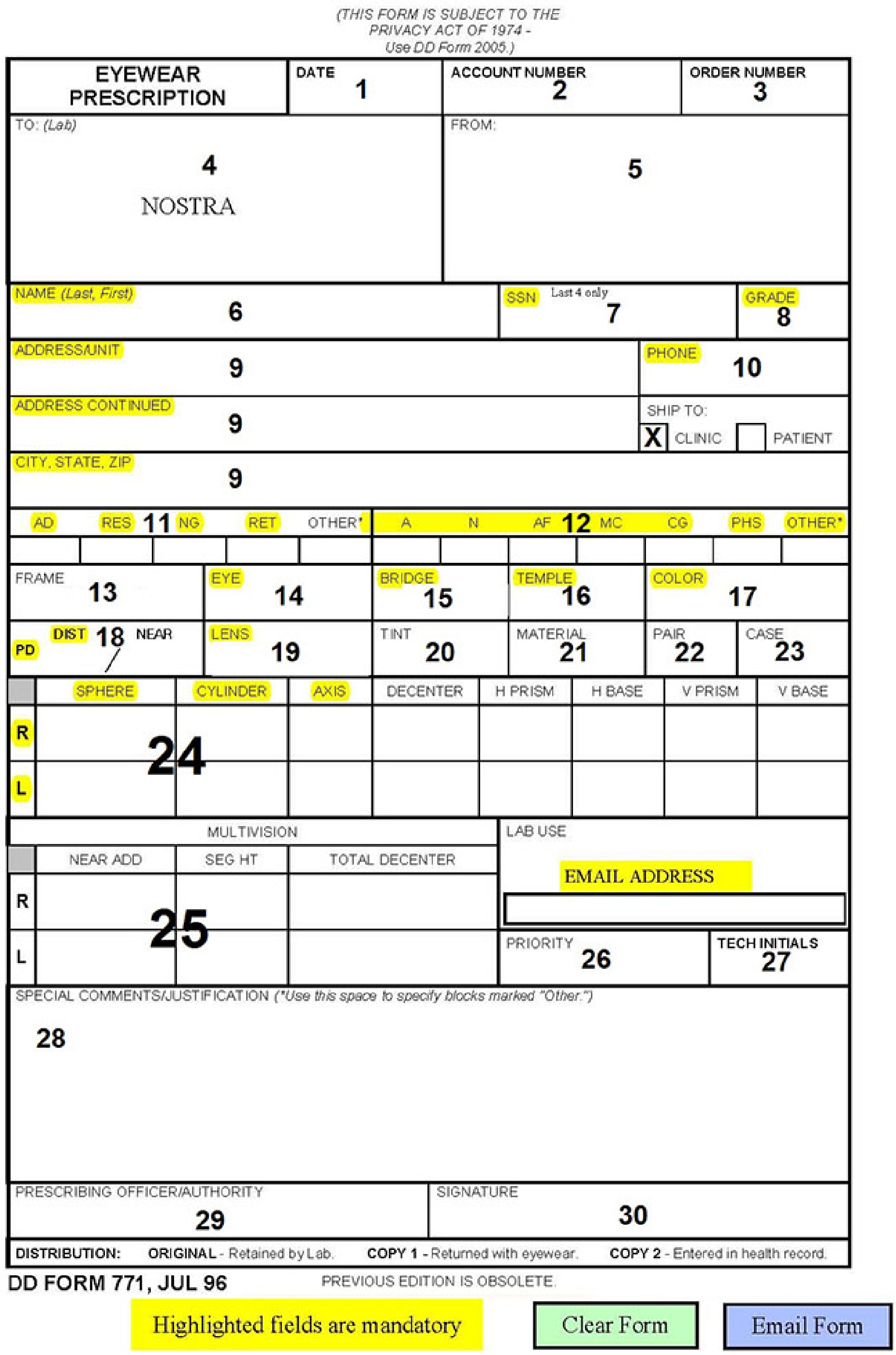
The easiest way to learn how to fill out a DD Form 771 is to go through the form, block-by-block. Look at figure 3–2. The large, bold numbers correspond with the point-by-point explanation below.

1. *DATE*: Enter date in the following sequence: day, month, and year (i.e., 30 Jun 17).
2. *ACCOUNT NUMBER*: The account number is required for clinics. Account numbers allow for tracking of orders.
3. *ORDER NUMBER*: The order number is a number assigned serially (to the Rx) within the fiscal year, a hyphen, and the last two digits of the fiscal year. Fiscal years for the military begin on 1 October of each year; thus, the first order you write on 01 October 2017 is 1–17. The second order follows numbered as 2–17, and so forth. The numbering starts over 1 October.
4. *TO (OPTICAL LABORATORY, INCLUDING ZIP CODE)*: Your clinic is assigned to use a specific military fabrication lab, depending on your location. If unsure of your designated lab, contact NOSTRA to find out which lab services your area (base). That lab's address is entered in this block. Some Air Force bases must use two different optical laboratories, one for single vision prescriptions and another for multifocals. If you mail forms to different laboratories, be sure to use the correct address for the type of Rx ordered.
5. *FROM*: Enter the address of your ophthalmic clinic here. This tells the laboratory where to mail the finished spectacles.
6. *NAME:* Patient's information.
7. *SSN:* Patient's information.

8. *GRADE:* Patient’s information.
9. *ADDRESS/UNIT*: Enter the patient’s organization or address here. If your clinic mails out spectacles, the cheapest mailing option is to use base distribution system to get eyewear to your active duty patients. For those members, enter the patient’s unit information here (usually the squadron/office symbol). If there is a need to mail spectacles to an active duty member’s home or if the patient is retired, enter the home address here.
10. *PHONE*: Patient’s information.
11. *STATUS:* Select only one to indicate whether the patient is active duty, Reserve, National Guard, retired, or other.
12. *BRANCH:* Select appropriate branch to indicate whether the patient is Army, Navy, Air Force, Marine Corps, Coast Guard, Public Health Service, or other.
13. *FRAME:* Enter frame style desired.
14. *EYE*: Enter the eye size required.
15. *BRIDGE*: Enter the bridge size required.
16. *TEMPLE*: If applicable, enter the temple length and the style desired. If the eyewear does not have a temple, enter “None.”
17. *COLOR:* If applicable, enter the frame color desired.
18. *PD (DIST/NEAR)*: Enter patient’s PD here. If the Rx is for a multifocal (i.e., bifocal or trifocal), be sure you enter *both* the distance and near PD. If the Rx is for single vision lenses (i.e., DVO or NVO) you may enter only the applicable PD under the designated header (write the distance PD under the *DIST* header and the near PD under the *NEAR* header).
19. *LENS:* Enter the style lens required/desired.
20. *TINT:* Enter the type of tint material required/desired.
21. *MATERIAL:* Enter the lens material required.
22. *PAIR:* Enter the number of pairs desired. This is typically, “1,” unless you are ordering flight frames for a member on active flight status, in which case it could be, “2.” Even then, however, it is best to order each pair individually so each receives its own order number and processes as a separate order.
23. *CASE*: Number of cases. It typically supports and matches the number of pairs you entered in the previous block.
24. *RX INFO (SINGLE VISION)*: For single vision lenses (i.e., DVO, IVO, or NVO), put the Rx in this section of the DD Form 771. If ordering a multifocal, the distant portion of the prescription goes in this section and the “Add” portion goes in the section below. When prism is required, be sure to specify the amount in the “*Prism*” box and base direction (UP, DN, IN, or OUT) in the “*Base*” box.
25. *RX INFO (MULTIVISION)*: For a multifocal Rx, put the near “Add” power and segment height measurement in this section. If the multifocal is a trifocal, write the word “Total” after the segment height measurement. Do not put anything in the decentration section. The optical fabrication lab calculates the decentration for you.
26. *PRIORITY:* P (Down Pilot), R (Readiness), VIP (07 and above), T (Trainee), S (Standard issue), F (FOC).
27. *TECH INITIALS*: The tech ordering the glasses puts his or her initials in this block.
28. *SPECIAL COMMENTS/JUSTIFICATION*: You use this block for any additional information required to clarify the prescription and/or for justifications. For instance, if one SPH is plus and the other is minus, be sure to make a comment, such as “opposite signs verified.” If any special justification is needed for the Rx, enter is here. For example, if you ordered high-

index material because the Rx is -6.50 SPH, (justified for powers greater than or equal to +/- 6.00 in any meridian), write,"High-index requested due to high myopia."

29. *PRESCRIBING OFFICER/AUTHORITY:* Doctor's name.
30. *SIGNATURE:* The prescribing optometrist or ophthalmologist must sign this block.


(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - Use DD Form 2005.)

EYEWEAR PRESCRIPTION | DATE 1 | ACCOUNT NUMBER 2 | ORDER NUMBER 3

TO: (Lab) 4 NOSTRA | FROM: 5

NAME (Last, First) 6 | SSN Last 4 only 7 | GRADE 8

ADDRESS/UNIT 9 | PHONE 10

ADDRESS CONTINUED 9 | SHIP TO: X CLINIC PATIENT

CITY, STATE, ZIP 9

AD RES 11 NG RET OTHER* | A N AF 12 MC CG PHS OTHER*

FRAME 13 | EYE 14 | BRIDGE 15 | TEMPLE 16 | COLOR 17

PD DIST 18 NEAR / | LENS 19 | TINT 20 | MATERIAL 21 | PAIR 22 | CASE 23

	SPHERE	CYLINDER	AXIS	DECENTER	H PRISM	H BASE	V PRISM	V BASE
R	24							
L								

MULTIVISION

	NEAR ADD	SEG HT	TOTAL DECENTER
R	25		
L			

LAB USE
EMAIL ADDRESS
PRIORITY 26 | TECH INITIALS 27

SPECIAL COMMENTS/JUSTIFICATION (*Use this space to specify blocks marked "Other.")
28

PRESCRIBING OFFICER/AUTHORITY 29 | SIGNATURE 30

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Highlighted fields are mandatory | Clear Form | Email Form

Figure 3–2. DD Form 771 with blocks numbered.

Justifications needed for special purpose lenses, tints, coatings, and frames

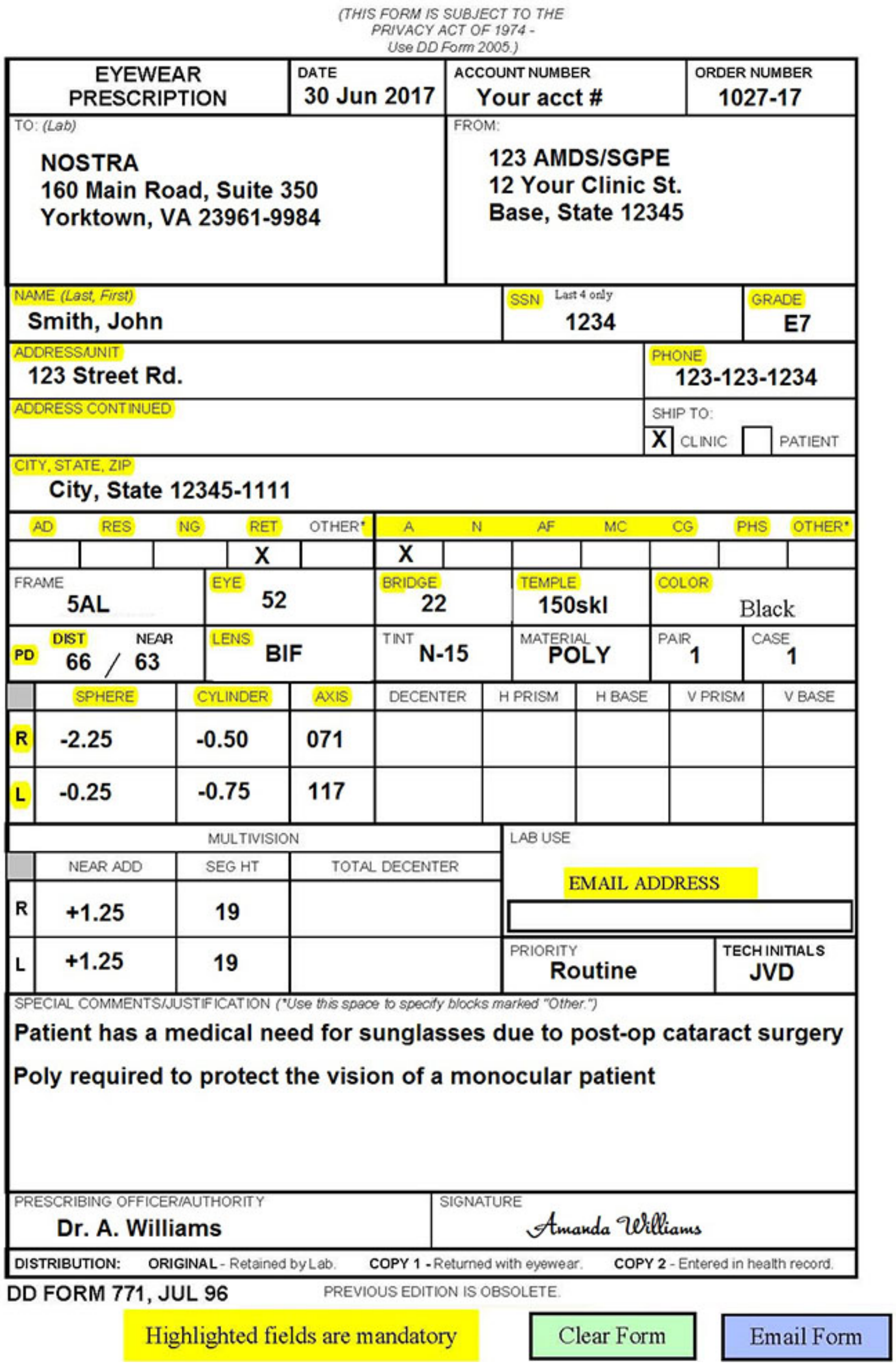
As previously discussed, some lenses, tints, coatings, and frames are only available with proper justification in the *SPECIAL COMMENTS/JUSTIFICATION* block of the DD Form 771 (fig. 3–2). If you request a special purpose tint, lens, or frame without the proper justification, it is likely the lab will kick back your order.

To prevent that, we discuss the more common special purpose items you may order, along with suggested justifications. Please note your justifications do not have to be *exactly* like the ones shown, as each case must be justified individually based on circumstances. However, these are the most frequently used justifications.

Frequently Used Justifications			
Special Purpose Lenses	**Special Purpose Tints**	**Special Purpose Coatings**	**Special Purpose Frames**
Polycarbonate Lenses	*Pink Tint (also called Rose or Soft Light Tint)*	*Antireflective Coating*	*AFF Frame*
"Patient (PT) is an active duty flyer who wears NVGs for flying." OR "Polycarbonate required to protect the functional eye of a monocular patient."	"PT works continuously on computers." OR "PT sensitive to fluorescent lighting."	"PT requires antireflective coating for performance of flight duties."	"Flight status verified." OR "Eligibility verified."
ST–35 (D–35) Bifocal	*N-15 Sunglasses*	*UV 400 Coating*	*FGG Flight Frame*
"PT requires a wide FOV (field of view) at near."	For retirees, "PT has a medical need for sunglasses due to post-op cataract surgery." No justification needed for active duty at this time.	"PT works continuously on computers." OR "PT has a medical need for UV coating due to (list the condition here)."	"PT is active duty Navy aviator (or flight line/flight deck personnel). OR "Eligibility verified."
Double D Bifocal			*FOC with Tint*
"PT's occupational need for double D bifocals has been verified."			"PT is a Wounded Warrior with a diagnosed TBI." OR "PT is a VIP." (O-7 and above)
8 × 35 Trifocal			
"PT requires a wide FOV at near and intermediate distances."			

Examples of completed DD Form 771

Figures 3–3 and 3–4 are examples of what a completed DD Form 771 might look like. So many combinations of frames, lenses, and prescriptions exist, listing them all would be impossible. With time and experience, filling out an order form correctly becomes easy. Remember, if you are in doubt about how to properly complete an order form, just contact the NOSTRA or your assigned fabrication lab. A simple phone call could save weeks of delay.



(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - Use DD Form 2005.)

EYEWEAR PRESCRIPTION	DATE 30 Jun 2017	ACCOUNT NUMBER Your acct #	ORDER NUMBER 1027-17

TO: (Lab)
NOSTRA
160 Main Road, Suite 350
Yorktown, VA 23961-9984

FROM:
123 AMDS/SGPE
12 Your Clinic St.
Base, State 12345

NAME (Last, First): Smith, John | SSN Last 4 only: 1234 | GRADE: E7

ADDRESS/UNIT: 123 Street Rd. | PHONE: 123-123-1234

ADDRESS CONTINUED | SHIP TO: X CLINIC ☐ PATIENT

CITY, STATE, ZIP: City, State 12345-1111

AD	RES	NG	RET	OTHER*	A	N	AF	MC	CG	PHS	OTHER*
			X		X						

FRAME	EYE	BRIDGE	TEMPLE	COLOR
5AL	52	22	150skl	Black

PD DIST / NEAR	LENS	TINT	MATERIAL	PAIR	CASE
66 / 63	BIF	N-15	POLY	1	1

	SPHERE	CYLINDER	AXIS	DECENTER	H PRISM	H BASE	V PRISM	V BASE
R	-2.25	-0.50	071					
L	-0.25	-0.75	117					

MULTIVISION

	NEAR ADD	SEG HT	TOTAL DECENTER
R	+1.25	19	
L	+1.25	19	

LAB USE
EMAIL ADDRESS

PRIORITY: Routine | TECH INITIALS: JVD

SPECIAL COMMENTS/JUSTIFICATION (*Use this space to specify blocks marked "Other.")
Patient has a medical need for sunglasses due to post-op cataract surgery
Poly required to protect the vision of a monocular patient

PRESCRIBING OFFICER/AUTHORITY: Dr. A. Williams | SIGNATURE: Amanda Williams

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Highlighted fields are mandatory | Clear Form | Email Form

Figure 3–3. Example of a completed DD Form 771.

(THIS FORM IS SUBJECT TO THE PRIVACY ACT OF 1974 - Use DD Form 2005.)

EYEWEAR PRESCRIPTION	DATE 30 Jun 2017	ACCOUNT NUMBER Your acct #	ORDER NUMBER 1028-17
TO: (Lab) NOSTRA 160 Main Road, Suite 350 Yorktown, VA 23961-9984		FROM: 123 AMDS/SGPE 12 Your Clinic St. Base, State 12345	
NAME (Last, First) Greenfield, Samantha		SSN Last 4 only 4321	GRADE O3
ADDRESS/UNIT 123 Street Rd.			PHONE 321-321-4321
ADDRESS CONTINUED			SHIP TO: X CLINIC ☐ PATIENT
CITY, STATE, ZIP City, State 12345-1111			

AD	RES	NG	RET	OTHER*	A	N	AF	MC	CG	PHS	OTHER*
X							X				

FRAME	EYE	BRIDGE	TEMPLE	COLOR	
5AS	48	20	140skl	Black	
PD DIST / NEAR	LENS	TINT	MATERIAL	PAIR	CASE
59 / 56	ST-35	CL	Plas	1	1

	SPHERE	CYLINDER	AXIS	DECENTER	H PRISM	H BASE	V PRISM	V BASE
R	-1.00	-0.75	180				1.0	BU
L	+1.00	-0.50	090					

MULTIVISION			
	NEAR ADD	SEG HT	TOTAL DECENTER
R	+2.00	17	
L	+2.00	17	

LAB USE

EMAIL ADDRESS

PRIORITY: Routine

TECH INITIALS: JVD

SPECIAL COMMENTS/JUSTIFICATION (*Use this space to specify blocks marked "Other.")

Patient requires wide FOV

Note prism OD 1.0 BU

Unlike signs verified

PRESCRIBING OFFICER/AUTHORITY: Dr. A. Williams

SIGNATURE: Amanda Williams

DISTRIBUTION: ORIGINAL - Retained by Lab. COPY 1 - Returned with eyewear. COPY 2 - Entered in health record.

DD FORM 771, JUL 96 PREVIOUS EDITION IS OBSOLETE.

Highlighted fields are mandatory | Clear Form | Email Form

Figure 3–4. Example of a completed DD Form 771.

The spectacle order logbook

Most ophthalmic clinics process several hundred prescriptions weekly. It is very important to have a system to track all those spectacle orders and their production status. When you use SRTSweb, the program keeps this record for you automatically. Unfortunately, when you have to order spectacles manually with the DD Form 771, you must also manually maintain a system to track all those orders.

The spectacle order logbook is a consolidated record of the orders sent from your clinic to the fabrication lab. Written in a ledger, the logbook is a supplement to the suspense file of active DD Forms 771 you will maintain. The format of the logbook may vary from base to base. The following is an example of how a logbook might look.

Order number	Date ordered	Patient's rank & and name	SSAN	SQDN and duty phone	Type of specs ordered	Date rec'd	Date P/U
1							
2							
3							
4							

Mailing the DD Form 771

Once you have filled out the DD Form 771 and annotated the orders in the spectacle order logbook, you are ready to send the orders off to the optical fabrication lab. At the end of each day, mail the first two copies (copies #1 and #2) of all DD Forms 771 to the lab, and keep the third copy (copy #3) in the suspense file at your clinic until the spectacles arrive from the lab. This helps you track your orders.

Receiving spectacles from the lab

When you get the spectacles from the lab, copy #2 of DD Form 771 is wrapped around the spectacles. Use this copy to help you find and pull copy #3 of the DD Form 771 from your suspense file. Lab personnel keep copy #1 of the DD Form 771 for their files.

Annotate the spectacle order logbook with the date the spectacles arrived, and then verify the spectacles against what you ordered. AFI 44−17 indicates that, on average, 10 percent of received orders should be checked each month by the receiving clinic to ensure spectacles are not defective and meet ANSI Z80.1 and Z80.5 standards. To do this, you would pick out spectacles at random and verify them against the DD Form 771 used to order them.

If the spectacles are within ANSI standards, wrap the two copies (#2 and #3) of the DD Form 771 around the spectacles and notify the patient to pick them up.

If the spectacles are *not* within ANSI standards, send them back to the lab with copy #2 of the DD Form 771 and a brief explanation of the error. Keep copy #3 in the suspense file. Make a note on copy #3 and in your spectacle order logbook as to what you have done with the spectacles. As a courtesy to patients, you need to contact them and inform them of the delay. This is an important part of customer service. If you keep your patients informed, they are more likely to be understanding and less likely to be angered by the delay.

Notification of spectacles arrival

Assuming the spectacles checked out, or the spectacles you sent back to the lab have finally come back and are correct, you now need to get the glasses to the patient. There are a few basic methods of contacting the patient: by telephone, email, or a mailed post card including instructions on returning for adjustments.

The most *ineffective* method of contact is phoning the patient. This is not only time-consuming but also very frustrating. People give you wrong numbers or change their number between when they order the spectacles to the time they arrive. Busy numbers, no answers, and full or inactivated voicemail boxes all cause delays. In addition, some people never respond even if you do manage to leave a message. Using the telephone as your *primary* means of patient notification can be very inefficient. There are better ways.

With today’s email capability, electronic notification can be your best method of notification. Almost everyone uses email to some extent. Sending email costs nothing, the patient is notified immediately, and by using the return receipt, you know the patient received the message. If patients use their *out of office reply*, you also know when they should be back from leave, TDY, or deployment and know when you can follow-up.

Mailing the spectacles is another option. For patients on base, mail the glasses using the base distribution system and for patients off base, the US Postal Service (USPS). It saves on storage space and keeps the patient traffic to a minimum. Along with the glasses, you can include a note with your clinic hours and the best time to come by for frame adjustments. If you take a quick look at the glasses before mailing them and perform any obvious adjustments at that time, you may eliminate the need for the patient to return at all, as many are happy with the fit once they receive them.

If you do not get a response within three to four weeks after notifying your patient the spectacles have arrived, attempt a second notification. If the patient still does not respond within another three or four weeks, you can disassemble the spectacles for spare parts, or send them back to the fabrication lab for their reuse.

Dispensing spectacles

When the patient comes in to pick up the spectacles, place copy #2 of the DD Form 771 in the patient’s medical record and give the patient copy #3 of DD Form 771.

Tracers

Sometimes, the original DD Form 771 gets lost in the mail or at the fabrication lab. When this happens, you must send a “tracer” order. Do not send a tracer until *at least* 45 days have passed since the original order. Sometimes, a backlog at the lab extends the time you have to wait before sending a tracer but 45 days is usually a reasonable amount of time for an order.

To send a tracer, use the original copy #3 of DD Form 771 from your suspense file to fill out another form just like it, to include the original order number. Write the word “TRACER” with red ink in the remarks section and up by the “Order Number” box. Staple copy #3 of the new tracer order to the original copy #3 and place both in your DD Form 771 suspense file and then annotate in the prescription order logbook the date the tracer was sent.

Because there is a delay in receiving the order, be sure to notify the patient of the situation and what you are doing to fix it. Again, if you keep your patients informed, they are more likely to be understanding and less likely to be angered by the delay.

413. Ordering spectacles using SRTSweb

SRTSweb allows ophthalmic clinics to collect prescription information and electronically transmit the prescriptions to their supporting fabrication lab. In addition, SRTSweb allows the clinic to track and reorder prescriptions, generate specific reports, and eliminate the need for handwritten logbooks.

Accessing SRTSweb

SRTS transitioned from a program-based software to a web-based application. As a web-based application, there is no need for each clinic location to install, maintain, or update software. There is little or no impact to ordering facilities during server upgrades, maintenance, or back-ups. All the clinics have to do is access the application.

You can reach the SRTSweb URL at the following address: https://srtsweb.amedd.army.mil/. You will need to read and accept the user agreement to proceed. If you do not have an account, press the “Request New Site/Facility” (fig. 3–5) link and the Facility Account Request Form will appear. Complete the registration form and click the **Submit** button. An email notification will be sent to the requester’s email provided once NOSTRA creates the account.

If you do have an account but have not been granted system access, press the “Request System Access” link. After you complete and submit the information at that link, you will receive a phone call or email requesting you submit a DD Form 2875, *System Authorization Access Request (SAAR)*, (fig. 3–6 and 3–7) to confirm you are authorized to access the system. You need to ensure Parts I, II, and III are complete, with the exception of blocks 16a and 21−21b (Information Owner).

Figure 3–5. SRTSweb login screen.

Once you have an account and are granted access, your clinic administrator will provide you with a login. Your password will be emailed to you from SRTSweb. With these two items, you can now login to the site, or if your clinic admin added you with your DOD, you can login with your common access card (CAC).

SYSTEM AUTHORIZATION ACCESS REQUEST (SAAR)

PRIVACY ACT STATEMENT

AUTHORITY: Executive Order 10450, 9397; and Public Law 99-474, the Computer Fraud and Abuse Act.

PRINCIPAL PURPOSE: To record names, signatures, and other identifiers for the purpose of validating the trustworthiness of individuals requesting access to Department of Defense (DoD) systems and information. NOTE: Records may be maintained in both electronic and/or paper form.

ROUTINE USES: None.

DISCLOSURE: Disclosure of this information is voluntary; however, failure to provide the requested information may impede, delay or prevent further processing of this request.

TYPE OF REQUEST ☒ INITIAL ☐ MODIFICATION ☐ DEACTIVATE ☐ USER ID 10 Digits CAC # / EDI	DATE *(YYYYMMDD)* 20170630
SYSTEM NAME *(Platform or Applications)* SRTSWeb	LOCATION *(Physical Location of System)* Bldg 123, Suite 12, Room 1 FSH TX

PART I *(To be completed by Requestor)*

1. NAME *(Last, First, Middle Initial)* Smith, John J.	2. ORGANIZATION 123 AMDS	
3. OFFICE SYMBOL/DEPARTMENT NA	4. PHONE *(DSN or Commercial)* DSN 420-1234	
5. OFFICIAL E-MAIL ADDRESS Provide Email address if available(if not leave blank)	6. JOB TITLE AND GRADE/RANK Ophthalmic Technician/SSgt	
7. OFFICIAL MAILING ADDRESS 123 AMDS/SGPE (Optometry Clinic) 123 Street Rd. Your Base, State 12345	8. CITIZENSHIP ☒ US ☐ FN ☐ OTHER	9. DESIGNATION OF PERSON ☒ MILITARY ☐ CIVILIAN ☐ CONTRACTOR

10. IA TRAINING AND AWARENESS CERTIFICATION REQUIREMENTS *(Complete as required for user or functional level access.)*
☒ I have completed Annual Information Awareness Training. DATE *(YYYYMMDD)* 20170117

11. USER SIGNATURE John J. Smith	12. DATE *(YYYYMMDD)* 20170630

PART II - ENDORSEMENT OF ACCESS BY INFORMATION OWNER, USER SUPERVISOR OR GOVERNMENT SPONSOR *(If individual is a contractor - provide company name, contract number, and date of contract expiration in Block 16.)*

13. JUSTIFICATION FOR ACCESS

Justification: Request for access to SRTSWeb to order eyewear for my medical facility.

User instruction: Fill out PART I
PART I - USER ID - Provide 10 digit number from CAC.
PART I - Item 8 & 9 Required. (Item 9, if contractor, provide Company Name in line #27- Optional Information)

Supervisor instruction: Fill out PART II

IASO Instruction: Fill out block 22 thru 25.

14. TYPE OF ACCESS REQUIRED:
☒ AUTHORIZED ☐ PRIVILEGED

15. USER REQUIRES ACCESS TO: ☒ UNCLASSIFIED ☐ CLASSIFIED *(Specify category)*
☐ OTHER

16. VERIFICATION OF NEED TO KNOW I certify that this user requires access as requested. ☒	16a. ACCESS EXPIRATION DATE *(Contractors must specify Company Name, Contract Number, Expiration Date. Use Block 27 if needed.)*

17. SUPERVISOR'S NAME *(Print Name)* Amanda L. Williams	18. SUPERVISOR'S SIGNATURE	19. DATE *(YYYYMMDD)* 20170630
20. SUPERVISOR'S ORGANIZATION/DEPARTMENT 123 AMDS/SGPE	20a. SUPERVISOR'S E-MAIL ADDRESS amanda.williams@us.af.mil	20b. PHONE NUMBER DSN 420-1234
21. SIGNATURE OF INFORMATION OWNER/OPR	21a. PHONE NUMBER	21b. DATE *(YYYYMMDD)*

22. SIGNATURE OF IAO OR APPOINTEE	23. ORGANIZATION/DEPARTMENT 123 MDSS	24. PHONE NUMBER 420-3412	25. DATE *(YYYYMMDD)* 20170630

DD FORM 2875, AUG 2009 PREVIOUS EDITION IS OBSOLETE. Adobe Designer 9.0

Figure 3–6. Example of a completed DD Form 2875 (front).

26. NAME *(Last, First, Middle Initial)*
Smith, John J.

27. OPTIONAL INFORMATION *(Additional information)*
If contractor, enter company information here.

PART III - SECURITY MANAGER VALIDATES THE BACKGROUND INVESTIGATION OR CLEARANCE INFORMATION

28. TYPE OF INVESTIGATION Secret		28a. DATE OF INVESTIGATION *(YYYYMMDD)* 20160101	
28b. CLEARANCE LEVEL Secret		28c. IT LEVEL DESIGNATION ☒ LEVEL I ☐ LEVEL II ☐ LEVEL III	
29. VERIFIED BY *(Print name)* MSgt Michelle Mendez	30. SECURITY MANAGER TELEPHONE NUMBER 420-4312	31. SECURITY MANAGER SIGNATURE	32. DATE *(YYYYMMDD)* 20170617

PART IV - COMPLETION BY AUTHORIZED STAFF PREPARING ACCOUNT INFORMATION

TITLE:	SYSTEM	ACCOUNT CODE
	DOMAIN	
	SERVER	
	APPLICATION	
	DIRECTORIES	
	FILES	
	DATASETS	
DATE PROCESSED *(YYYYMMDD)*	PROCESSED BY *(Print name and sign)*	DATE *(YYYYMMDD)*
DATE REVALIDATED *(YYYYMMDD)*	REVALIDATED BY *(Print name and sign)*	DATE *(YYYYMMDD)*

DD FORM 2875 (BACK), AUG 2009

Figure 3–7. Example of a completed DD Form 2875 (back).

Once logged in, if you have Clinic Tech privileges, the screen you see contains a title bar and a menu of tabs (fig. 3–8). Directly below the tabs, the My SRTSweb Dashboard is displayed. The Dashboard can also be accessed by selecting the My SRTSweb tab from anywhere in the application.

Add patient

Under the SRTSweb tab is the option for **Patient Add**. Here you can enter new patient information.

You first need to select an ID type (fig. 3–8):

- Social security number (SSN) – 9 digits.
- DOD ID number – 10 digits.
- DOD benefits number – 11 digits.
- Provider ID number – 11 digits.

NOTE: Until all of Legacy patients are migrated over, use SSN when adding patients.

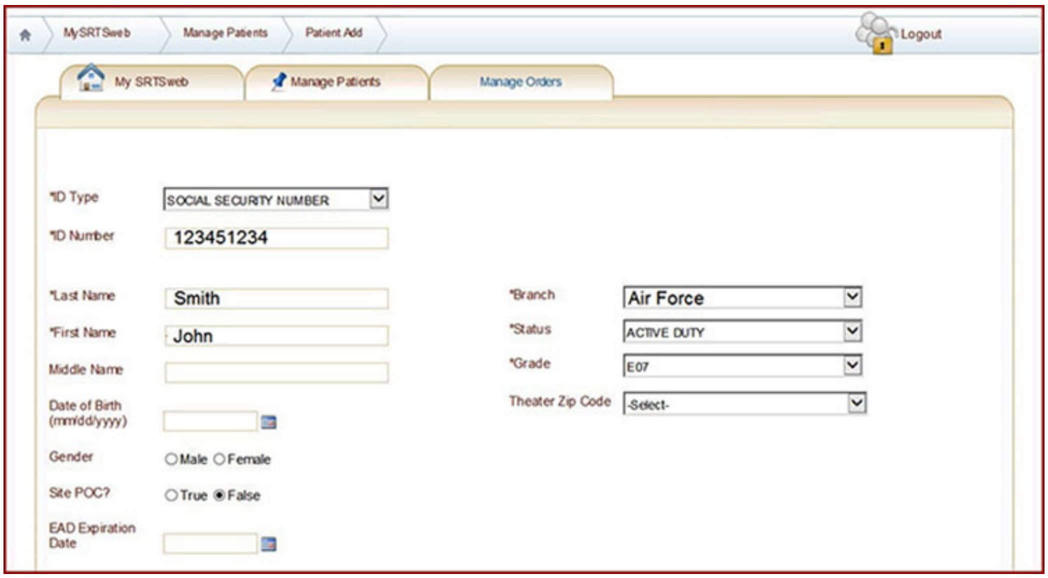


Figure 3–8. SRTSweb patient add ID type and number.

Next, enter the ID number appropriate for the ID type you selected (see note above). When you add a new patient, the Defense Management Data Center (DMDC) will load the patient's information from its database (fig 3–9).

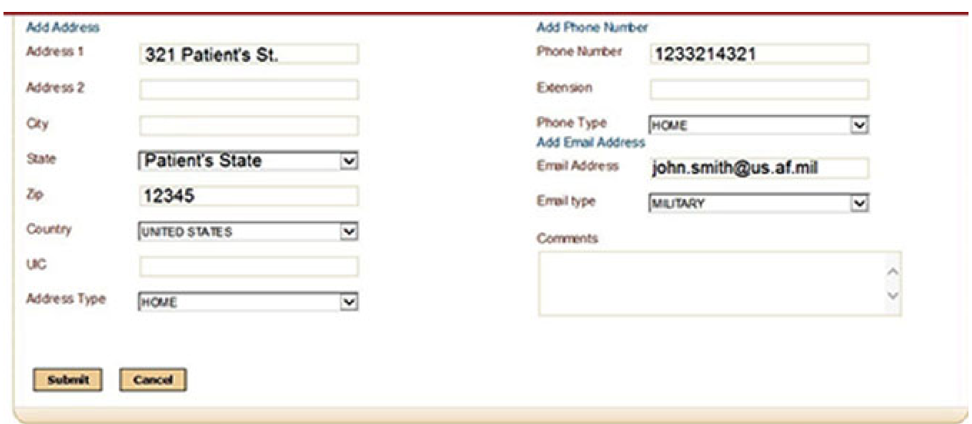


Figure 3–9. SRTSweb patient add patient information.

If the ID Type is a duplicate, the patient will be displayed. You will need to click on the **View** button to open the record. The View button shows that the ID number belongs to a patient who has already been added to SRTSweb. If the ID Type is a duplicate but the patient has an individual record but not a patient record, an Add button will be your option. You will need to click the **Add** button to open the record. At this point you can either update the record or start ordering. If you need to edit the record, you can update these fields:

- Facility (required).
- ID type (required).
- ID number (required).
- First name (optional).
- Last name (required).
- Date of birth (optional).
- Gender (optional).
- Extended active duty (EAD) expiration date (optional).
- Branch of service (required).
- Status (required).
- Rank (required).
- Theater zip code.

The bottom of the screen displays the patient's ID number, phone number, and email address, all of which you can edit for accuracy.

Search database for patient

If a patient is already in the SRTSweb database, you can use the **Manage Patients Search** screen (fig. 3–10) to find patient records already stored. You can search by last name, first name, patient's identification number, or social security number. SRTSweb maintains a patient's information for four years, after which the record is archived.

Figure 3–10. SRTSweb patient search screen.

There is also a **Quick Search** feature (fig. 3–11) that allows you to search for orders and patients, as well as add patients from anywhere within SRTSweb. The "Quick Search" function is anchored to the top of the page. The field only takes numeric values, so you can search for an order number (including the dash), a SSN, or a DOD ID number and click **Go**.

If you are using the **Manage Patients Search** screen to find a patient, a minimum of two characters must be entered to do a last name search. Once you enter your search criteria, you can then select to **Search Local** or **Search Global.** A list of patient records matching your search criteria is then displayed. From here, if find your particular patient, you can select the **Orders** button to the left of the patient record.

Figure 3–11. SRTSweb quick search feature.

If updates are needed to the patient's record before you place an order, click the **Edit** button, which is displayed on the upper right hand corner of the screen. The screen that comes up is very similar to the patient add screen discussed previously. You will be able to edit the following fields:

- Site to which the individual is assigned.
- Last name.
- First name.
- Middle name.
- Date of birth.
- Gender.
- Branch of service.
- Status.
- Grade.
- Theater zip code (for personnel in combat zones).
- EAD date.
- Any comments that are specific to the individual.

Also similar to the patient add screen, on the bottom of the screen you will see the patient's ID number, phone number, and email address, all of which you can edit for accuracy.

Order Management

Once you have added or searched and found your patient, to place an order click on **Order Management** on the **Patient Details** page (fig. 3–12).

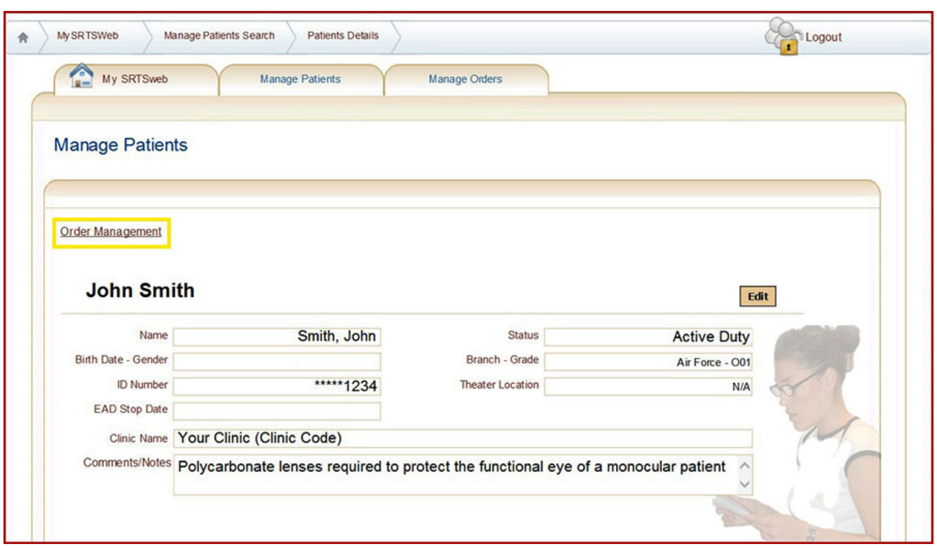


Figure 3–12. SRTSweb order management screen.

Here you will have the option to convert Reserve or National Guard members to active duty (fig. 3–13). If the member will be on active duty status for greater than 30 consecutive days, this conversion is necessary to entitle the member to a pair of FOC glasses.

Figure 3–13. SRTSweb Reserve/National Guard to active duty screen.

The Order Management tab has two options pertaining to patient exams and prescriptions: **Exams** and **Prescriptions**. The Exam and Prescription area has expandable or collapsible arrows that you can click to see or hide infor8mation.

Exams

To add a new exam record, click on the arrow to expand **Exams** and click on **Add Exam** (fig. 3–14). You can then tab and use the up/down arrow key after selecting the exam date. On the **Add Exam** screen you are able to add information for the following fields:

- Exam date.
- Right (OD) corrected.
- Right (OD) uncorrected.
- Left (OS) corrected.
- Left (OS) uncorrected.
- Both right and left for corrected.
- Both right and left for uncorrected. Comments.
- Provider's name.

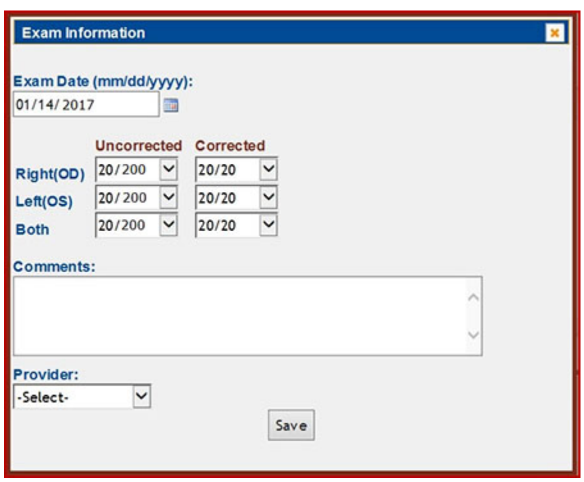


Figure 3–14. SRTSweb exam information screen.

If you need to edit a particular exam, click on the exam record to be updated. This gives you the ability to update the same fields as listed above.

Prescriptions

To add a prescription, click on the arrow to expand **Prescriptions** and click on **Add Prescription**. The Prescription Information screen will be displayed (fig. 3–15).

Figure 3–15. SRTSweb prescription information screen.

The **Prescription Information** screen automatically defaults the "Type" to full time wear (FTW). You can edit that field, as well as the following:

- Type.
- Distance vision only (DVO).
- Near vision only (NVO).
- Full time wear (FTW).
- Computer/Other.
- Sphere.
- Cylinder.
- Axis.
- Add.
- PD.
- Near PD.

You need to keep in mind that when entering a negative number, you can simply type or search for the number. However, for a positive number, you must enter a plus sign (+) before typing the number. The PD automatically defaults to 63 for distance and 60 for near. You can change these numbers by typing over these fields. When you type a distance PD, such as 60, SRTSweb automatically defaults the near PD down 3 millimeters, so in this case, to 57. If you need to enter a *monocular* PD instead, you can do so by clicking the "Mono" box (fig. 3–16).

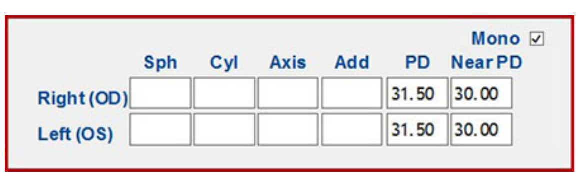


Figure 3–16. SRTSweb prescription information monocular PD screen.

If you need to enter prism for your patient's prescription, the prism box is defaulted to be collapsed. You will need to click **Expand Prism Values** to enter this part of the prescription.

Additionally, on the **Prescription Information** screen (fig. 3–17) you will select the provider associated with this patient's prescription

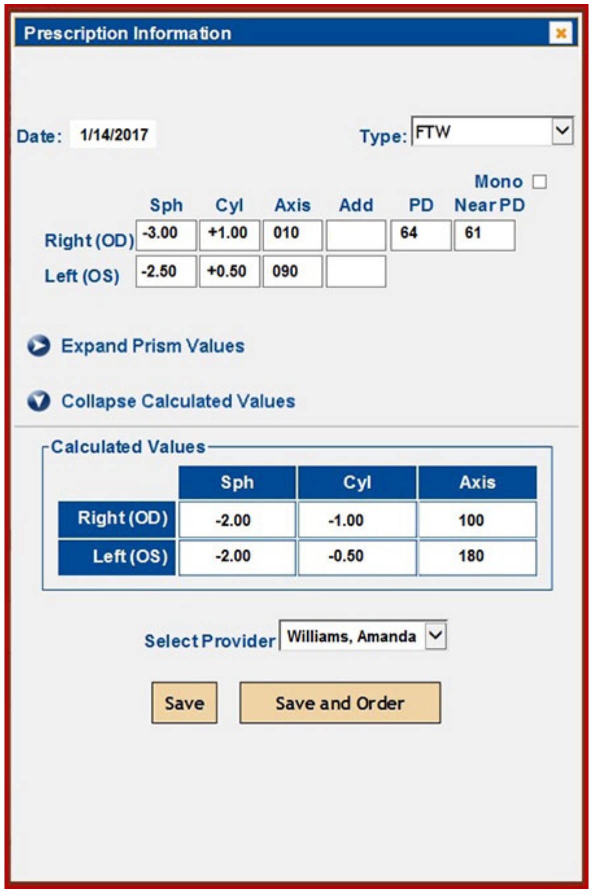


Figure 3–17. Example of a completed SRTSweb prescription information screen.

Add order

From your expanded Prescriptions tab, you have the ability to place an order by selecting the **Add Order** button in front of the prescription you want to use (fig. 3–18). You also can place an order from the **Add Prescription** screen by selecting the **Save and Order** button (fig. 3–19).

Figure 3–18. SRTSweb add order from expanded prescriptions tab.

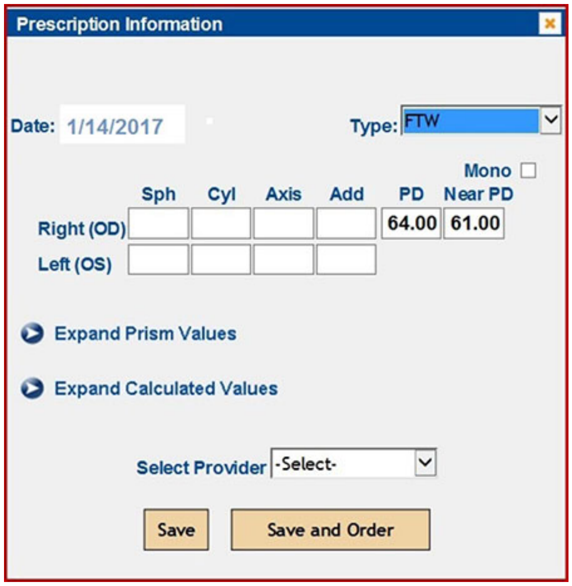


Figure 3–19. SRTSweb add order from add prescription screen.

At the **Eyewear Order Information** screen (fig. 3–20), you can then select options by using drop down arrows or by typing. You can click or tab to get from one field to another. The information you will need to enter includes:

- Priority.
- Frame.
- Color.
- Eye.
- Bridge.
- Temple.
- Lens.
- Tint.
- Material.
- Segment height.
- Pair.
- Production lab.
- Comments.

Once you have saved your order, from the expanded Prescriptions tab you can see the frame type and date ordered in the box on the right hand side. You can also open an order to check the status history by going to the **Order History** link above Prescriptions.

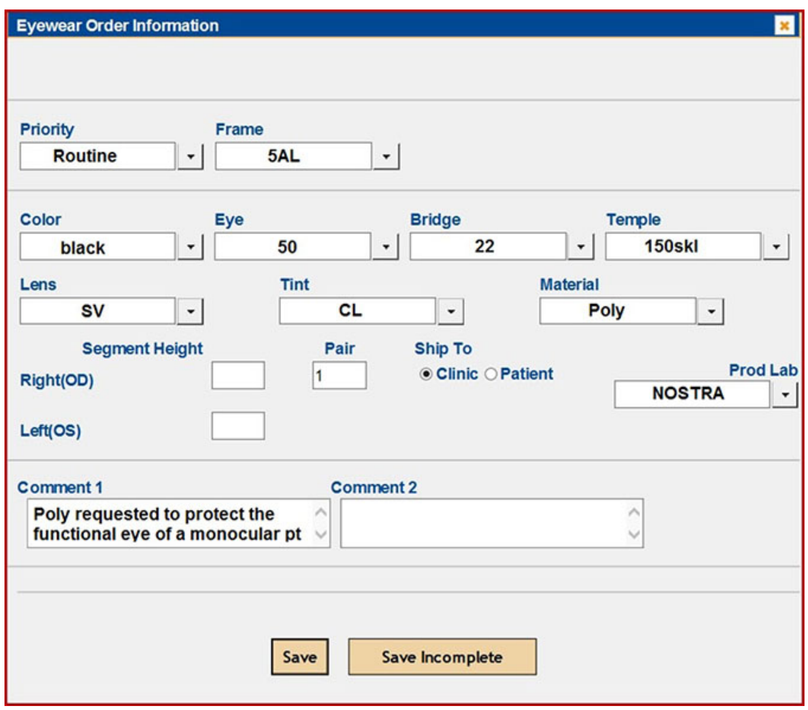


Figure 3–20. SRTSweb eyewear order information screen.

You still have the ability to edit an order as long as the status has not left the clinic. The order status is displayed on the right side of the screen next to the order date.

The following is a list of times when you are able to update an order:

- Clinic Created Order—Order is still at the clinic and may be updated, save as new, deleted or reprint the DD Form 771.
- Lab Rejected Order—Order may be updated, save as new, deleted or reprint the DD Form 771.
- Clinic Resubmitted Order—Order is still at the clinic and may be updated, saved as new, deleted or reprint the DD Form 771.

Incomplete orders

To update or delete any incomplete orders, click on **Incomplete Orders** above the Prescriptions tab. A list of all incomplete orders appears and you can select the appropriate order (fig. 3–21).

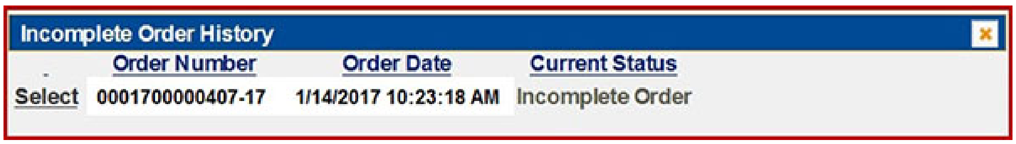


Figure 3–21. SRTSweb list of incomplete orders screen.

The Eyewear Order Information screen will come up and you can then edit any fields that need updated. Once you are done, you can then select **Update** at the bottom of the screen and your incomplete order becomes a completed order (fig. 3–22).

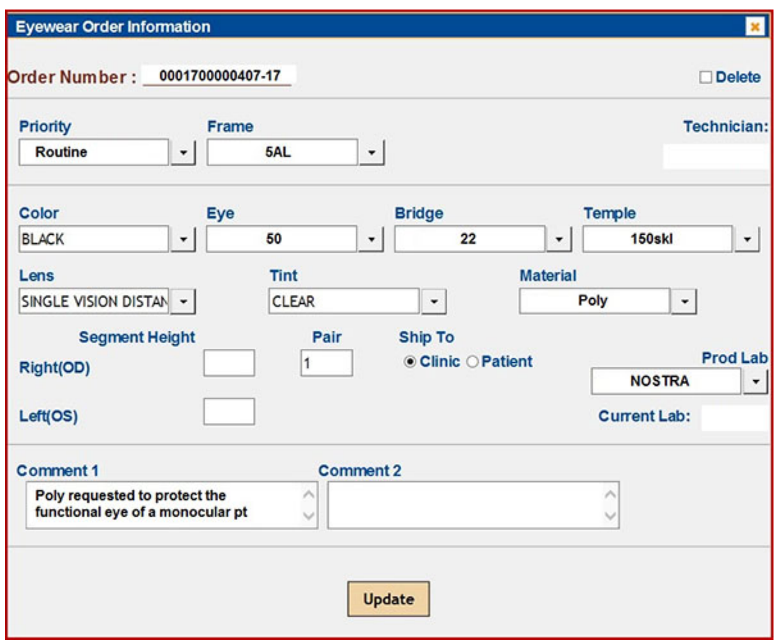


Figure 3–22. SRTSweb eyewear order information update screen.

Clinic Order Management

Under the **Manage Orders** tab you can find **Clinic Order Management**. Depending on the user role you've been assigned, this application allows you to accomplish any of the following:

- Check-in—enables the user to check-in orders from the lab.
- Dispense—enables the user to dispense glasses to the patient.
- Problems—enables the user to work orders that need attention.
- Outstanding—enables the user to follow-up on orders older than 10 days.

Check-in

This option allows you to display a list of all orders that have gone through the fabrication process. These orders have been dispensed from the lab and shipped back to the clinic to be checked in and dispensed to the patient. When an order arrives at the clinic, the order must be checked-in to indicate the clinic has received the order. You can check-in an order by four different methods:

- Type the order number into the single order field.
- Scan the bar code on the order documentation, which represents the order number after pressing bulk input.
- Locate the order in the list of active orders and checking the appropriate box.
- Type the order number into **Quick Search** and press **Check In**.

When dealing with a large quantity of glasses, *bulk input* is typically the easiest method. To do so, click on the check box labeled **Bulk Input.** The **Bulk Order Input** box appears (fig. 3–23). The order number will appear after you scan the order. After scanning, the **Check In** box will be checked. Click **Done** when finished and then **Submit** to check in the orders.

The order status will change to **Received by Clinic** and the order is now available to be dispensed to the patient. If the order is to be shipped to the patient, an option is displayed at the bottom of the screen to **Open** or **Save** a mailing label. This is your *only* chance to print or save a label for these orders so make sure you take the opportunity to do so.

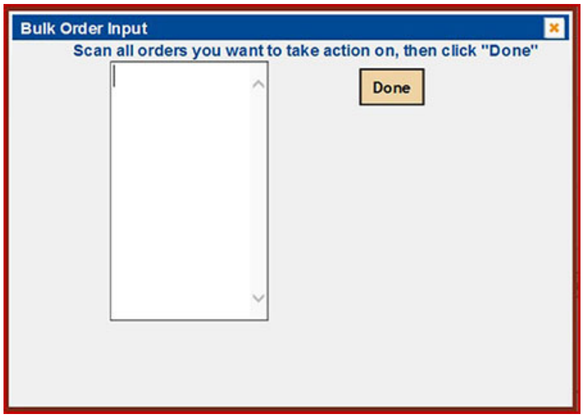
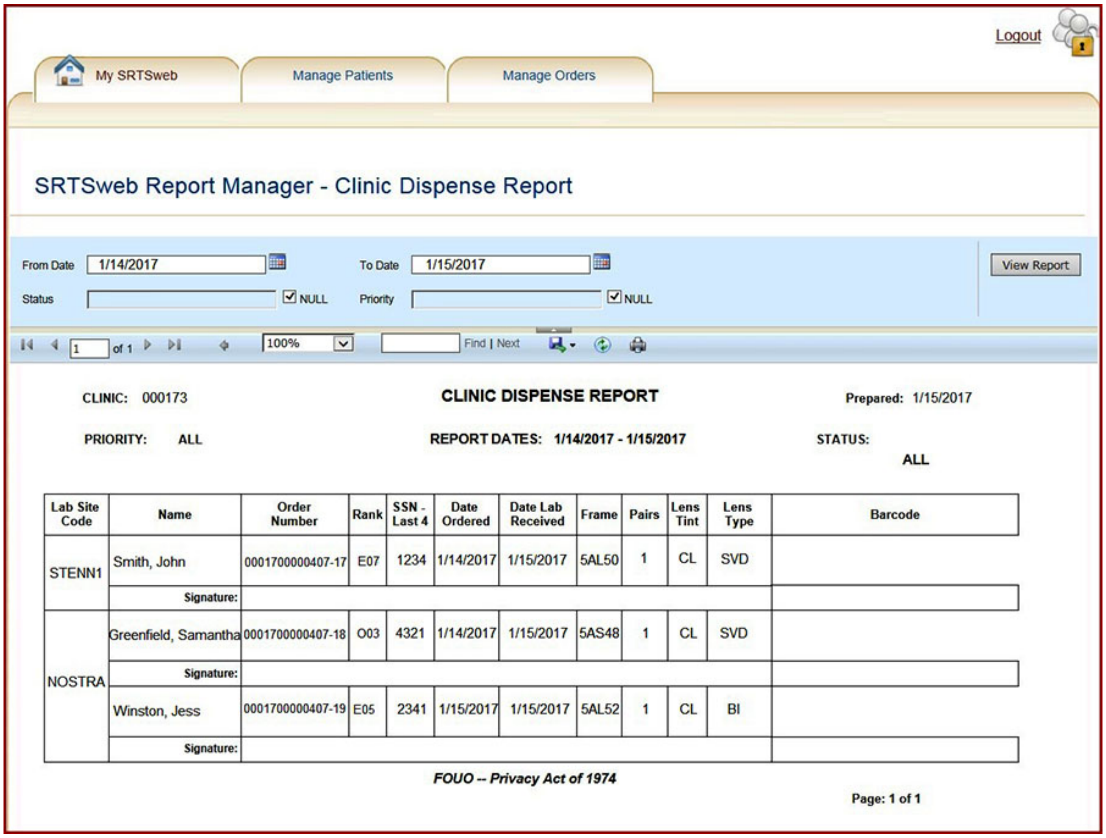


Figure 3–23. SRTSweb bulk input check-in screen.

Dispense

If your clinic policy is to have patients pick-up their glasses rather than mail them out, then you want to use the Dispense option. From here, you can print a **Clinic Dispense Report** (fig. 3–24), which provides a delivery confirmation report containing a signature line to be signed when the order is delivered to the patient. This report should be printed prior to processing in **Dispense Orders** and may be accessed from the **Report Manager** module located in the My SRTSweb tab.

To print the report, go to **My SRTSweb**, then **Reports Manager**, and next select from the dropdown menu **Clinic Dispense Report**. From there, select **Date Range**, **Status**, **Priority**, or check **Null** boxes. After these selections are made, the report is available by pressing **View Report**. You will then need to select a method of printing or saving from the **Export Drop Down** menu. To scan the DD Form 771 corresponding to the orders, you have a choice between **Single Order Check In** and **Bulk Input**. Again, when dealing with a large quantity of glasses, **Bulk Input** is typically the easiest method. Press **Close** when you have completed scanning. Once the data entry has been completed, click the **Submit** button to process the order(s). The order status will change to “Clinic Dispensed Order.”



CLINIC: 000173 CLINIC DISPENSE REPORT Prepared: 1/15/2017

PRIORITY: ALL REPORT DATES: 1/14/2017 - 1/15/2017 STATUS: ALL

Lab Site Code	Name	Order Number	Rank	SSN - Last 4	Date Ordered	Date Lab Received	Frame	Pairs	Lens Tint	Lens Type	Barcode
STENN1	Smith, John	0001700000407-17	E07	1234	1/14/2017	1/15/2017	5AL50	1	CL	SVD	
	Signature:										
NOSTRA	Greenfield, Samantha	0001700000407-18	O03	4321	1/14/2017	1/15/2017	5AS48	1	CL	SVD	
	Signature:										
	Winston, Jess	0001700000407-19	E05	2341	1/15/2017	1/15/2017	5AL52	1	CL	BI	
	Signature:										

FOUO -- Privacy Act of 1974

Page: 1 of 1

Figure 3–24. SRTSweb bulk clinic dispense report screen.

Problems

Selecting **Clinic Orders Problems** will display a list of orders with problems that require attention.

Clinic Orders Problems can include the following:

- Lab Rejected—clinic has the option to delete the order, reprint the DD Form 771 or resubmit the order with a status of “Clinic Resubmitted Order.”
- Incomplete Orders—can by updated and submitted the the clinic or deleted.

Overdue

Orders that are at the lab for over 10 days automatically go to the **Manage Orders—Clinic Order Management—Overdue** tab. You can print, save, or email an Overdue Orders Report from **Report Manager** after opening the report. This report will make it easier to follow-up with the lab on overdue orders.

Ordering spectacles manually versus SRTSweb

You can see why SRTSweb is the DOD standard for ordering eyewear. Most orders are done electronically using this system, which produces a completed DD Form 771 when an order is entered. However, since some remote locations do not have access to SRTSweb, paper or electronic copies of DD Form 771 can still be faxed, mailed, or emailed to a military fabrication lab. When a paper DD Form 771 is received, the lab enters the order into the system, thus adding it to the electronic system. As SRTSweb is constantly evolving to meet the demands of both the clinics and the fabrication labs. The most current information – to include how to obtain and use the system – can be found in the SRTSweb information section at: https://srtsweb.amedd.army.mil/Public/Support.aspx.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

412. Ordering spectacles manually

1. Correct the following Rx so it can be put on a DD Form 771 and sent to a fabrication lab:
   OD: +1.75 - 2 × 89
   OS: 1.25 - .5 × 12

2. It is 01 Oct 2018. The first patient of the day is a retiree who wants to order spectacles with a current prescription. If manually completing a DD Form 771, what order number do you record?

3. When manually ordering spectacles for a retiree and there is a need to mail the spectacles, what must you record in the ADDRESS/UNIT block of the DD Form 771?

4. You need to manually order an M–50 GMI. What do you record in the TEMPLE section of the DD Form 771?

5. If a manually ordering half-eye spectacles, what do you record in the PD (DIST/NEAR) block of the DD Form 771?

6. What goes in the SPECIAL COMMENTS/ JUSTIFICATION section of the DD Form 771?

7. What justification would you enter to request an N–15 tint for an active duty patient?

8. Do you need to maintain a manual spectacle order logbook when you order spectacles with SRTSweb?

9. What is the spectacle order logbook?

10. If mailing DD Form 771, which copies of the form are sent to the fabrication lab?

11. Which copy of DD Form 771 is wrapped around the spectacles when they come back from the optical fabrication lab?

12. When you receive an order that you mailed to the fabrication lab, what should you do when the spectacles arrive at your clinic?

13. A pair of spectacles arrived from the fabrication lab. You attempted to notify the patient twice now and it has been four weeks since the second notification. What can you do with the spectacles?

14. If you manually ordered a pair of spectacles, what do you do with the second and third copies of the DD Form 771 when the patient picks it up?

15. At *least* how much time must pass before you can send a tracer to the fabrication lab for a mailed order that has not arrived?

413. Ordering spectacles using SRTSweb

1. When using SRTSweb, will server upgrades impact your ability to order spectacles?

2. As well as submitting the required information through the SRTSweb link, what additional form do you have to submit to confirm you are authorized to access the SRTSweb system?

3. What are the different ID types you can use to add a patient?

4. Name the two different places you can start a search for a patient in the database.

5. SRTSweb is showing that a National Guard patient is not on active duty status. However, the patient has provided a copy of her orders indicating she has been activated for 180 days. Where in SRTSweb are you able to convert her National Guard status to active duty?

6. On which screen would you enter the patient’s corrected and uncorrected vision?

7. On which screen would you select the provider associated with the patient’s prescription?

8. Once at the **Eyewear Order Information** screen, list all the information you are able to enter.

9. What four applications are available under **Clinic Order Management**?

10. What is *typically* the easiest method to check-in large quantities of eyewear?

11. What report makes it easier to follow-up with the lab on overdue orders?

3–2. Verifying, Repairing, and Adjusting Spectacles

When your clinic receives spectacles from the lab, or when patients get a new pair of glasses and feel their vision is off, it is your job as an ophthalmic technician to verify the accuracy of those prescriptions. As previously discussed, you can save a lot of time simply by taking a quick look at the glasses received from the lab before dispensing them to your patients. This gives you an opportunity to send the spectacles back to be remade or to make any obvious repairs or adjustments that might be needed.

When patients receive a new Rx and feel their vision is not quite right, you can often save a lot of time by first verifying (neutralizing) their prescription to ensure it was made correctly. This prevents your clinic from having to dedicate more time and resources to a patient whose only issue might be an incorrectly made pair of glasses. If you suspect their vision complaint might be related to the fit of their new frame, you will need to know how to solve those issues.

This section gives you the tools to be able to handle these situations. You will learn how to neutralize, repair, and adjust spectacles so that you can better support your provider and your patient population.

414. Neutralizing lenses

Although lensmeters are commonly referred to as “lensometers” in a clinical setting, the term “lensometer” is actually the trade name of the American Optical (AO) Company. Other manufacturers refer to similar equipment as lensmeter, Vertometer, Vortexometer, or Focimeter. We’ll use the term lensmeter when discussing the equipment.

A lensmeter is used to determine the power of a lens, locate the optical center of a lens, measure the prismatic effect of a pair of spectacles, duplicate a prescription from an old one, and to verify a prescription. Verifying a prescription is one of the most frequently performed tasks for an ophthalmic technician. Before a provider can determine the refractive status of a patient, he/she needs to know the patient’s previous Rx. For this reason, you will become very familiar with this procedure. Typically, you will perform *automated* lensometry, but as we previously discussed, there will be those rare occasions when you will be expected to perform *manual* lensometry. For that reason, we will breakdown how to neutralize spectacles using a manual lensmeter in the following lesson.

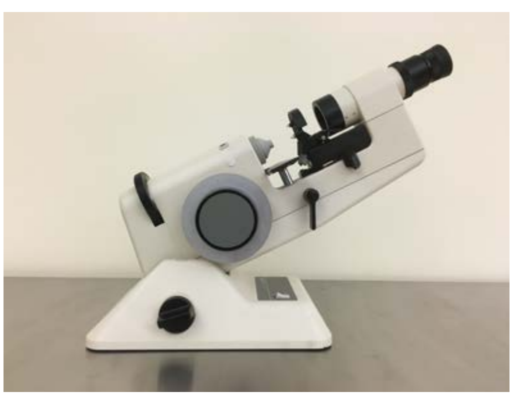


Figure 3–25. Manual lensmeter.

External parts of the manual lensmeter

Figure 3–25 shows a common manual lensmeter and figure 3–26 shows the primary components.

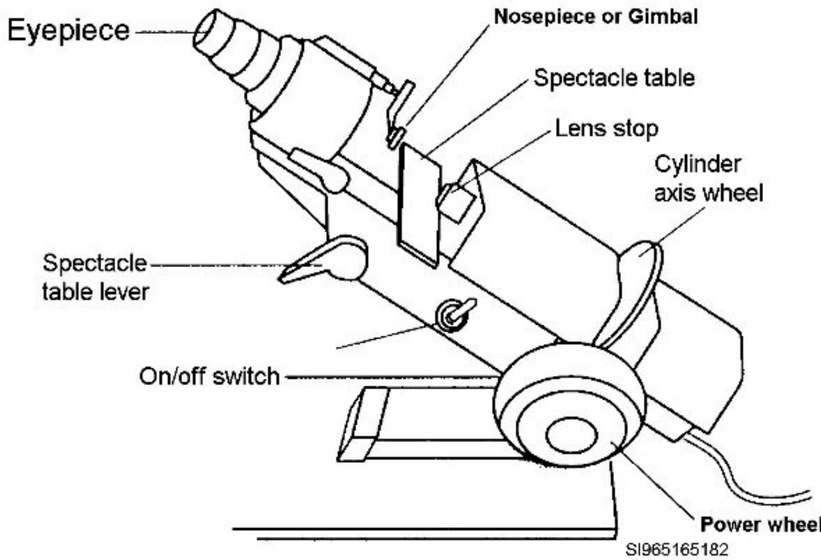


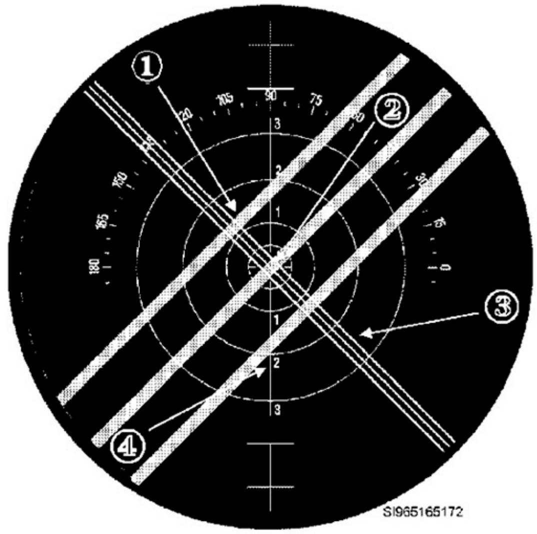
Figure 3–26. Primary components of a manual lensmeter.

Internal parts of the manual lensmeter

Figure 3–27 shows an internal view of the reticle of a lensmeter. Figure 3–28 shows the internal view of the target seen in a lensmeter. The two sets of lines that are perpendicular to one another are the sphere lines (three thin lines close together) and the cylinder lines (three thick lines farther apart). Use the power wheel of the lensmeter to focus and then take a dioptric reading from the power wheel (power drum).

1. Center
2. Prism Diopter (Power Values)
3. Median Cross-Line

Figure 3–27. Lensmeter reticle.



1. Cylinder Power Lines
2. Optical Center of a lens (point where sphere and cylinder lines cross each other)
3. Sphere Power Lines
4. Reticle Median Cross-Line

Figure 3–28. Target as seen through a lensmeter.

Setting up a manual lensmeter

Although the instrument manufacturers may vary, you will need to adjust the eyepiece on all lensmeters to compensate for any refractive error you might have, or your readings will be inaccurate.

With the power wheel set on zero, focus the eyepiece by turning it counterclockwise (CCW) as far as possible and then slowly rotating it clockwise (CW) until the reticle comes into sharp focus.

Next, you want to calibrate the lensmeter properly. Look into the eyepiece; you should see the bright sphere and cylinder power lines (fig. 3–29). Now, turn the power wheel until the sphere and cylinder power lines (mires) are sharp and clear (fig. 3–30). Center the mires as needed by moving the spectacles. With the mires centered, you are measuring through the optical center and getting the most accurate reading.

Figure 3–29. Unfocused sphere and cylinder power lines (mires).

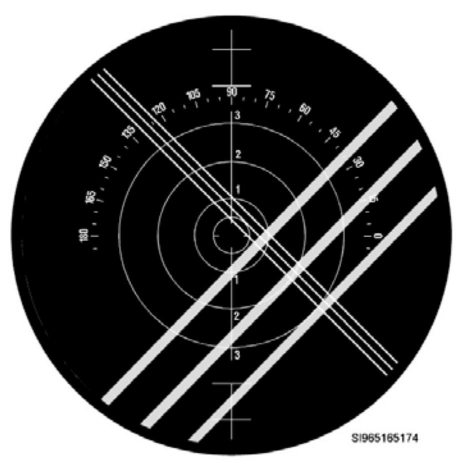


Figure 3–30. Unfocused sphere and cylinder power lines (mires).

Look at the power wheel. It should read zero (0) diopters, *exactly*. If it does not, repeat the procedure. If the machine still does not read zero, contact the medical equipment repair office for calibration. Once you have focused the eyepiece to your eye and have verified proper calibration of the lensmeter, you are ready to neutralize a pair of spectacles.

When neutralizing a pair of spectacles, *always* check the right lens first. Pull back the nosepiece (gimbal) and insert the lens with its concave side against the lens stop. Accomplish an initial centering of the lens by aligning the crossing of the sphere and cylinder lines. It may look something like figure 3–31.

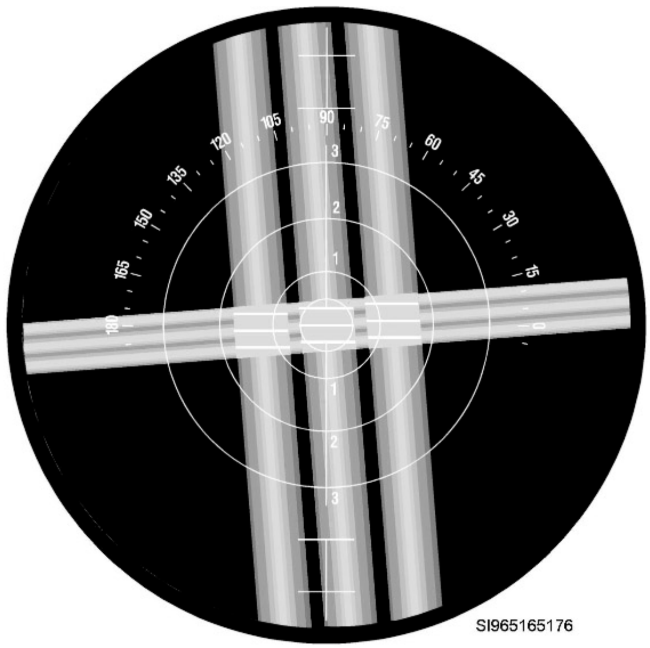


Figure 3–31. Centering a lens.

Performing manual lensometry

The following steps cover the neutralization procedures for single vision lenses, the upper portion of a multifocal lens, and a multifocal "Add."

Single-vision lenses and upper portion of a multifocal

Start with the power wheel at +9.00. Begin turning the top of the power wheel away from you (i.e., in the minus direction) until the first set of power lines comes into focus. If the sphere and cylinder power lines of the target come into focus at the same time (fig. 3–32), the lens is spherical and has no cylinder power to it. Simply record the dioptric reading from the power wheel, followed by the letters "SPH."

If the sphere and cylinder power lines *do not* come into focus at the same time, *the lens has some cylinder power*. To read the power of a cylindrical or spherocylindrical lens, rotate the power wheel until the first set of power lines come into focus. You want the thin lines to come into focus first, as this will give you the prescription in minus cylinder form. If the thicker lines come into focus first, simply rotate the axis wheel about 90° and start over with the power wheel at +9.00D. Rotate the power wheel until the thin (spherical) lines come into focus. Once this occurs, stop rotating the power wheel.

Now rotate the axis wheel of the lensmeter until the sphere power lines are straight and further in focus (fig. 3–33). Once you have the spherical lines in focus, take the dioptric reading from the power wheel. Record this as the spherical portion of the prescription. *Do not move the axis wheel anymore* *from this point on!* Read the axis wheel and record the measurement as the prescription axis. At this point, you must now determine the cylinder power.

Figure 3–32. Simple spherical lens.

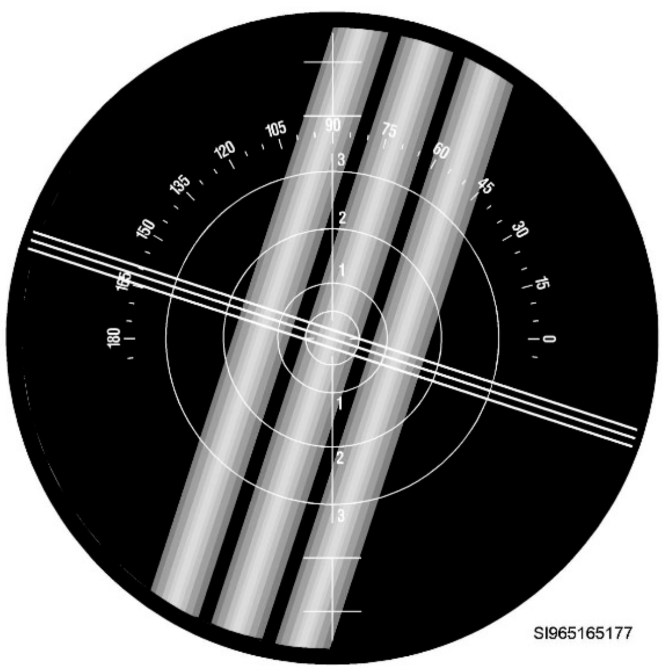


Figure 3–33. Sphere power lines in focus; cylinder power lines not in focus.

NOTE: On the power wheel, numbers in the red area indicate minus dioptric power. The numbers in the black area indicate plus dioptric power. The scale is divided into 0.12 diopter increments from zero to ±3.00 diopters and in 0.25 diopter increments from ±3.00 to ±20.00 diopters.

Now, focus the cylinder power lines by rotating the power wheel in the minus direction some more (fig. 3–34). The distance traveled from where the sphere power lines were in focus and to where the cylinder power lines are in focus is the minus cylinder power. Remember the cylinder power is *not* taken off the power wheel when the cylinder lines are clear. Cylinder power is the dioptric distance traveled from where the sphere power lines were in focus to where the cylinder power lines came into focus. Now record the cylinder sign (it should be minus since you traveled in the minus direction to get to your cylinder power lines) and the power.

Example:

The sphere lines are straight and focused at black 2.00. You note your axis is at 043. The cylinder power lines come into focus at black 1.00. This means you have traveled in the minus direction 1 diopter. Therefore, the prescription for this lens is: +2.00 -1.00 x 043.

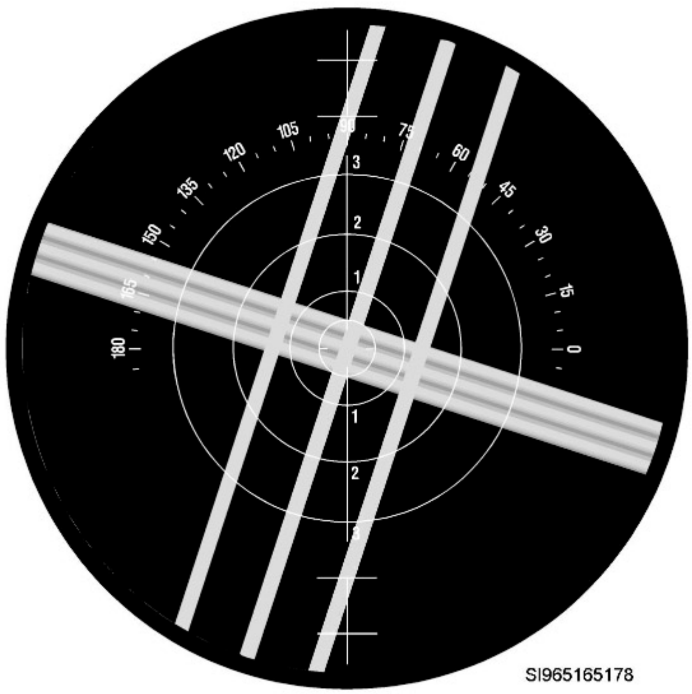


Figure 3–34. Cylinder power lines in focus; sphere power lines not in focus.

If you have single-vision spectacles, you repeat the procedure for the second lens. If you are neutralizing multifocal spectacles, you need to continue and measure the near-vision segment “Add” power.

Measuring the “Add” of a multifocal

There are two methods to measure the “Add” power of the near-vision segment of a bifocal or trifocal—the *practical* method and the *exact* method.

Practical method

The practical method is a common technique for all types of multifocal lenses in the lower power range (i.e., a distance spherical power of less than +4.00 diopters).

1. Read and record the power of the distance portion of the lens.
2. Raise the spectacles in the lensmeter, using the spectacle table lever, until the near segment is under the nosepiece of the instrument.

3. Focus the sphere power lines (in the near segment). *Do not move the axis wheel.*
4. Read the power wheel. The “Add” power for the near segment is the difference between the reading shown and the original distance sphere power. For example, if the distance sphere power was + 4.00 and the power wheel now reads +5.50, then you traveled in the plus direction 1.50 diopters and the “Add” power is +1.50.

Exact method

For higher power multifocal lenses (i.e., distance sphere powers +4.00 diopter or greater) use the exact method.

1. After neutralizing the distance prescription, turn the spectacles around so they are “looking away from you” (concave lens surface toward you).
2. Raise the spectacles in the lensmeter, using the spectacle table lever, until the near segment is under the nosepiece of the instrument.
3. Focus the sphere power lines (in the near segment). *Do not move the cylinder axis wheel.*
4. Read the power wheel as before. Once again, the “Add” power for the near segment is the difference between the sphere power readings. Remember, distance traveled from the distance sphere power reading to the bifocal sphere power reading.

Occasionally, the sphere power lines may not be visible through the lensmeter when you are trying to measure the power of the near segment. If this happens, use your diopter compensation knob to offset the prismatic effect of the lens. Rotate until the sphere power lines come into the field of view.

One final word about measuring “Add” powers—the vast majority of time the “Add” power is the same in both right and left lenses but, not every time. You need to *measure the “Add” power separately for each lens*. Just repeat the procedures used to neutralize the right eye.

Progressive add lenses

The distance and near portion of a progressive add lens (PAL) can be accurately neutralized only by using the templates of the manufacturer that makes the lens. Otherwise, you just have to “guesstimate” where the true OC is and what the near “Add” is.

Maintenance of manual lensmeter

Maintaining the lensmeter is very easy to do. The following information indicates necessary procedures to keep the machine in working order.

Dust covers and dust

Every lensmeter comes with a dust cover. Use it exactly for that—to keep dust off the eyepiece and moving parts. Make sure the cover is always in place when the instrument is not in use. If the exterior lenses of the lensmeter collect dust, you can dust them off with a lens cloth.

Changing bulbs

Occasionally the bulb burns out. The only authorized maintenance you can perform in the clinic is changing the light bulb:

- On the AO lensometer, crank the power wheel in the plus direction to +20.00D, loosen the screw at the rear of instrument, and slide the cover back. Unscrew the bulb and replace it.
- On the Marco lensmeter, pull down the lamp access cover—hinged at the bottom. Unscrew the bulb and replace it. Then, return the lamp cover to the original position.
- On the Bausch & Lomb (B&L) vertometer, crank the power wheel in the minus direction to –20.00D and open the slide door. The bulb is in a flip-out apparatus for easy replacement. Simply flip the apparatus out, remove the bulb, and replace it.

Autolensometry

The following information specifically describes the Humphrey® lens analyzer; however, most autolensmeters work in a similar fashion. You will need to refer to the user's manual for your particular piece of equipment to ensure the most accurate results.

Unlike manual lensometry, with automated lensometry you do not have to memorize commands, as the basic operation is menu driven. There are icons at the bottom of every screen leading you through the process. From these icons, you can also perform other options such as printing and changing the way the instrument is set up. Just push a button below the icon to select an operation. Push the printer button and you receive a printout of the measurement.

Performing autolensometry

Start with the measure screen (fig. 3–35). To access the measure screen press the measure icon. Then position the right lens over the read head (fig. 3–36). If you have bifocals or trifocals, make sure only the distance portion is over the read head. Slide the lens left, right, up, or down to center the cross hairs on the screen (fig. 3–37). Make sure both lenses are against the lens table (fig. 3–38). Otherwise, you are likely to get an inaccurate reading. Lower the lens holder, align the cross hairs, and press the store button. This places the sphere, cylinder, and axis into memory. If the lenses are single vision, repeat the process for the left lens.

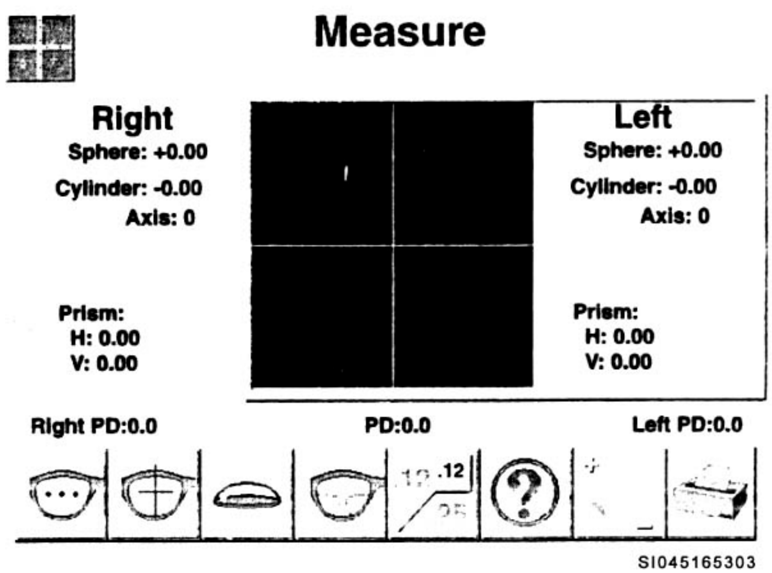


Figure 3–35. Autolensmeter measurement screen.

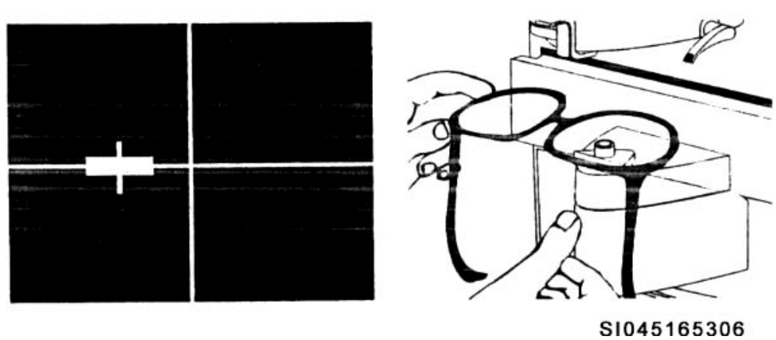


Figure 3–36. Placing OD lens over read head (not centered).

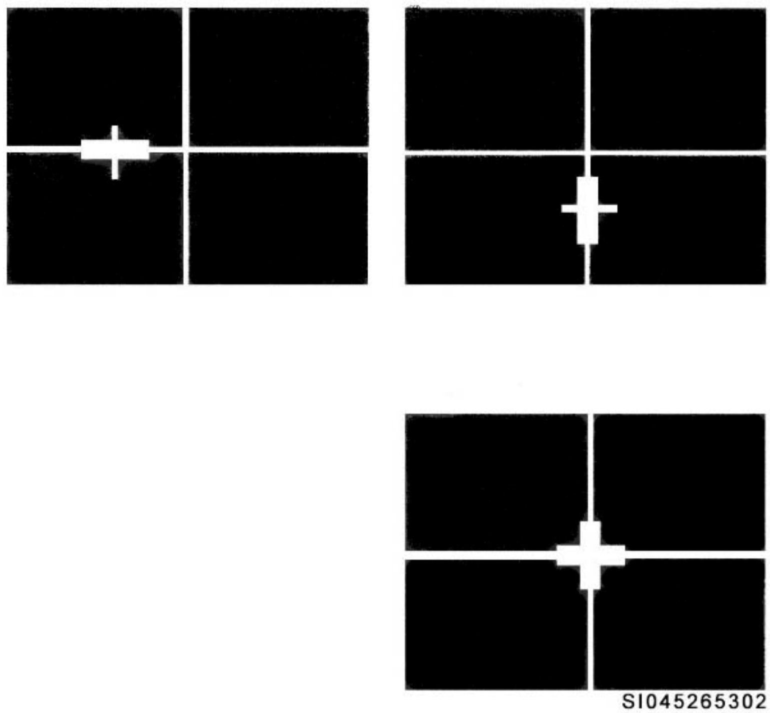


Figure 3–37. Centering the lens.

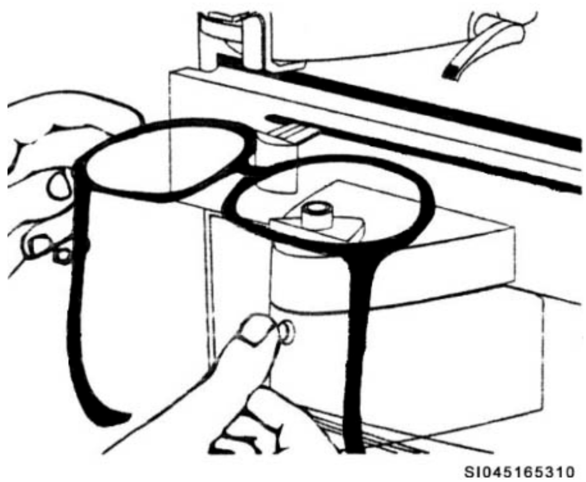


Figure 3–38. Both sides of frame against lens table.

If you have a multivision lens, do not remove the spectacles from the lens analyzer. If you do, you will have to *re-measure* the distance portion (using the steps previously covered). Once you have the distance portion stored in memory, gently slide the lens so the near portion is over the read head. The screen automatically displays the “Add.” Press the store button. You are now ready to measure the left lens. Once you finish the left lens, you can transcribe the Rx to the patient’s exam record.

If at times the lens analyzer seems to function erratically, gently lift the read head cover. There you might find some dust buildup. Use a soft lens cloth to wipe it clean. This should eliminate any further problems. When precisely determining the spectacle Rx, use the PD mode and measure each lens at the patient’s monocular PD. This allows you to see if there is any induced prismatic effect. Using the PD mode is the most accurate method of measuring a lens, checking for prism, or verifying the Rx from the lab.

Take quick readings with the OCD mode. The lens analyzer automatically calculates the distance between the optical centers along with the power of the lens at the optical (assuming you have aligned the cross hairs properly). Do not use the OCD mode when there is prism in the Rx.

A nice feature with the autolensmeter is the ability to read PAL lenses. Switch to the PAL setting and place the right lens over the read head. The instrument directs your alignment of the lens (fig. 3–39). Get your distance portion read and press the store button. The instrument stores the reading and guides you to the bifocal power (fig. 3–40). Once you have the bifocal lined up correctly, a plus sign shows up on the screen (fig. 3–41). Press store to save the Rx, slide over, and do the left eye.

For more in-depth functions such as measuring contact lenses and custom setups, consult your owner's manual.

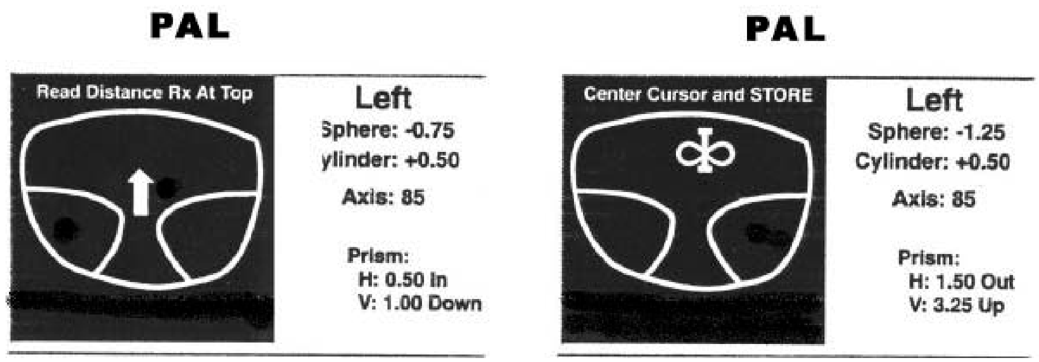


Figure 3–39. PAL alignment.

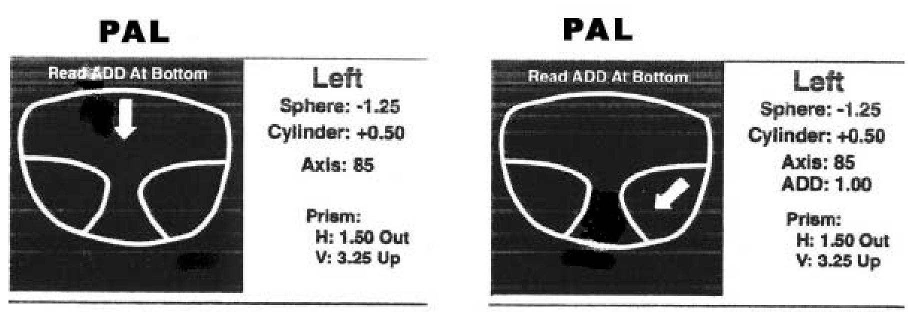


Figure 3–40. Guide to bifocal power.

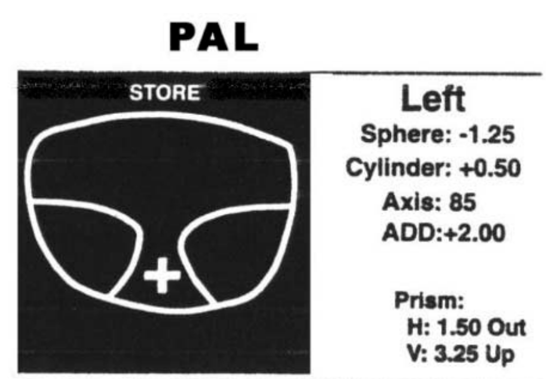


Figure 3–41. PAL lined up correctly.

415. Verifying spectacles

To verify spectacles, you need a standard with which to compare. Just because spectacles are not made *exactly* to the prescription does not necessarily make them unacceptable for wear. If they are within ANSI Z80.1 standards, they can still be dispensed to patients.

Development and approval of the ANSI Z80.1 standard

The Optical Laboratories Association (OLA) and the Standards Committee Z80 (comprised of a MD, a PhD, and a doctor of optometry (OD) develop the standards for ophthalmic lenses. Once they develop a standard they feel is both stringent yet achievable, they submit it to the American National Standards Institute for processing and approval. ANSI verifies the proposed standards meet the requirements for due process, consensus, and other criteria.

Once ANSI is satisfied with the proposed standards submitted by the OLA and the Standards Committee Z80, they approve it as an American National Standard. These standards are important but keep in mind they are not a legal, enforceable requirement. *Adherence by ophthalmic laboratories to ANSI Z80.1 standards is voluntary*. In the military, the fabrication laboratories *do* adhere to ANSI standards. Therefore, we verify all spectacles against those standards.

If there is a question or a need for clarification about the ANSI Z80.1 standards, do not call ANSI. They merely approve the standard. To get specific information about interpreting the standard, contact the OLA in Merrifield, Virginia.

ANSI Z80.1 standards for ophthalmic lenses

The ANSI Z80.1 standards do not cover frames or temples. They cover only ophthalmic lenses. Therefore, if you get the wrong frame or temple length, or the incorrect eye or bridge size, contact the lab and work out the problem with them. You and the lab have to decide if your clinic can fix the problem in-house or return the spectacles to the lab to have the error corrected. If there is a problem with the lenses, the ANSI Z80.1 standards are there to guide you. Use them as a backup when you need to return a pair of spectacles to the lab for a problem. You have something definitive to compare your findings against and to back you up if someone questions your decision to return a pair of spectacles. *The key is you must know what the standards are*. The next few paragraphs cover the ANSI standards for various aspects of ophthalmic lenses.

Physical appearance of lenses

Acceptable ophthalmic lenses do not have pits, scratches, grayness, bubbles, cracks, or watermarks. Hairline scratches essentially invisible to the eye without intense scrutiny may be acceptable.

Multifocal segments

For vertical location, segments should be within 1 mm of the requested height. This means if you ordered 20-mm segment heights and received segments (both at 21 mm or both at 19 mm), this would be acceptable.

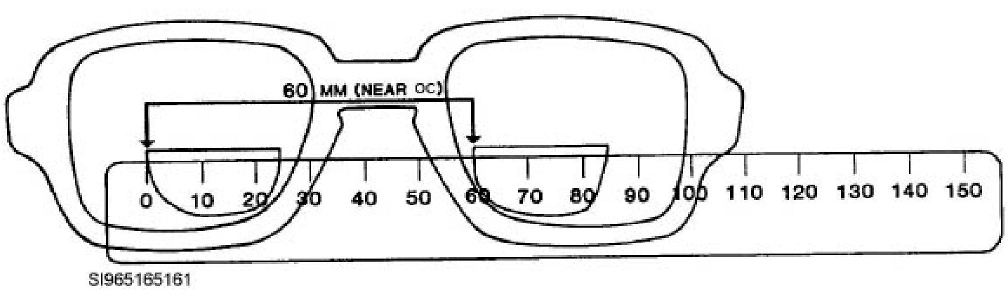


Figure 3–42. Measuring the near OCs in a multifocal.

However, ANSI standards also state the difference *between* the segment heights must not exceed 1 mm. Therefore, if you ordered 20-mm segment and received spectacles having a segment height with one lens at 19 mm and the other segment height at 21 mm, the spectacles would *not* meet the standard. While each lens is within 1 mm of what you ordered, the total difference between the lenses is 2 mm. This is unacceptable.

For horizontal location, the multifocal segments must be within 2.5 mm of the original order of the patient's near PD. If the patient's near PD is 60 mm, the segments could be as far apart as 62.5 mm or as close as 57.5 mm and still be acceptable. Figure 3–42 shows how to measure this.

Single vision lens OCs, or multifocal lens OCs (distance portion)

The OCs of a single vision lens, or of the distance portion of a multifocal lens, must be within 2.5 mm of the requested order. Find and mark the OCs using a lensmeter. Then use a PD ruler to measure the distance between the marks you made on each lens.

For example, assume a patient has a PD of 64 mm. The OCs for this patient's spectacles could be as far apart as 66.5 mm or as close as 61.5 mm, and still be acceptable. Assuming you measured the OCs and found them to be 3 mm or more off from the original order, you are still not going to be able to reject the spectacles without measuring the induced horizontal prismatic effect. The ANSI standards allow a total of 0.67D of unwanted horizontal prism. If you measure the spectacles and find they exceed the tolerance for unwanted horizontal prism, then you can reject them. (We will cover measuring for horizontal prism later in this lesson.)

Base curve

If a specific base curve (BC) is requested, the lab can vary from it by only ± 0.75D. For example, you requested a base curve of **+6.00D**, a base curve of as much as +**6.75D** would be acceptable, as would a BC of as little as +**5.25D** because +6.75D and +5.25 meet the ANSI standard.

Figure 3–43. Lens clock.

To measure BC, you need a lens clock (fig. 3–43). First, calibrate the lens clock. You can check the calibration of your lens clock by placing all three of the posts of the lens clock against a known flat surface, such as a piece of glass. The reading should be zero. If it is not, medical equipment repair personnel should adjust the lens clock or you can recalibrate a lens clock yourself. Turning the center pin clockwise moves the needle in the negative direction. Moving the center pin in the counter clockwise direction moves the needle in the positive direction.

Assuming your lens clock is calibrated correctly, use it to measure BC by holding it perpendicular to the front (convex side) of the lens and reading the black numbers of the lens clock. Black means plus, and since you are measuring the positive (convex) side of the lens, it is very important you look at the black scale of the lens clock.

When measuring BCs, you may find the front lens surface has two curves. If so, *the weaker curve is the base curve*. For example, as you rotate around the front of a lens and you find maximum and minimum curves of +6.00 and +5.00. The weaker curve is the +5.00, so +5.00 is the BC.

Listed are some tips to help you avoid trouble and inaccurate readings:

- Do not push down on the lens clock very hard, or you may scratch the lens with the lens clock.
- Keep the lens clock perpendicular to the lens surface as you rotate it.
- Keep the center post of the lens clock as close to the center of the lens as possible.
- Read the *black* numbers when measuring the *front* surface of a lens.

Rx tolerances

The Rx received does not have to be the exact Rx requested, but it should be close. The ANSI standards give ranges of tolerance based on the requested sphere, cylinder, and axis. ANSI standards indicate the *percentage* of variations allowed, and actually gives those variations in dioptric increments too small for most lensmeters to read.

One final note: 0.12D and 0.13D is essentially the same thing. They are so close that both represent one-eighth of a diopter. Therefore, if you find two numbers are mathematically different by 0.13D, consider this equal to 0.12D when comparing against the ANSI standards. This makes sense, since it seems wasteful to reject a lens simply because it is off by only 0.01D.

Sphere power

The following table shows the allowable tolerances for sphere power.

If sphere power requested is:	Then the maximum acceptable deviation would be:
PL to ± 6.50D	± 0.12D
±6.75D and above	± 0.25D

Here is an *example*:

Rx ordered:	OD +6.50D SPH OS +6.50D SPH
Rx received	OD +6.67D SPH OS +6.87D SPH

In this case, the OD lens is acceptable since it is not off by more than ±0.12D. However, reject the OS lens because it is off by more than ±0.25D.

The ANSI standard is based on the power ordered; and in this case, a power from PL to ±6.50D is allowed to be off by a maximum of only ±0.12D. It is not until you order a sphere power of **±6.75D** (or more) that the power received can be off by ±0.25, and still be acceptable.

Cylinder power

The following table shows the allowable tolerances for cylinder power.

If cylinder power requested is:	Then the maximum acceptable deviation would be:
Zero power to –4.50D	±0.12D
–4.75 and above	±0.25D

Here is an *example*:

Rx ordered: OD: PL –4.50 × 090
OS: PL –4.50 × 090

Rx received: OD: PL –4.37 × 090
OS: PL –4.25 × 090

In this case, once again, the OD lens would be acceptable since it is not off by more than ±0.12D. However, the OS lens is off by ±0.25D, so you would reject that lens.

Remember the ANSI standard is based on the power ordered; and in this case, a power from **Zero** to **–4.50D** is allowed to be off a maximum of ±0.12D. It is not until an order with a cylinder power of **–4.75** (or more) that the power can be off by ±0.25 and still be acceptable.

Cylinder axis

The amount the cylinder axis requested could be off depends on the amount of cylinder *power* requested. As a rule, the stronger the cylinder power, the more accurate the axis must be. The following table shows cylinder power and the axis variation allowed.

If cylinder power ordered is:	Then the maximum axis deviation from what was ordered is:
–0.25D cylinder power	±7°
–0.50D or –0.75D cylinder power	±5°
–1.00D, –1.25D, –1.50D cylinder power	±3°
–1.75D cylinder power or more	±2°

Here are some examples:

- If an Rx of –1.00 **–0.25** × 100 is ordered, the axis received could be off by up to 7°. This means an axis anywhere from 093° to 107° would be acceptable. Reject anything outside this range.
- If an Rx of –0.50 **–0.75** × 060 is ordered, the axis received could be off by up to 5°. This means an axis anywhere from 055° to 065° would be acceptable. Reject anything outside this range.
- If an Rx of –6.75 **–1.00** × 180 is ordered, then the axis received may be off by up to 3°. This means an axis anywhere from 177° to 003° is acceptable. Reject anything outside this range.
- If an Rx of PL **–4.75** × 075 is ordered, the axis received can be off by up to 2°. Meaning an axis anywhere from 073° to 077° is acceptable. Again, reject anything outside this range.

Here are some tips to help you remember how much the axis can be off for the various cylinder powers and still be acceptable:

- –0.**25**
  Think, "**2** + **5** = **7°**."
- –0.**5**0 and –0.7**5**
  Think, "**5**0 and 7**5** can be off by **5°**."
- **–1.00**, **–1.25**, **–1.50**
  Think, "**Three numbers** that can be off by **3°**."
- **–1.75** and above
  Think, "This power is getting **two** strong so it can only be off by **2°**."

Just keep in mind the *more* the cylinder power, the *less* the variation allowed in the axis.

Some examples of verifying lens powers

Here are a few example exercises for you to see how this all fits together. In the example, you see the Rx that was ordered and the Rx that was received. You need to decide whether the spectacles are within the ANSI standards or not.

Example #1:

Ordered	Received
OD: +3.00 –4.00 × 054	OD: +3.12 –4.12 × 056
OS: +6.25 –4.50 × 055	OD: +6.50 –4.62 × 058

For the OD Rx in this example, you can see the sphere power is off by 0.12D, the cylinder power is off by 0.12D, and the axis is off by 2°. This lens is okay. A sphere or cylinder power off by only 0.12D is *always* okay. An axis off by only 2° is also *always* okay.

For the OS Rx in this example, you can see the sphere power is off by 0.25D. This exceeds sphere power tolerances, unless the requested sphere power is ±6.75D or more. In this example, a difference of 0.25D is a good reason for rejection. The cylinder power is off by 0.12D. This is okay. As stated above, a lens can always be off by 0.12D. The axis is off by 3°. For a cylinder power of –1.75D and above, the maximum the axis can be off is 2°, so in this example, a 3° difference is unacceptable.

Example #2:

Ordered	Received
OD: –7.00 –0.50 × 179	OD: –7.25 –0.75 × 009
OS: –6.50 –1.75 × 178	OS: –6.75 –1.62 × 001

The OD sphere power ordered is over ±6.50, so its tolerance is 0.25D. This means the –7.25D received in this example is acceptable. The cylinder power is only –0.50, so it can only be off by 0.12D, but it is off by 0.25D in this example. This is unacceptable. Based on the requested cylinder power of –0.50, the axis received in this example is allowed to be off 5°. Unfortunately, the axis received is off by 10°. This is another unacceptable error and you must reject the order.

The OS sphere power is off by 0.25D. The ANSI standard says a sphere power up to ±6.50D must be within 0.12D, making the –6.75D received unacceptable. The cylinder power is off by 0.12D, which is always acceptable regardless of the lens power. The axis is off by 3°. Based on the requested cylinder power of –1.75D, the axis is only allowed to be off by 2°. This axis is also unacceptable. This will be discussed in the repair section later, but if a minor axis variation such as this is a problem, you can try rotating the lens a degree or two in the frame, using axis-aligning pliers, to avoid rejecting the lens.

The important thing to remember with ANSI standards is to look at *what you ordered*. The original order (i.e., the prescription requested) determines what the ANSI standards should be, not the spectacles received.

"Add" power

How far off an "Add" power for a multifocal can be depends on the amount of "Add" power requested. If an "Add" of +0.75D up to +4.00D is *ordered*, then the maximum amount the "Add" power *received* can be off is ±0.12D. If an "Add" power of +4.25D or more is ordered, the "Add" power received could be off by up to ±0.25D and still be accepted.

It would be *very rare* for you to order a multifocal Rx with an “Add” in excess of +4.00D. This being the case, the vast majority of multifocal “Add” powers you verify have an allowable variation of only ±0.12D. The following table shows the tolerances allowed.

If the requested “Add” power is:	**Then the maximum the “Add” power could be off would be:**
+0.75 to +4.00D	±0.12D
+4.25 and above	±0.25D

Prismatic effect

You may order spectacles with or without prism (**Δ)**. Upon receipt from the lab, the amount of vertical and/or horizontal prism in a pair of spectacles must fall within certain tolerances.

Vertical prism

The ANSI standards state vertical prism [i.e., base up (BU) or base down (BD)] must be within **0.33Δ** of the ordered Rx. Therefore, if no vertical prism was ordered, the most you could have without causing the rejection of the spectacles is 0.33Δ. If you find *0.50Δ or more*, reject the spectacles and return them to the lab.

To measure vertical prism when you did not originally order vertical prism, optically center the lens with *the strongest power* in the lensmeter. Then, without moving the lensmeter table, move to the other lens and look to see where the OC lines up with the prism diopter circles of the reticle. Did the move cause the optical center to move up or down? If so, you have some vertical prism. Using the reticle inside the lensmeter, you can determine how much BU or BD prism is present. The amount seen represents the *total* amount of vertical prism. If the amount of prism is 0.33Δ or less, the lenses are acceptable.

To check for vertical prism, you must be able to identify which lens has the stronger power. Let’s do a few examples to see if you can determine this.

Example:

OD: –1.50 –2.00 × 090
OS: –1.50 –1.00 × 180

To find which lens has the stronger power, add your sphere and cylinder power together. In this instance, you’re not worried about the signs; you will want to completely disregard them. Look at the right eye first. When you add 1.50 and 2.00 together, you get 3.50 total power for the right eye.

Now look at the left eye. You drop the signs and add 1.50D and 1.00. The result is 2.50. You can now see the right lens (3.50 total power) is stronger than the left lens (2.50 total power). This means you would optically center the right lens first. Then, without moving the lens table, move over to the left lens and determine the total amount of vertical prism, if there is any present. If the optical center moved up, you would have BU prism in the left eye. No vertical displacement of the optical center means no vertical prism.

Let’s try another example:

OD: +2.00 –4.00 × 180
OS: +4.00 –2.00 × 180

Based on the Rx above, you need to determine which lens to center in your lensmeter first. Remember you are looking for the lens with the stronger total power.

In this case, both lenses have a total power of 6.00D (2.00 plus 4.00D for the right lens and 4.00 plus 2.00D for the left lens). *They are the same power*, so neither lens is stronger. Therefore, it would not matter which lens you center first. Your vertical prismatic measurement would be the same either way. If you want to be consistent, you can pick the right lens as your starting point when total powers are equal.

If there was vertical prism ordered, start by optically centering the lens where there is *not* supposed to be any prism. Once you have this lens optically centered, move over (without adjusting the lens table) and see if there is any deviation of the optical center. If there is, compare to the Rx and using ANSI standards, determine if the spectacles are acceptable.

Horizontal prism

The ANSI standards state horizontal prism [i.e., base in (BI) or base out (BO)] must be within 0.67Δ of the original order. Therefore, if no horizontal prism is ordered, the most you can have without rejecting the spectacles is a total of 0.67Δ base in or base out prism. If you find 0.75Δ or more, reject the spectacles and return them to the lab.

If no BI or BO prism was on the original order, you first measure the distance between the OCs of the lenses to determine if there is even a need to check for unwanted horizontal prism. If the distance between the OCs of each lens is within 2.5 mm of the PPD, there is no need to measure for horizontal prism.

It is only when the difference between the OCs and the PPD are off by 3 mm or more that you must measure the total amount of horizontal prism present. To do this, you're going to need a felt-tipped marker and a PD ruler.

Let us assume you ordered DVO spectacles for a patient with a distant PD of 64. When you get the spectacles, you find and, using your felt-tipped marker, "dot" the OC of each lens with a lensmeter. You then use your PD ruler to measure the distance between the dots on the lenses. You find the OCs are only 60 mm apart. This is a difference of 4 mm. Since this is greater than the allotted 2.5mm difference, you need to check for horizontal prism. What you want to check is *the prismatic effect where the patient actually looks through the spectacles*. You know your PPD is 64 mm but that you received spectacles with OCs only 60 mm apart. Therefore, the OCs are a *total* of 4mm too close together. Your PPD is further *out* than where the OCs have been placed.

This means that in order to measure the horizontal prismatic effect where the patient looks through these lenses, you need to measure *out* from your dotted OCs. The OCs are a *total* of 4 mm too close and you have 2 eyes being affected. Therefore, you will want to split that total difference between the 2 eyes. When you divide your total of 4 mm by 2, you find that the OCs need to be moved 2 mm *out in each lens*. You will want to mark each lens with a new dot at this point, 2 mm *out* from your previous dot. The new dots you just marked represent the place where the patient's eyes (which are 64 mm apart) actually look through the lenses. Now you can center these new dots in the lensmeter and see how much horizontal prism the patient experiences when looking through each lens. Let's say you find 0.25Δ BI in one lens and 0.50Δ BI in the other. Add together the BI prism from each eye, giving you a total unwanted prismatic effect of 0.75Δ. This exceeds the total acceptable amount of 0.67Δ. These spectacles are unacceptable.

Let us do another example. The patient has a near PD of 60 mm. The 5A NVO Rx spectacles you ordered for the patient arrive at your clinic and you measure the Rx and dot the OCs with the lensmeter. You measure the dots from one OC to the other and find the OCs are 68 mm apart. You see the PPD and the lens OCs are off by a *total* of 8 mm. This means a difference of 4 mm in each eye. Since you have more than 2.5 mm difference between the PPD and the OCs, you have to measure for horizontal prism.

The OCs are at 68 and the PPD is at 60. Therefore, the OCs are a *total* of 8mm too far apart. Your PPD is further *in* than where the OCs have been placed. To measure prismatic effect at the point where the patient looks through the lens, you need to measure *in* 4 mm on each lens, and make a new dot. This new dot represents where the patient would actually look through the lenses. Center this dot in the lensmeter and see how much unwanted prismatic effect is present.

Let's say in one eye you see 0.75Δ of BI prism; and in the other eye, you see 0.50Δ of BO prism. BI and BO prisms cancel each other out, so the *total* induced prismatic effect would only be 0.25Δ BI. This is well below the ANSI allowable amount of 0.67Δ. These spectacles would be acceptable (at least from the standpoint of horizontal prism).

You center the new dots you made on the lenses in the lensmeter by using a felt tipped-marker to draw a vertical line through the dots to the top of the lenses. This gives you have a visible reference mark to use when centering the lenses.

Admittedly, there are a number of lensmeter steps to measure horizontal prism. If you'd prefer a mathematical procedure, one does exist. Prentice Rule is another route you can use to determine horizontal prism. Whichever method you use is up to you as long as you grasp the concept and feel comfortable doing it.

Using Prentice Rule to calculate horizontal prism in spherical lenses

Prentice Rule is a method using a mathematical formula to calculate prismatic effect. The formula is easiest to use on simple spherical lens prescriptions. However, if the major meridians are within ±10º of 180 and 090, it can work on spherocylindrical lens prescriptions as well. We'll discuss how the formula works on simple spherical lenses first, and then move on to how it works on the spherocylindrical lens Rxs.

The Prentice Rule is a simple mathematical formula. You take the Rx for one eye, multiply it by the number of millimeters the OC is off from the desired location of that lens, and then divide the answer by 10. The result is the amount of prismatic effect found in that lens. Once done, you have to figure out if the prism is BI or BO. Here is the Prentice Rule formula:

Dec**entration (in mm) × lens **Rx = **PRISM** Amount

10

Look at the example below:

The patient's Rx is

OD: –2.00 SPH
OS: –3.00 SPH

The **OC**s of the spectacles measured **62 mm**.

The **PPD** measured **68 mm**.

You will take 68 mm – 62 mm and find a total of 6 mm difference in decentration (dec) between the desired (PPD) and what you actually received (the OCs). This means a 3-mm difference in each eye. The Prentice Rule formula looks like this for the **OD**:

3 mm (***dec***) × **2.00D** (***Rx***) = **6.00**
6.00 ÷ **10** = **0.6Δ**

The formula for the **OS** looks like this:

3 mm (***dec***) × **3.00D** (***Rx***) = **9.00**
9.00 ÷ 10 = **0.9Δ**

Now you just need to determine if the prism is BI or BO. This depends on the lens type, whether it is a plus or minus lens. Remember, a plus lens looks essentially like two prisms put base to base and a minus lens looks like two prisms put apex to apex. Using this concept, draw a picture of your lenses. The point where the bases or apexes come together is your OC location. Then you just figure out where the patient's eyes are in relation to the OCs.

Going back to our example, each lens was a minus lens, so draw two minus lenses, as shown in figure 3–44. Mark the OCs, which are at 62 mm. Now draw where the patient's eyes actually look through the lenses—out at 68 mm in this case. The nearest base for each eye is the base that is **OUT (**fig. 3–44). Combining this knowledge with Prentice Rule results, you could tell there is **0.6Δ BO** in the OD and **0.9Δ BO** in the OS. Since 0.6Δ **BO** prism and 0.9Δ **BO** prism are added together, the *total* prismatic effect is **1.5Δ BO** and far exceeds the allowable ANSI standard of 0.67Δ.

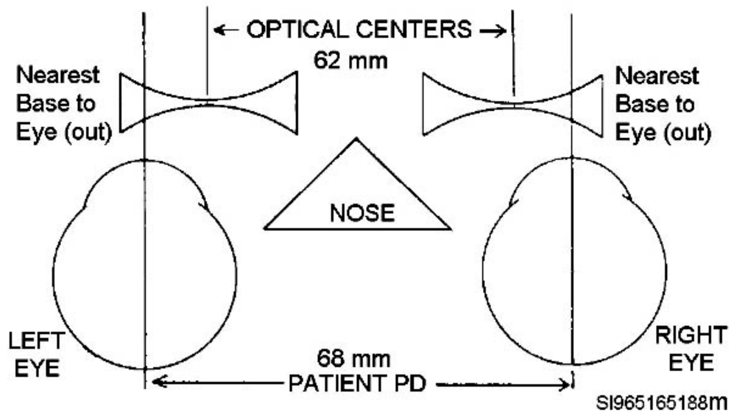


Figure 3–44. Two minus lenses with OCs 62 mm apart and PPD at 68 mm.

Another way to determine the base direction is to look at the type of lens (plus or minus power) and the PD and OC centers. In this example, the OD is a minus lens. With a *minus* lens, you want to start with the measurement that was *manufactured*. Of the two measurements (PD and OC), the OC was the *manufactured* measurement. Therefore, we start with the OC and go towards the PD. To go from 62 mm to 68 mm you travel in an *out*ward direction. Therefore, your base direction is BO. Now look at the left eye. Again this is a minus lens so we start with the OC (remember *minus* = *manufactured*). The OC is 62 mm, the PD is 68, and just like the right lens, the induced prism is BO because you went out from 62 to 68.

If the lens is a plus lens, we use this reminder: *plus* = *PD*. When you have a plus power lens, you start with the PD and go to the OC.

Try a plus power Rx, using the Prentice Rule:

The patient's Rx is:

OD: +4.50 SPH
OS: +5.00 SPH

The **OC**s of the spectacles received is **60 mm**.

The **PPD** is **70 mm**.

The total amount of decentration error is 10 mm. This means each lens is off by 5 mm. Now apply the Prentice Rule.

OD: **5 mm** (***dec***) × **4.50** (***Rx***) = **22.5**
22.5 ÷ 10 = **2.25Δ**

OS: **5 mm** (***dec***) × **5.00** (***Rx***) = **25**
25 ÷ 10 = **2.50Δ**

The spectacles have plus lenses (two prisms base to base) with the OCs at 60 mm and the PPD at 70 mm. The nearest base for the patient's OS and OD would be *in* (fig. 3–45). Therefore, the 2.25Δ **BI** and the 2.50Δ **BI** are added together; and the *total* prismatic effect would be **4.75Δ BI**.

Because we have a *plus* lens, we know we start with *PD* and go to the OC. Therefore, we can figure the direction as follows:

OD is a +4.50 so we start with the PD and go to the OC – 70 mm to 60 mm. We went *in* from 70 to get to 60. Therefore, the prism direction is BI.

OD is a +5.00 so we start with the PD and go to the OC – 70 mm to 60 mm. We went *in* from 70 to get to 60. Therefore, the prism direction is BI.

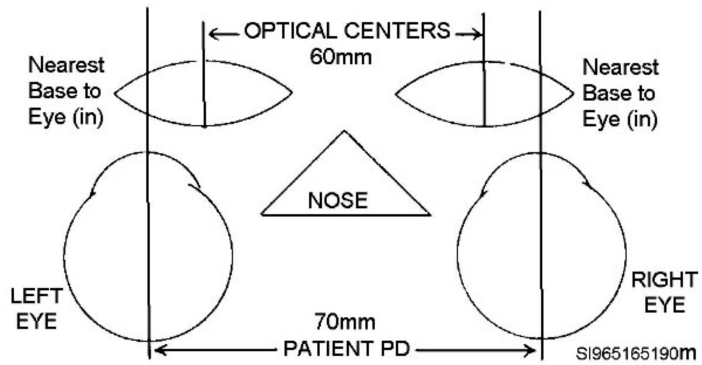


Figure 3–45. Two plus lenses with OCs 60 mm apart and PPD at 70 mm.

Let us do one more example using a simple spherical Rx, but this time we have one plus lens and one minus lens so you can see what occurs in such a case.

The patient's Rx is

OD: –1.00 SPH
OS: +2.00 SPH

The **OC**s of the spectacles is **69 mm** apart.

The **PPD** is **61 mm**.

The *total* amount of decentration is 8 mm. This means each eye is off by **4 mm**. When you apply the Prentice Rule, the amount of prism looks like this:

OD: **4 mm** (dec) × **1.00** (Rx) = **4.00**
4.00 ÷ **10** = **0.4Δ**

OS: **4 mm** (dec) × **2.00** (Rx) = **8.00**
8.00 ÷ **10** = **0.8Δ**

The left lens is a plus lens, looking like two prisms placed base to base. The right lens is a minus lens, looking like two prisms placed apex to apex. The nearest base for the patient's eye in the OD lens is *in*. The nearest base for the patient's eye in the OS lens is *out* (fig. 3–46). **0.4Δ BI** and **0.8Δ BO** have opposite prisms directions that cancel each other out. Therefore, the only prism that remains is from the OS lens as it has *the most prismatic effect*. In this case, the OS lens has more prismatic effect, so the remaining total amount of prism would be **0.4Δ BO**.

Using our *plus* Rx = starting with *PD* and *minus* Rx = starting with (*manufactured*) OC, we can figure the direction as follows:

OD is a –1.00 so we start with the OC and go to the PD – 61 mm to 69 mm. We went *out* from 61 to get to 69. Therefore, the prism direction is BO.

OD is a +2.00 so we start with the PD and go to the OC – 69 mm to 61 mm. We went *in* from 69 to get to 61. Making the prism direction is BI.

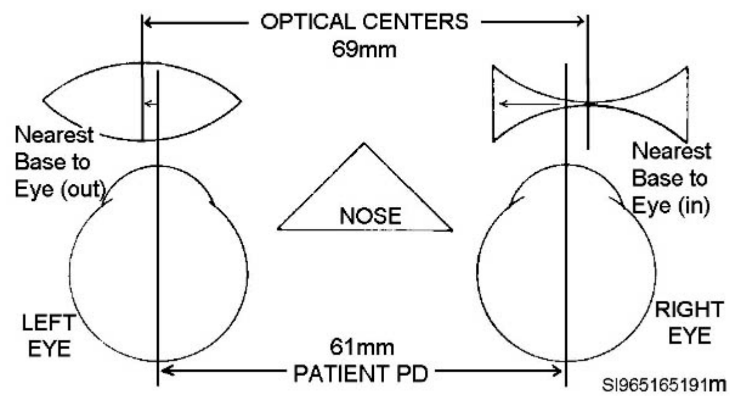


Figure 3–46. A plus lens and a minus lens with OCs 69 mm apart and PPD at 61 mm.

Using Prentice Rule to calculate horizontal prism for spherocylindrical lenses

There is one major difference when using the Prentice Rule for calculating prismatic effect on spherocylindrical lenses. Before you can apply the Prentice Rule formula to a spherocylindrical lens, you must find out how much power is in the horizontal (180°) meridian of the Rx. Once you find the total power for the horizontal meridian, use that dioptric power in the Prentice Rule formula just as you did before.

For our purposes, the horizontal meridian encompasses any axis within ±10° of 180 (i.e., between 170° and 010°). Trying to calculate the amount of power in the horizontal meridian when a lens does not have a major meridian within this range (170° to 010°) gets complicated. For these cases, just go back to the lensmeter method to determine prismatic effect.

If you remember your optical cross, determining the power in the horizontal and vertical meridians is easy. If not, read this next part carefully. It is a shortcut to figuring out the power in each meridian, so you do not have to do an optical cross.

There are two rules about sphere power:

1. Sphere power is on all meridians.
2. The sphere power is “married” to the axis of the Rx. Meaning the only power on this axis is the sphere power.

Example:

Assume the Rx is –2.00 –1.00 × 090. In this example, there would be –2.00D of power at the 090° (vertical) meridian, because the axis is 090 and the sphere power is –2.00 and the two are married; only –2.00 can go on the 090° meridian.

The cylinder power goes on the meridian 90º away from the one shown in the Rx. Therefore, the –1.00 goes at the 180° meridian. However, remember rule #1 about sphere power: it goes on all meridians. Therefore, at the 180° meridian there is the –1.00D cylinder power and the –2.00D sphere power. This gives a *total power* in the 180° meridian of –3.00D for the Rx –2.00 –1.00 × 090. This is the Rx power you would use when doing your Prentice Rule calculations.

Let’s try another example:

The Rx is +3.00 –3.00 × 180. Remember, you want the power of the horizontal (180°) meridian. The sphere power is +3.00D and the axis is 180. Sphere power is married to the axis. Therefore, in this example, that’s it: +3.00D is the total power in the 180° meridian.

How about another one:

The Rx is –0.50 –0.50 × 080. The power at the 080º meridian is the sphere power of –0.50. The horizontal meridian 90º away is 170°. The power at this meridian is a combination of the sphere and the cylinder power, so –0.50 plus –0.50 gives a total of –1.00D in the 170° meridian. –1.00D is the power you use in the Prentice Rule formula to calculate prismatic effect.

Using the Prentice Rule, calculate the prismatic effect for the following spherocylindrical lens prescription:

Patient Rx:

OD: –3.50 –1.25 × 100
OS: –4.00 –2.00 × 175

Begin by figuring out the power in the horizontal meridians of each lens. For the OD, the power in the 100° meridian is –3.50, and the power in the 010° meridian (the horizontal meridian) is –4.75. So, use **–4.75** in the Prentice Rule formula for the OD.

For the OS, the 175° meridian is already the horizontal meridian, so the power at that meridian is **–4.00**. You would use –4.00 in the Prentice Rule formula for the OS. Now you can move on to the other information needed to use the Prentice Rule formula: the OC and PPD measurements.

OCs received at **60 mm.**

Patient's **PD** is **50 mm.**

There is a *total* decentration difference of 10 mm, which translates to 5 mm for *each eye*.

OD: **5 mm** (dec) × **4.75** (horizontal meridian power) = **23.75**
23.75 ÷ 10 = **2.375Δ**
OS: **5mm** (dec) × **4.00** (horizontal meridian power) = **20.00**
20.00 ÷ 10 = **2.00Δ**

Now you have to figure out if the prism is going base in or base out. Use the same concepts as before. To determine where the nearest prism base is, you can use the method of drawing out the lenses and placing the eye (PPD) in the appropriate location in relation to the OCs. The other option is to look at the Rx and move from the PD to the OC (+ power) or OC to the PD (– minus power). If you look at figure 3–47, you see two minus lenses drawn with the OCs shown at 60 mm and the patient's eyes at 50 mm. The nearest base for each eye is *in*. So 2.375ΔBI and 2.00ΔBI are added together, giving a total prismatic effect of **4.375ΔBI**.

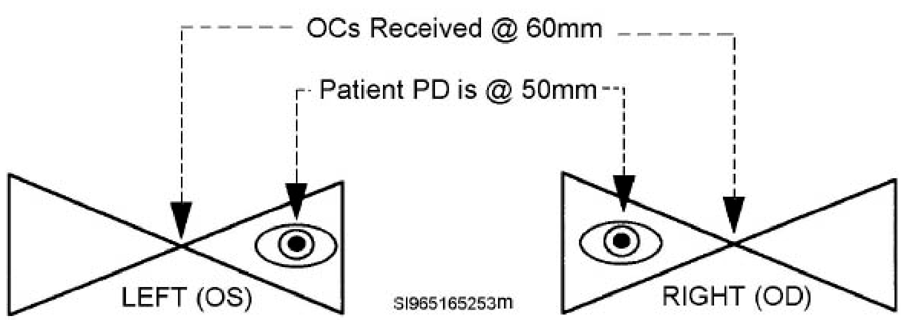


Figure 3–47. Two minus lenses.

Here's another example just to make sure you have it.

The patient's Rx is:

OD: +2.00 –1.00 × 085
OS: +4.00 –5.00 × 090

You need to determine the horizontal meridian power for the OD. You should end up with **+1.00** (+2.00 and –1.00 at the 175° meridian).

Next, you need to determine the horizontal meridian power for the OS. You should end up with **–1.00D** (+4.00 and –5.00 at the 180° meridian).

The **OC**s received at **60 mm**.

The patient's **PD** is at **70 mm**.

The *total* decentration is 10, which is 5 mm in each eye.

OD: **5 mm** (dec) × **1.00** = **5.00**
5.00 ÷ 10 = **0.5Δ**
OS: **5 mm** (dec) × **1.00** = **5.00**
5.00 ÷ 10 = **0.5Δ**

The OS lens is a minus lens. The OD lens is a plus lens. Draw a picture of the two lenses with the OCs and the patient's PD. This reveals the nearest prism base for the OS lens is *out*. The nearest prism base for the OD is *in* (fig. 3–48). 0.50ΔBO and 0.50ΔBI cancel out each other. In essence, the *total* induced prismatic effect is *zero.*

Using the Prentice Rule can speed up your verification process at times, but it requires a lot of practice to get to the point where it becomes second nature. If you follow the rules and examples given here, you should be able to understand the process and apply your knowledge to calculate prismatic effect, regardless of whether the Rx is a simple sphere or a spherocylindrical lens with at least one of its major power meridians within ± 010° of 180 (i.e., between 170° and 010°).

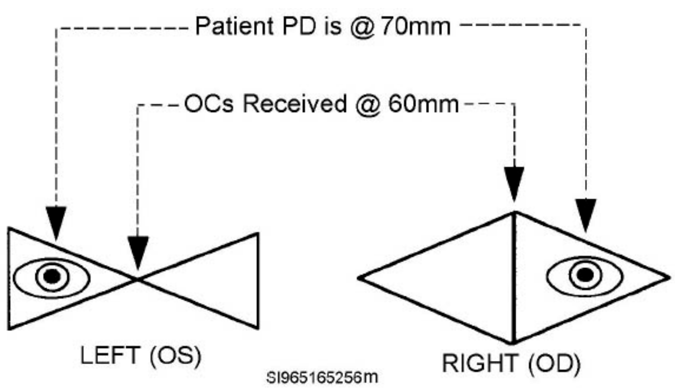


Figure 3–48. Lens powers the same; no prismatic effect.

Spectacle verification checklist

Here's a quick checklist you can follow when verifying a pair of spectacles.

1. Ensure frame size, style, and temples are accurate.
2. Examine lenses for defects.
3. Measure the segment heights.
4. Neutralize Rx: sphere, cylinder, axis, (and "Add" if spectacles are multifocal).
5. Check for prism tolerances: vertical and horizontal.

416. Repairing and adjusting spectacles

While not the most glamorous part of working at the ophthalmic clinic, repairing and adjusting spectacles is vital to the job. Patients come in every day with broken glasses they need repaired or to pick up glasses they need adjusted. In addition, flight members may come in with problems unique to their flight frames and their required gear when flying. Whatever the problem, they all are depending on your help.

Repairing and adjusting spectacles can actually be a very satisfying task to perform because you can help so many people so easily. This is one of the tasks you will come to master. You will be the expert, not the doctor. It makes a difference to patients who have been struggling with a frame and they will remember and speak positively of you.

So let's look at how to solve some of the problems patients might bring to you.

Repairing spectacles

Repairing spectacles is as easy as replacing the broken or damaged parts of the frame. Unfortunately, if the lenses are damaged or broken, you will have to reorder a completely new pair of spectacles rather than repair anything. The only parts you can replace or repair are on the frame itself: the frame front and temples (fig. 3–49).

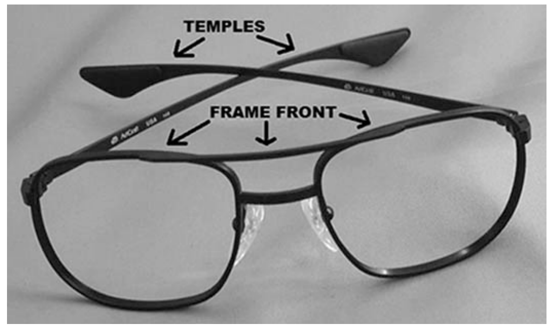


Figure 3–49. Frame front and temples.

Temples

One of the most common problem with temples, particularly with the half-eye frames, is the rivets holding the hinge barrels. Over time, through wear and tear, they work themselves loose. You can easily remedy loose rivets with a hinge and staking tool (fig. 3–50). The hinge and staking tool is like a little press that can be used in many different ways to aid in repairing spectacles.

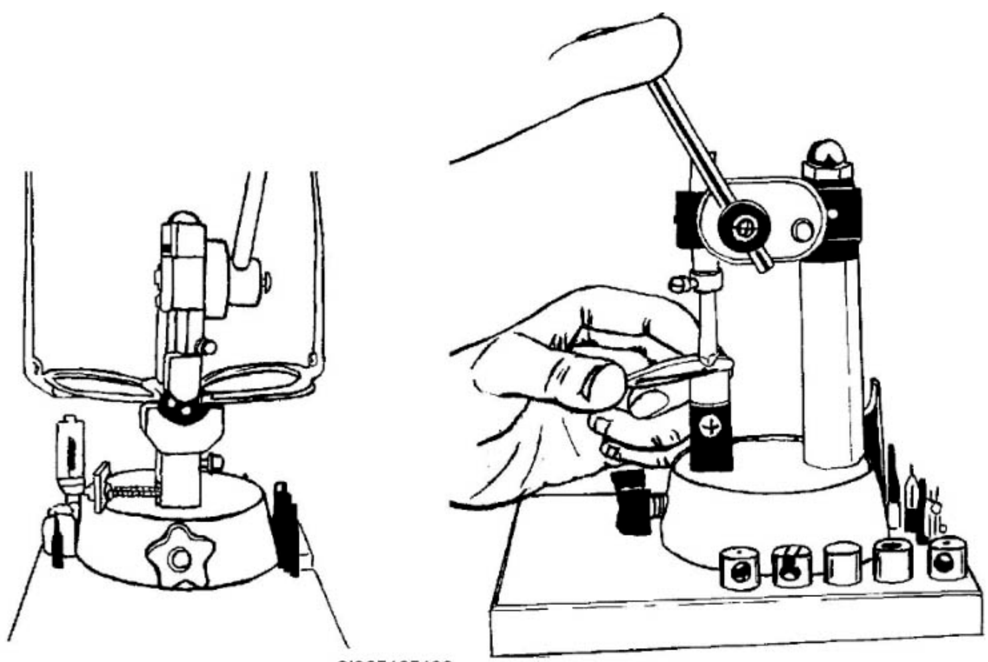


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Figure 3–50. Hinge and staking tool.

If you have a frame that has rivets on the temple or frame front that need tightened, put the peening punch into the hinge and staking tool, line up the loose rivet, and pull the lever of the tool to compress the rivet.

If you do not have a hinge and staking tool, you may be able to tighten the rivets using the rivet-burnishing pliers. However, these pliers require you to squeeze *really hard* to get any noticeable difference.

An automatic punch is another tool used for tightening rivets. You set the temple against something hard (e.g., an optician's anvil), place the tip of the punch against the rivet needing tightened, and push down on the punch. The punch compresses and then releases with a "thunk", peening the rivet. Noisy and obnoxious, but it works. You probably have to repeat the process three or four times to get the rivet tight enough.

Another problem you may encounter with half-eye temples is that the plastic may split where the rivets go through the plastic. If this happens, you will need to replace the temples.

To replace a temple, remove the old screw using an optician's screwdriver (fig. 3–51) and an optician's anvil (or the edge of a table). Use the anvil (or table) so you can put the hinge against it and use a fair amount of downward pressure on the optician's screwdriver as you unscrew the old screw. By pushing down as you loosen the old screw, there is less chance of the optician's screwdriver slipping out of the slot and stripping the screw head. Before you try removing a screw, you should check to see if it is flared. If it is, file off the flared section to allow the screw to back out easier.

Figure 3–51. Optician's screwdrivers.

The other reason for using the anvil or table is safety. If the optician's screwdriver slips out of the slot in the screw head, you do not want your hand to be on the other side or you may stab and injure yourself.

When you install the new temple also put in a new screw. You want to tighten it down firmly and then flare the tip of the screw with the flaring pliers (also called screw or rivet peening pliers) (fig. 3–52). You flare the tip of the screw to keep it from coming out on its own. Keep in mind, however, that you may have to remove this screw one day. There is no need to flare the screw tip with all your might when a gentle squeeze of the flaring pliers is sufficient.

Figure 3–52. Flaring (screw or rivet peening) pliers.

If you do strip the screw head, and the optician's screwdriver is no longer effective, try the screw remover/extractor (fig. 3–53). This tool looks like the optician's screwdriver, except the tip has multiple sharp points to "bite" into the metal of the screw. You need to push this tool into the screw head with a lot of downward pressure, so the "teeth" bite into the metal and do not slip as you turn the tool to remove the screw. Again, use a hard supporting surface (not your hand) under the spectacles as you do this.

Figure 3–53. Screw remover/extractor.

Flight frame temples

Often, you will find that either a fellow ophthalmic technician, the patient, or a combination of both, have bent and adjusted the temple of a flight frame so many times that it is beyond repair. In those cases, rather than try to straighten it out, just replace the temple. Nose pads on the flight frames are also a high-repair item. They frequently break or come off so it is beneficial to keep extra nose pads on hand. They are easy enough to change: remove the screw holding the nose pad in, remove and replace the nose pad, and then re-insert the screw.

Replacing frame fronts

Some problems, such as a crack in the frame front or a broken bridge bar, require you to remove the patient's lenses and replace the frame front. Because you will be removing the lenses from their set position in the frame, you will need to know the patient's most recent prescription. If you cannt find it in AHLTA or SRTSweb, you will need to neutralize the patient's spectacles with a lensmeter and mark them *before* you disassemble them. This allows you to put the axis of the lenses back where they were before you removed them from the frame.

To replace the lenses from most plastic frame fronts, the easiest method is heating the old frame in the frame warmer (fig. 3–54) and then pushing the lenses out of the *front* of the frame.

If the lenses are cut similarly and they might be easily confused, when you pop the lenses out of the old frame front you will want to mark which lens is which (i.e., "R" or "L"). If you do confuse the lenses, you should have the obtained the patient's Rx before beginning, so you can use the lensmeter to help determine the left lens from the right.

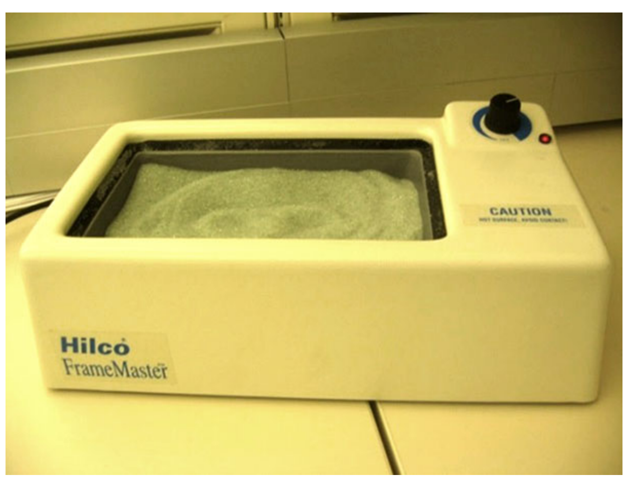

Figure 3–54. Spectacles frame warmer.

Once the lenses are out, you're ready to put them in a new frame front. This requires heating the new frame front until it is warm, but not "mushy." Insert the lenses into the new frame front temporal side first, then nasal side last. Always insert from the front of the frame. If it takes you a little while to get the first lens in, you probably need to reheat the frame a bit before trying the second lens. Be careful to avoid distorting and twisting the new frame when trying to get the lenses in. Sometimes, the lenses go in easily and sometimes they are almost impossible to get in. If you have trouble getting the lens into a particular frame front, grab a different one. Frame fronts marked the same size can vary slightly, so one frame might be a tad “looser” than another frame.

On rare occasions, you may find the lenses go into the replacement frame front too easily. So easily, in fact, that the lenses may actually be a bit loose in the frame. You can try shrinking the frame around the lenses by sticking the frame into the frame warmer to warm it up, and then quickly immersing the frame into cold water. If you do this several times, the plastic might shrink enough to hug the lenses securely.

Keep in mind, if the patient’s original frame was 50–20, you should replace it with a 50–20; if it were a 46–18, replace it with a 46–18. If you change the bridge size, you in effect change the decentration of the lenses. For a person who has a powerful Rx, this could cause problems by inducing unwanted prismatic effect. Of course, you cannot change the eye size because the lenses are cut to fit a specific sized-frame. However, if you want to change the temple length, you can find an alternate size that best suits the patient. Unfortunately, you do not have the same leeway with the bridge or eye size.

Once you get the lenses into the new frame, you need to reorient the axis. You will need to use the lensmeter to read the axis of each lens. If the axis is off, you will need to adjust it by using the frame warmer to heat the frame a little. This allows you to rotate the lens using the axis aligning pliers (fig. 3–55).

Figure 3–55. Axis aligning pliers.

While looking at the spectacles from the front (i.e., as if they were on the patient), you rotate the lens CCW to increase the axis and CW to decrease the axis. Use figure 3–56 to help you visualize. Notice, it does not matter if it is the right or the left lens; you still rotate the lenses just as described. One way to remember which way to rotate the lens, think of it as a clock. If you want more time; that is, more axis, you turn the clock back (CCW); if you want less time (i.e., less axis) you turn the clock forward (CW).

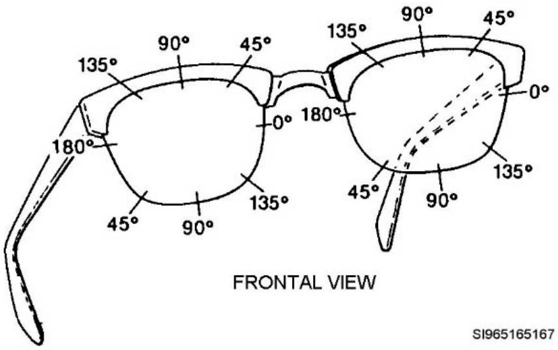

Figure 3–56. Frame front with axis meridians shown.

Flight frame fronts

When repairing flight frames, remember these frames exist to satisfy an occupational need. You are not just repairing for a good fit and pleasant cosmetic appearance but the frame must also remain structurally sound. While you may be able to bend a distorted frame back into a shape that fits and looks okay, you need to ensure it is still structurally acceptable. All the repairs and adjustments to a moderately distorted frame may have weakened the metal. In these cases, it is probably best to remove the lenses and replace them in an entirely new frame front.

You may also encounter stripped screw holes for the eyewires or temples in the flight frame front. You will know this is the case when you try to tighten the screws and they never actually get snug—they just keep spinning. The lenses of the flight frame are held in place by tension from the eyewire screw, so it is especially important the screw fit snuggly. You will need to replace the frame front in these instances.

Another issue may be that the flight frame is broken where the temple mounts to the front, or where the eyewire screws into the front. While rare, it does happen. To fix this problem, simply replace the frame front.

As stated earlier, when working on flight frames, you have to take wear and tear seriously. If damage to a flight frame front occurs, replace it before something actually breaks. The risks to flyers are plentiful enough without adding problem spectacles to the list.

Replacing a flight frame front is easy. As before, establish the Rx before taking the lenses out of the old frame so you can get the lenses back to the correct cylinder axis when you reassemble it. Remove the lenses. To do this, you have to remove the eyewire tension screws. Follow the earlier advice about using a solid backing to support the spectacles as you unscrew them so you do not stab yourself.

Once the lenses are out, discard the old frame and get a new one. Put the lenses in the eyewire of the new frame and tighten the eyewire tension screws just enough to hold the lenses in place without falling out. Check the axis of each lens with the lensmeter. Adjust as necessary with the axis aligning pliers. Once you get the axis correct, finish tightening the eyewire tension screws just as snugly as you can without stripping the screw heads. Now, use the flaring pliers (i.e., screw and rivet peening pliers) to flare the tip of the screws so they do not back out on their own. For flight frames, this is an especially important step. You really do not want a lens falling out on a flyer during flight duties.

Adjusting spectacles

Before you actually fit a pair of spectacles to a patient, you need to start with spectacles that are straight and aligned. Often, if you do this from the beginning, the patient is satisfied with the fit as is. Then, if they do not fit perfectly, you're at least a lot closer to getting them to fit the patient than if you did nothing.

When adjusting glasses, your goal is to get the nose pads (if adjustable), frame front, and temples to a neutral and straight starting position. From there you can move on to actually fitting the spectacles specifically to the patient. What follows are step-by-step procedures for getting a pair of spectacles *ready* for a patient fitting.

Step 1: Align adjustable nose pads (if applicable)

If the spectacles have adjustable nose pads (fig. 3–57), you need to ensure the tops of the pads are closer together than the bottoms and the pads are the same distance from the eyewires on both sides. Finally, the pads should be sloped back slightly (i.e., flared more at the rear than at the front). All this allows the nose pads to conform to the shape of the nose.

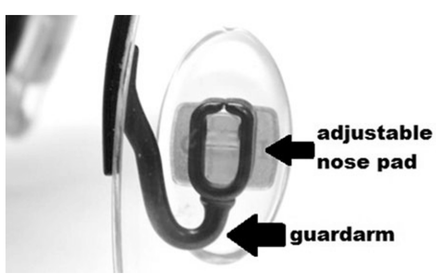

Figure 3–57. Adjustable nose pads.

There are two tools used to adjust adjustable nose pads. Of the two, the easiest to use is the European pad-adjusting pliers (fig. 3–58). These pliers grab a portion of both the guard arm and the pad itself, making manipulation of the pad to the desired position relatively easy.

Figure 3–58. European pad adjusting pliers.

The chain or snipe nose pliers is another tool used for adjusting the guard arms on which the nose pads are mounted (fig. 3–59). Using this tool requires a little more skill to get the adjustment just right, but it is a good choice for the more experienced technician.

Figure 3–59. Chain or snipe nose pliers.

A word of warning about manipulating adjustable nose pads: Do not adjust them too much. They have the tendency to snap off just as the tab of a Coke® can if bent excessively. That is the reason aligning adjustable nose pads is step #1. If you do happen to accidentally snap off a nose pad and end up having to replace the frame front, you have not spent a lot of time getting the frame front and temples adjusted yet.

Step 2: Frame front

Next, you want to ensure the frame front is not twisted and make sure the frame has a slight curve toward the patient's head (face form). "Face form" is the term used when the frame front curves slightly to match the curve of the face.

You can check whether the frame front is twisted or not by looking at the frame front from above. Look to see if the lower eyewires are an equal distance from the edges of the upper eyewire. If they are not, the frame front is twisted. If it is twisted, and you are working with a plastic frame, you can straighten it out by heating the frame at the bridge, and then twisting the frame back into alignment using your hands.

A note on using the frame warmer: Whenever you are heating a plastic frame in a salt or glass-bead frame warmer, move the frame around continuously. This accomplishes two things: (1) distributes heat to the frame evenly and (2) prevents of "pitting" or "stippling" of the plastic by the salt or glass beads.

If a metal frame is twisted, you do not heat the frame to correct the problem. Just twist the frame front as necessary to get the eyewires lined up with each other or replace the frame. Once you have gotten the frame front untwisted, you want to check to see that it has some “face form.”

You want just a little curvature, nothing too excessive. You can put some “face form” into a plastic frame by heating it at the bridge and bending each side of the frame back slightly. The flight frames usually have good face form “as is,” but if you feel they need some adjustment; just bend the frame slightly with your hands. Bend at the bridge and be careful not to twist the eyewires in the process.

Once the frame front is correct, you can move on to adjusting the temples. You will want to check the temples for horizontal and vertical alignment.

Step 3: Horizontal temple alignment

To check the horizontal temple alignment, hold the spectacles so you are viewing them from the side, or you can set the spectacles upside down on a flat surface. Either way, make sure you have the temples opened as wide as they can go. Now look at the temples. Do they appear parallel and level with each other? If not, move one temple up or the other temple down until they are parallel. If you have the spectacles lying on their back on a flat surface, they are aligned horizontally when the bent portions of the temples touch the table at the same time.

If the temples are not aligned horizontally and you do not know which temple to bend up or down, keep this in mind: the standard pantoscopic angle is approximately 8–10° (fig. 3–60).

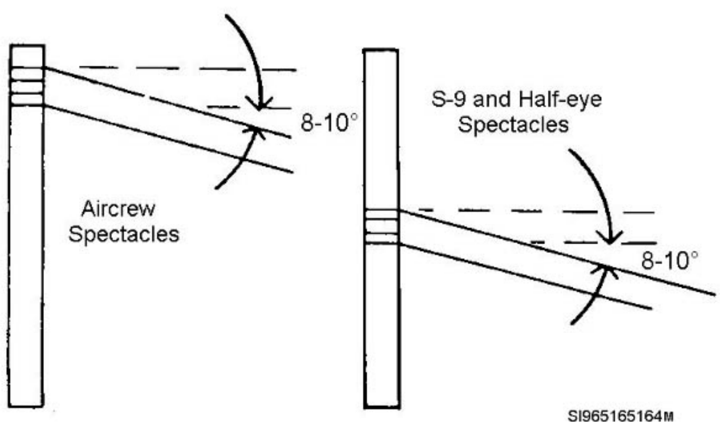

Figure 3–60. Correct pantoscopic tilt for spectacles.

Adjust the temple farthest from this desired range leaving the temple in the correct position alone. If both temples are in the wrong position, or actually causing retroscopic tilt (fig. 3–61), adjust both of them.

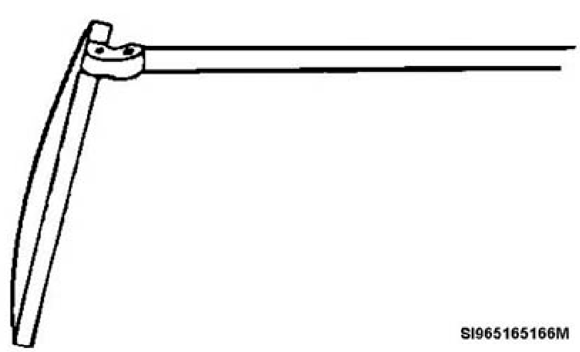

Figure 3–61. Retroscopic (incorrect) tilt.

On plastic frames, use the Zyl temple-angling pliers to adjust the temple angle (fig. 3–62). With this tool, you grab the hinge of the temple needing adjustment and twist up or down to adjust the temple higher or lower.

Figure 3–62. Zyl temple angling pliers.

Use the finger piece pliers to adjust the temple angle on the flight frame (fig. 3–63).

Figure 3–63. Finger piece pliers.

With this tool, you grab the hinge of the temple needing adjustment, but instead of twisting the hinge with the tool, you hold the hinge still. Then, you grab the temple itself with your free hand, and bend it up or down. Use the finger piece pliers to hold the frame front/hinge area steady so your manual manipulation of the temple does not twist the frame or hinge area, causing a lens to chip or the frame to weaken structurally.

Once you get the temples level with each other horizontally and have the desired pantoscopic tilt (standard pantoscopic angle for all spectacles is approximately 8−10°), you are ready to move on to getting the temples parallel and straight vertically.

Step 4: Vertical temple alignment

To check the vertical temple alignment, hold the spectacles with the lenses "looking" at the floor and the temples sticking up. Be sure the temples are open to their fullest position. Do the temples rise perfectly perpendicular from the frame and are they parallel to each other? If not, you need to adjust the temples, in or out, as appropriate.

To adjust a temple not opening far enough, you file material off the butt of the temple. Filing removes material from where the temple contacts the frame and allows the temple to open farther before contacting the frame. This applies to both the metal and plastic frames. Use a fine-toothed metal file on the metal frames and a coarser file on plastic frames (fig. 3–64).

To adjust a temple opening too far is a bit trickier. In essence, too much material is missing and the temple is opening too far before the butt contacts the frame. You cannot add material to the butt of a temple. Instead, you have to bend the temple inward from a point as close to the hinge as you can manage.

Figure 3–64. Files that can be used on spectacles.

With a plastic frame, heat up the temple near the hinge. Then, with the Zyl gripping pliers, also known as end-piece gripping pliers (fig. 3–65), grab the temple as near the hinge as you can and bend in. Be sure you have the metal part of the tool on the inside of the temple and the padded portion on the outside of the temple, so the tool does not mar the temple. With the gripping pliers, hold the temple firmly, and with your free hand bend the temple inward, right at the point where the tool is holding the temple. Again, you bend the temple with your hand. The tool just holds the temple at the hinge and provides a pivot point for your bend.

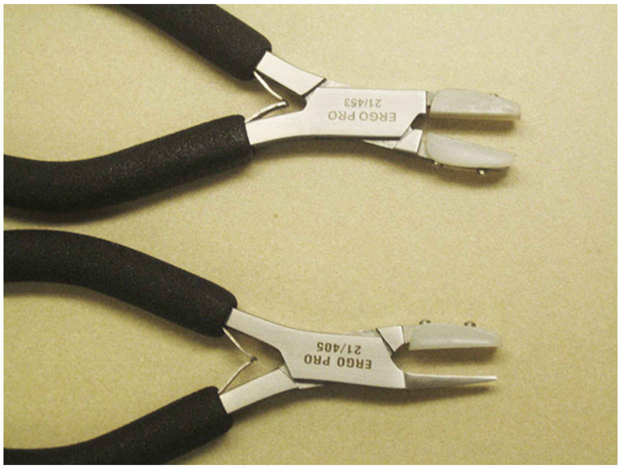

Figure 3–65. Zyl gripping pliers.

With the temple still warm, you can fine-tune it until you get it straight and parallel with the other temple. Once you get it where you want it, dunk the warm part of the temple in cold water to "set" your adjustment. This prevents the temple from "migrating" back to where it was before you made the adjustment.

To adjust a metal frame temple inward, just use the same tool and technique you would use for the plastic frames, but skip the frame warming/cooling portion.

Once you have gotten the temples vertically perpendicular to the frame front and parallel to each other, you are ready to fit the frame to the patient.

Fitting the frame to the patient

If you have pre-adjusted the spectacles into correct alignment and if the person who selected the frame size and temple length for the patient did a good job, the spectacles fit the patient 80 percent of the time without further adjustment. For the other 20 percent of patients, you need to do some fine-tuning to get things just right. Follow the steps below for assessing and correcting spectacles to fit your patient.

Step 1: Adjust nose pads (if applicable)

Before you start tweaking the other parts of the frame, check to see if nose pads are sitting on the patient's face correctly. You want the nose pads to have even, complete contact with the nose. You can tell if a nose pad is pushing harder in one area or another by observing the pads from the front, top, and sides. If part of the nose pad seems to be "in the flesh" more than another part, it is probably pushing in harder at that point. Adjust it with the European pad adjusting pliers or the chain/snipe nose pliers until you have even contact of the nose pads on the nose. If the nose pads are adjusted incorrectly, they will leave red marks on the patient's nose.

Step 2: Level spectacles on face

Determine if the spectacles are level on the patient's face. Get eye level with the patient and look straight at him or her to see if one lens is higher than the other lens. The patient's eyebrows can be a poor guide for assessment, because they vary so much. Instead, look at the location of the patient's eyes in the frame. Is each eye in approximately the same location in both lenses? This is easiest to assess when you are fitting a bifocal or a trifocal, as the segments make good reference points.

Because of the segment lines, you must assess bifocals and trifocals with an even more critical eye than a single vision pair of spectacles. Both eyes need to encounter the segments at the same time when the patient looks downward. If one lens is higher than the other lens, one eye could end up looking through the segment portion of the lens while the other eye is still looking through the distance portion of the other lens. This, obviously, can throw off a patient's vision.

If one side of the frame is sitting *higher* on the face, bend the temple on the higher side *up*. (Refer to the previous section if you need instruction again on adjusting temple angle.) Conversely, on the side sitting *lower*, you bend the lower temple *down* to get the same results. Just think of it this way: to correct an unleveled frame, you move the temple in the direction of the problem. For example, the left lens sits lower than the right, so you move the left temple down.

Remember you must have pantoscopic tilt (fig. 3–66) when you have completed all adjustments.

You definitely do not want retroscopic tilt (fig. 3–67). Think "retro" is wrong.

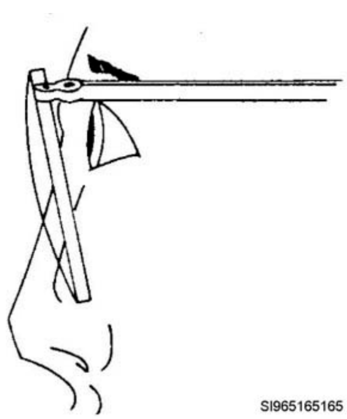

Figure 3–66. Frame with a desirable 8–10° pantoscopic tilt.

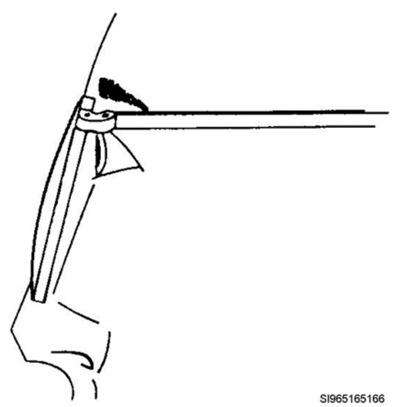

Figure 3–67. Frame with undesirable retroscopic tilt.

Step 3: Lenses equal distant from the face

The next thing to check is the distance each lens is from the face. Have the patient sit down and look straight ahead. Stand so you are above them, looking down. From there you can see if both lenses are the same distance from each eye. If so, you're good to move on to the next step. If not, you need to adjust the spectacles so the lenses are an equal distance from the patient's face. The rule of thumb here is the same as before: move the temple in the direction of the problem.

For example, if you observe that the left lens seems to be sticking *out* more, move the left temple *out* more. If you feel, the right lens is *in* too close, move the right temple *in* closer to the head. If you need instructions on how to adjust a temple in or out, refer back to the previous section on temple alignment.

Step 4: Temple bend in correct location

The last step is to check the fit of the temples in relation to the ears. For spectacles with comfort cables (CC), you are looking to get the initial curve of the CC at the top of the ear. You are also bending the very tip of the CC out slightly so it is not poking into the patient's head or ear. Beyond that, let the patient know he or she can manipulate the CC portion of the temple to customize the temple to what feels most comfortable for them.

The temple you spend the most time adjusting is the skull temple. You want the bend to be at the top of the ear, and you want the temple to follow the curvature of the back of the ear without pushing against the ear (fig. 3–68).

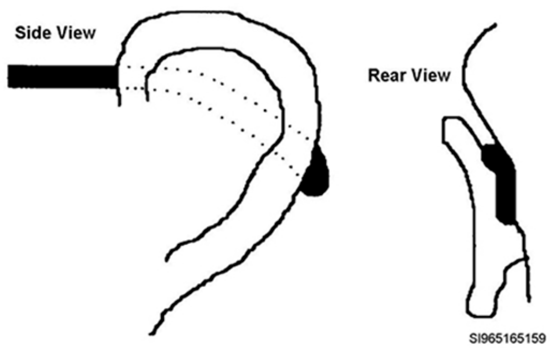

Figure 3–68. Proper fit of a skull temple.

You also want the temple to follow the contours of the patient's head as much as possible, without pushing into the patient's head (fig. 3–69).

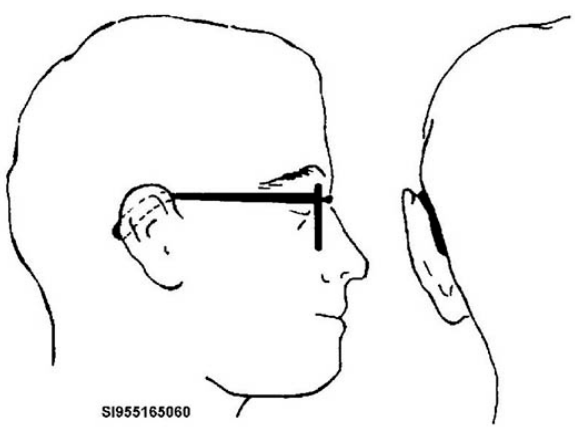

Figure 3–69. Proper temple bend and contouring to a patient's head.

If you need to readjust the bend of a plastic temple, heat it up and straighten it out first. If you are using a salt or glass-bead frame warmer, remember to keep the temples moving as you heat them so they are not "pitted."

Always straighten the temple first. This avoids getting a "double bend" in the temple. A double bend is uncomfortable for the patient and causes sore spots on the top of the ear.

Checklist for fitting the frame to the patient

As a final inspection of frame fit, evaluate these areas:

1. Adjust nose pads to fit evenly, without digging in. Check nose pad alignment by viewing from the front, the side, and above.
2. Frame front is level in relation to the patient's eyes, when viewed from the front.
3. When viewed from above, frame front is equal distance from each eye.
4. Temples correctly contoured, when viewed from the side and the rear.

417. Fit issues unique to flight equipment

The eyes and brain are an aircrew member's best weapons. Everyone in the ophthalmic clinic is working together to ensure a flyer's eyes are performing at their fullest capacity and are able to take in all information necessary to accomplish the mission. The doctor's role is to give aircrew members the correct Rx. Your role is to make sure the flyers' prescription eyewear is usable with all of the unique flight equipment they have to wear. Sometimes, this involves modifying eyewear to fit with all the various flight equipment pilots may need.

The MBU-13/P CB mask

Certain aircrew members may be required to maintain an aircrew chemical, biological, radiological, nuclear (ACBRN) equipment bag if there is a possibility that they will deploy to a CBRN threat area. Depending on their mission, some aircrew members have unique ACBRN requirements necessitating the use the MBU-13/P CB flight mask. Aircrew and "Quick Start" crewmembers required to use this mask can order an additional pair of flight frames specifically modified for use with this mask. If you correctly annotate the order request in the "Comments" section of the Eyewear Order Information screen of SRTSweb or the "Special Comments/Justification" block of the DD Form 771, the fabrication lab will actually provide the spectacles with the correct temple modification already installed. However, if you need to make the modification yourself, let's go over how to do so.

First, use the end cutter pliers (fig. 3–70) to cut the temples of the flight frame down to a length of only 15–20 mm. The cut temple ends are then filed smooth (fig. 3–71). Now, you can slide the modified temples into the insert holes of the MBU-13/P CB mask, and bend the ends of the temples over slightly so the spectacles cannot fall out. It is very important you file the temple ends smooth so they do not damage the rubber of the mask or injure the individual who puts on the mask.

Figure 3–70. End cutting pliers.

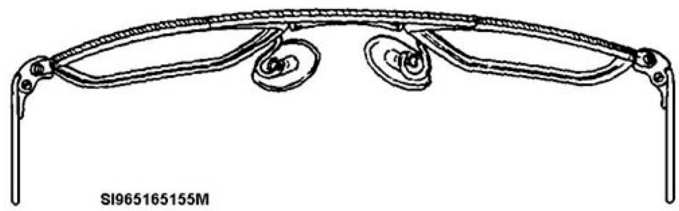

Figure 3–71. AFF frame modified for use in the MBU-13/P CB mask.

The oxygen mask

Some aircrew members have difficulty wearing a flight frame while wearing an oxygen mask. The mask gives the patient a very wide bridge, which can cause the flight frame to sit too high on the nose. You can try the following solution to resolve this particular fit issue.

To adjust the fit, cut the nose pads off a pair of the aircrew member's flight frames. You will want to ensure this area sits comfortably on the member's face, so be sure to then file the area smooth. Cutting off the nose pads widens the bridge of the flight frame. The spectacles should now sit lower on the nose and better straddle the oxygen mask.

The full-pressure-suit helmet

Sometimes, aircrew members who wear the full-pressure-suit helmet find that their spectacles keep sliding down their nose. If the frame width is too wide and does this, it can end up getting "wedged" out of the helmet. To prevent the frames from moving, you can adjust the temples on the flight frame as follows:

1. At approximately ½ inch from the butt of each temple, make a bend *inward* at an angle of about a 45° (fig. 3–72).
2. At approximately ½ inch from the first bend, make a bend outward at an angle of about a 45° (fig. 3–72).

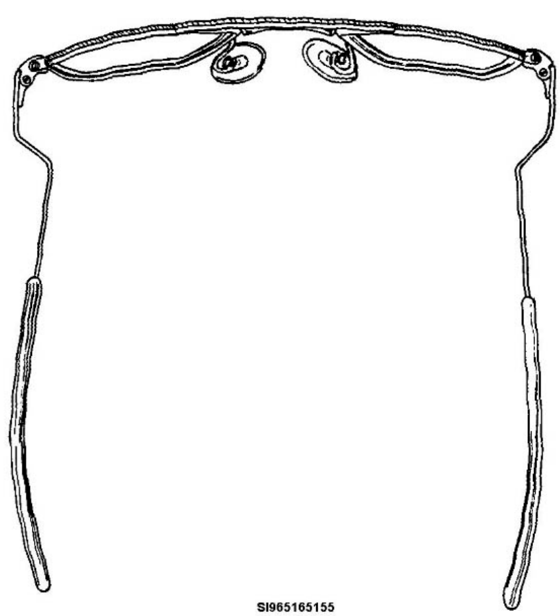

Figure 3–72. AFF modified for use in the full-pressure-suit helmet.

Now the frame will better fit the full-pressure-suit helmet.

The lessons above covered a lot of information on different spectacles and spectacle procedures. With everything you covered, you should have no problem when it comes to ordering spectacles with a DD Form 771 or using SRTSweb. SRTSweb is a little more involved, but your coworkers or supervisor can help guide you through the steps.

When it comes to neutralizing, repairing, and adjusting spectacles, time and experience will have you adjusting frames like a pro and teaching someone else the basics someday.

Self-Test Questions

After you complete these questions, you may check your answers at the end of the unit.

414. Neutralizing lenses

1. How is the eyepiece of a lensmeter focused?

2. How is calibration of the lensmeter checked?

3. What does it mean if the sphere and cylinder lines *do not* focus at the same time?

4. How is the cylinder power calculated?

5. What two methods are used to measure the “Add” power in multifocals?

6. When using a manual lensmeter, what is used to accurately measure a progressive addition lens?

7. Name three maintenance procedures that keep a lensmeter in working order?

8. When changing light bulbs on lensmeters, how does the procedure differ between the B&L vertometer, and the AO lensometer?

9. When using the automated lensmeter, what happens if both lenses are not against the table?

10. The autolensmeter PD mode is the most accurate method for which procedures?

415. Verifying spectacles

1. What is the name of the standard that governs tolerances for spectacles fabrication?

2. Are the standards for ophthalmic lenses enforceable by law?

3. What type of physical marring to a spectacles lens is acceptable?

4. When measuring the base curve of a lens, you find the front surface of the lens has a meridian of maximum curvature and 90° away it has a meridian of minimum curvature. Which reading is the base curve?

5. What is the dioptric tolerance for a lens with a sphere power of +7.00D?

6. What dioptric tolerance for sphere and cylinder powers is *always* considered within standards?

7. How far off can the “Add” power be in a +1.50D lens?

8. Which lens do you start with when measuring for vertical prism? What if both lenses are the same power?

9. What is the given tolerance for horizontal prism according to the ANSI standards?

10. What are the two acceptable ways of checking or calculating horizontal prism?

11. Name the five items on the verification checklist you need to reference when verifying a pair of spectacles.

416. Repairing and adjusting spectacles

1. Name the three tools used to tighten loose rivets on the half-eye frames.

2. Why do you want to ensure your hand is not on the other side when using pressure to remove a screw?

3. When you install a new temple, what other new item should you use?

4. Which side of the lens should you insert into a frame front first?

5. In what direction do you rotate a lens to *increase* the axis?

6. What specific parts of the frame do you adjust to get the frames in a “neutral and straight” starting position?

7. What two things are accomplished by moving spectacles around in a salt or glass-bead frame warmer?

8. Which file would you use on a metal frame to file off excess material on the butt of a temple? On a plastic frame?

9. How would you position the Zyl gripping pliers so you would not mar the temple?

10. When adjusting frames for a patient, how should the nose pads fit?

11. After adjusting the frames to a patient’s face, what should you look at to ensure the frames are level?

12. Which items are included in a final inspection checklist for frame fitting?

417. Fit issues unique to flight equipment

1. How do you adjust the temples on the flight frame to fit the MBU 13/PCB mask?

2. How can you resolve the issue regarding the flight frame and oxygen mask?

3. Describe the procedures for adjusting the flight frame when an aircrew member has problems with the frames and full-pressure-suit helmet.

Answers to Self-Test Questions

412

1. OD: +1.75-2.00x089.
   OS: +1.25-0.50x012.
2. 1–18.
3. The retiree's home address.
4. "None".
5. Enter only the applicable near PD under the *Near* header.
6. Any additional information required to clarify the spectacles prescription and/or for justifications.
7. None; no justification needed for active duty at this time.
8. No; the program keeps this record for you automatically.
9. A consolidated record of orders sent from your clinic to the fabrication lab.
10. Copies #1 and #2.
11. Copy #2.
12. Pull your file copy of the DD Form 771 (copy #3); annotate the prescription order logbook with the date the spectacles arrived; verify the spectacles against the DD Form 771 showing what was ordered; if they are within ANSI standards, notify the patient to pick up the spectacles; if they are not within ANSI standards, send the glasses back to the lab and inform the patient of the delay.
13. You can disassemble the spectacles for spare parts, or send them back to the fabrication lab for their reuse.
14. Copy #2 goes in the patient's medical record and copy #3 goes to the patient.
15. At least 45 days.

413

1. There is little or no impact to ordering facilities during server upgrades.
2. DD Form 2875.
3. (1) SSN.
   (2) DOD ID number.
   (3) DOD benefits number.
   (4) Provider ID number.

4. (1) The **Manage Patients Search** screen.
   (2) The **Quick Search** feature.
5. Under **Order Management** on the **Patient Details** page.
6. On the **Add Exam** screen after you've expanded the **Exams** section.
7. **Prescription Information** screen.
8. (1) Priority.
   (2) Frame.
   (3) Color.
   (4) Eye.
   (5) Bridge.
   (6) Temple.
   (7) Lens.
   (8) Tint.
   (9) Material.
   (10) Segment Height.
   (11) Pair.
   (12) Production lab.
   (13) Comments.
9. (1) Check-in.
   (2) Dispense.
   (3) Problems.
   (4) Outstanding.
10. Bulk input.
11. Overdue Orders Report.

414

1. With power set at zero, turn the eyepiece as far as possible CCW and then slowly rotate it CW until the reticle comes into sharp focus.
2. Looking into the lensmeter, turn the power wheel until the sphere and cylinder power lines are clear and sharp. Look at the power wheel, it should read zero, exactly. If it does not, recheck. If it still does not read zero, the lensmeter needs calibration.
3. The lens has some cylinder power.
4. By determining the distance traveled between the points where the sphere power lines are in focus to the point where the cylinder power lines are in focus.
5. Practical and exact.
6. Templates of the lens manufacturer.
7. Using dust covers when instrument is not being used, dusting exterior lenses, and changing the light bulb.
8. B&L vertometer power wheel is turned in the minus direction to –20.00D and the AO lensometer power wheel is turned in the plus direction to +20.00D.
9. The axis reading will be inaccurate.
10. Measuring a lens, checking for prism, or verifying the Rx from the lab.

415

1. ANSI Z80.1.
2. No.
3. Hairline scratches that are essentially invisible to the eye without intense scrutiny.
4. The weaker curve (minimum curve).
5. ± 0.25D.

6. A sphere or cylinder power that is only off by 0.12D.
7. ±0.12D.
8. Optically center the lens with *the strongest power* in the lensmeter first. If neither lens is stronger, it does not matter which lens you center first. For consistency, you can always pick the right lens when total powers are equal.
9. 0.67Δ.
10. A lensmeter or the Prentice Rule.
11. (a) Ensure frame size, style, and temples are accurate.
    (b) Examine lenses for defects.
    (c) Measure the segment heights.
    (d) Neutralize Rx: sphere, cylinder, axis, (and "Add" if spectacles are multifocal).
    (e) Check for prism tolerances: vertical and horizontal.

416

1. The hinge and staking tool, the rivet burnishing pliers, and the automatic punch.
2. For safety; if the optician's screwdriver slips out of the slot in the screw head, you may stab and injure yourself.
3. A new screw.
4. Temporal side first.
5. CCW.
6. The nose pads (if adjustable), the frame front, and the temples.
7. (1) Even heat distribution to the frame.
   (2) Prevention of "pitting" or "stippling" of the plastic by the salt or glass beads.
8. Use a fine-toothed metal file on metal frames; use a courser file on plastic frames.
9. You would have the metal part of the tool on the inside of the temple and the padded portion would be on the outside of the temple.
10. They should have even, complete contact with the nose.
11. Look at the locations of the patient's eyes in the frames.
12. (a) Adjust nose pads to fit evenly, without digging in. Check nose pad alignment by viewing from the front, the side, and above.
    (b) Frame front is level in relation to the patient's eyes, when viewed from the front.
    (c) When viewed from above the frame front is an equal distance from each eye.
    (d) Temples correctly contoured, when viewed from the side and the rear.

417

1. Cut the temples to a length of 15–20 mm and file the cut ends smooth.
2. Cut the nose pads off a pair of flight frames and file the area smooth.
3. At approximately ½ inch from the butt of each temple, make a bend inward at an angle of about a 45°. At approximately ½ inch from the first bend, make a bend outward at an angle of about a 45°.

Complete the unit review exercises before going to the next unit.

Unit Review Exercises

Note to Student: Consider all choices carefully, select the *best* answer to each question, and *circle* the corresponding letter. When you have completed all unit review exercises, transfer your answers to the Field-Scoring Answer Sheet.

Do not return your answer sheet to the AFCDA.

71. (412) What do you have to do with prescriptions that are written in plus (+) cylinder format before they can be put on a Department of Defense (DD) Form 771, Eyewear Prescription?
    a. Change the left eye (OS) sphere sign to a minus sign.
    b. Convert them to intermediate vision only.
    c. Convert them to distant vision only.
    d. Transpose them.

72. (412) When does the numbering for spectacle orders need to be reset?
    a. 1 Jan.
    b. 1 Jun.
    c. 1 Sep.
    d. 1 Oct.

73. (412) When manually completing a Department of Defense (DD) Form 771, if the patient prescription calls for prism, in which section would you enter if it is base up, base down, base in, or base out?
    a. LENS.
    b. RX INFO.
    c. MATERIAL.
    d. SPECIAL COMMENTS/JUSTIFICATION.

74. (412) What is an appropriate justification for the 8x35 trifocal?
    a. Patient (PT) is on flight status.
    b. No justification is required.
    c. Patient (PT) requires wide field of view (FOV) at near.
    d. Patient (PT) requires wide field of view (FOV) at near and intermediate distances.

75. (412) If you manually order spectacles, which copy of the Department of Defense (DD) Form 771 do lab personnel keep for their files?
    a. Copy #1.
    b. Copy #2.
    c. Copy #3.
    d. None; they return all copies.

76. (412) If spectacles are *not* picked up from the clinic after numerous attempts have been made to notify patients they are ready, the spectacles can be
    a. sent to the military personnel flight for disposition.
    b. sent to the patient’s commander for disposition.
    c. dissassembled and used for spare parts.
    d. sold to the local Lions Club.

77. (413) In SRTSweb, which is *not* an ID type available under the **Patient Add** option?
    a. DOD ID Number.
    b. Patient ID Number.
    c. DOD Benefits Number.
    d. Social Security Number.

78. (413) When conducting a patient search in SRTSweb, once you enter your search criteria on the **Manage Patients Search** screen, you can then select either **Search Local** or **Search**
    a. **International**.
    b. **Regional**.
    c. **Global**.
    d. **All**.

79. (413) On the **Prescription Information** screen in SRTSweb, what is the default "Type?"
    a. Full Time Wear (FTW).
    b. Near Vision Only (NVO).
    c. Distance Vision Only (DVO).
    d. Intermediate Vision Only (IVO).

80. (413) Which is *not* information you would enter on the **Eyewear Order Information** screen in SRSTweb?
    a. Lens.
    b. Frame.
    c. Cylinder.
    d. Production lab.

81. (414) When neutralizing a spherocylindrical lens, what should you do after the *first* set of power lines come into focus to get the sphere power lines to be straight?
    a. Focus the second set of lines first.
    b. Rotate the axis wheel until the lines are straight.
    c. Orient the power wheel until the lines are straight.
    d. Place the spectacles in the lensmeter for convex neutralizing.

82. (414) When the distance spherical power of a lens is +5.00 diopters (D), which method do you use to determine the "Add" power?
    a. Exact.
    b. Convex.
    c. Practical.
    d. Concave.

83. (414) When doing autolensometry on a multivision lens, if you remove the spectacles from the lensmeter after measuring the distance portion. you will have to start
    a. in the exact middle of the multifocal segment.
    b. 10 millimeters (mm) up from the bottom of the lens.
    c. by re-measuring the distance portion.
    d. at the optical center (OC) of the lens.

84. (415) Who do you need to contact for specific information and/or interpretation of the American National Standards Institute (ANSI) standard Z80.1?
    a. Optical Fabrication Laboratory.
    b. Optical Laboratories Association.
    c. American National Standards Institute.
    d. Ophthalmic Schoolhouse, Ft. Sam Houston.

85. (415) American National Standards Institute (ANSI) standard Z80.1 covers ophthalmic
    a. temples.
    b. frames.
    c. fitting.
    d. lenses.

86. (415) The optical centers (OC) of a single vision lens, or of the distance portion of a multifocal lens, must be within how many millimeters (mm) of the requested order?
    a. 2.5 mm.
    b. 3.0 mm.
    c. 3.5 mm.
    d. 4.0 mm.

87. (415) When using a lens clock on an ophthalmic lens, you find that the front lens surface has two curves, one is +6.00 and the other is +5.75. What do you record for the final *base* curve measurement?
    a. –0.25.
    b. +0.25.
    c. +5.75.
    d. +6.00.

88. (415) What is the allowable tolerance for *unwanted vertical* prism (Δ) in spectacles?
    a. 0.12Δ.
    b. 0.33Δ.
    c. 0.37Δ.
    d. 0.67Δ.

89. (415) The Prentice Rule is easiest to use on simple spherical lens prescriptions but can work on spherocylindrical lens with prescriptions within which range of meridians?
    a. ±10 degrees (°) of 30 and 120.
    b. ±10 degrees (°) of 50 and 140.
    c. ±10 degrees (°) of 60 and 150.
    d. ±10 degrees (°) of 180 and 090.

90. (415) You are verifying a lens and find that the right eye has 0.4 prism (Δ) base in (BI) and the left eye has 0.8Δ base out (BO). What is the total amount of prism for this lens?
    a. 0.4Δ BI.
    b. 0.4Δ BO.
    c. 1.2Δ BI.
    d. 1.2Δ BO.

91. (416) The rivet peening pliers can be used to
    a. adjust temples.
    b. tighten hinges.
    c. flare screw tips.
    d. remove screws and rivets.

92. (416) The best option to repair a crack on a standard issue (5A) frame front is to
    a. replace the frame front.
    b. order a new pair of 5A spectacles.
    c. use spectacle glue to fill in the crack.
    d. heat the frame front in the frame warmer.

93. (416) When the prescription for a patient's spectacles is unavailable, the *first* thing to do before replacing the frame front is to
    a. check the four-point alignment of the new frame.
    b. remove the temples from the old front.
    c. remove the lenses from the old front.
    d. neutralize the lenses and mark them.

94. (416) To remove lenses from most plastic frame fronts you would
    a. thoroughly cool the frame.
    b. pop the lens out through the back.
    c. pop the lens out through the front.
    d. cut the eyewire and remove the lens.

95. (416) You should use a lensmeter after you mount new lenses to ensure
    a. the proper base curve.
    b. the proper axis alignment.
    c. that the pupillary distance (PD) is measured correctly.
    d. that the lenses are put in the correct frame.

96. (416) Lenses are held in place in the aircrew frame by tension from
    a. a hinge rivet.
    b. a temple screw.
    c. an endpiece rivet.
    d. an eyewire screw.

97. (416) Which pliers can be used for nose-pad adjustment?
    a. Peening.
    b. Endpiece.
    c. Burnishing.
    d. Snipe nose.

98. (416) The standard pantoscopic tilt is approximately
    a. 3 to 5 degrees (°).
    b. 5 to 7 degrees (°).
    c. 8 to 10 degrees (°).
    d. 10 to 12 degrees (°).

99. (416) Which pliers are used to hold the frame-front hinge area steady while you adjust the temples?
    a. Finger piece.
    b. Zyl gripping.
    c. European pad.
    d. Rivet burnishing.

100. (416) A flight frame needs to be modified for aircrew members and "Quick Start" crew members who are required to use which mask?
    a. M–50.
    b. M17–A.
    c. MCU–2P.
    d. MBU–13/P CB.

Student Notes

Glossary of Terms, Abbreviations, Acronyms, Roots, and Symbols

Terms

aberrations—Blurred of distorted image quality that results from inherent physical properties (shape, curvature, density) of an optical device (lens or prism).

accommodation—Increase in optical power by eye to maintain clear image (focus) as objects are moved closer. Occurs through a process of ciliary muscle contraction and zonular relaxation, causing the crystalline lens to “thicken” in its middle, getting rounder and increasing its optical power.

amplitude—The maximum displacement of a waveform. The greater the amplitude of a light wave, the brighter the light will appear.

apex—Extreme point of any structure resembling an angle. Often used to refer to the pointy tip of a prism.

astigmia—Optical defect in which refractive power is not uniform in all meridians. Light rays entering eye are bent unequally by different meridians, preventing formation of a sharp point focus on the retina. Instead, light rays form two focal lines. Corrected by a cylinder (toric) eyeglass or contact lens.

biconcave—Having two concave surfaces on opposite faces.

biconvex—Having two convex surfaces on opposite faces.

bifocal—Lens having two sections with different focal points.

binocular—Pertaining to both eyes.

cataract—An opacity of the crystalline lens.

concave—Surface that curves inward.

convergent—Two or more light waves proceeding towards a point.

convex—Surface that curves outward.

cornea—Transparent anterior portion of the fibrous tunic.

cylinder—Converges or diverges light to focus along one axis. Forms a line focus. Has zero power in one meridian and maximum power 090° away.

deviation—Change in direction of a light ray as in passing through a prism.

diffuse reflection—When light strikes a rough surface, such a wall, and the rough surface reflects the light, making it very hard to determine where any given ray of light will go since the rough surface abnormalities of the wall can send light rays in all directions.

diopter (D)—Unit designating the refractive power of a lens.

diplopia—Double vision.

dispersion—Breaking up of white light into its component colors.

distortion—Defect in a lens that causes a straight line to appear curved.

diverge—Two or more light rays proceeding away from a point.

fixate—Act of directing the eye toward the object of regard.

focal length (FL)—Linear distance between a point of reference and the focal point.

frequency—The number of waves passing a fixed point in one second.

fusion—Act or process of blending or uniting two images.

heterophoria—Condition in which there is a latent tendency of the eyes to deviate that is prevented by fusion. Thus, a deviation occurs only when a cover is placed over an eye; when uncovered, the eye straightens.

heterotropia (strabismus)—Misalignment of eyes caused by extraocular muscle imbalance, so that one fovea is not directed at same object as the other. Deviation is present even when both eyes are uncovered.

hyperopia—Commonly called farsightedness, a refractive error in which, because the eyeball is short or the refractive power of the lens is weak, the point of focus for rays of light from distant objects falls behind the retina.

infinity—In optical science, a term used to denote a distance so great that the rays of light from it appear parallel.

infrared—Light waves beyond the red portion of the visible spectrum; they are longer wavelengths than can be seen by the human eye.

interpupillary distance (PD)—Distance between the centers of the pupils.

lateral—Toward or pertaining to the temporal side of the eye.

light—Term commonly used for radiant energy which affects our eyes and gives us vision. Light is that which we see by.

limbus—Transitional zone between cornea and sclera.

malingering—Feigning or deliberately giving false test responses to gain desired results.

meridian—Imaginary line drawn through or from the optical center or optical axis.

minus lens—Lens that diverges light.

monocular—Pertaining to one eye.

multifocal—Lens with two or more foci due to additional segments.

myopia—Commonly called nearsightedness—a refractive condition of the eye represented by the location of the conjugate focus of the retina at some finite point in front of the eye, when accommodation is said to be relaxed.

nasal—Toward the nose.

oblique—Slanted.

oculus dexter (OD)—Right eye.

oculus sinister (OS)—Left eye.

oculus uterque (OU)—Both eyes.

ophthalmic—Pertaining to the eye or related functions.

ophthalmologist—Treats eye diseases and performs surgery. Has an MD and has taken a residency in ophthalmology.

ophthalmology—Treatment of the pathological or unhealthy eye.

optician—One who dispenses glasses or contact lenses.

optometrist—One who has at least six years of college, is concerned with vision and non-medical visual care. Diagnoses and refers eye diseases. Uses lenses and prisms to correct refractive visual defects.

orthophoria—Absence of eye deviation (or tendency toward deviation); no ocular movement is elicited by covering an eye while the other eye views a visual target. Eyes are aligned correctly and do not deviate.

plano (PL)—Surface with zero curvature.

plus lens—Lens that converges light to a real focus.

presbyopia—Condition wherein the accommodative power of the eye decreases with advancing age due to loss of elasticity of the crystalline lens.

prism (BU base up, BO base out, BD base down, BI base in)—Wedge-shaped piece of glass or transparent material having plane or curved sides. Has an apex and a base. Light deviates towards its base, but objects seen through a prism appear to move toward the apex.

prism diopter—One prism diopter produces a deviation of 1 cm at a distance of 1 meter.

pupil—Opening in the center of the iris.

pupillary reflex—Constriction/dilation of the pupil on exposure to light stimulus.

radius of curvature—The distance from the center of curvature to the surface. A curve with a short radius of curvature will be steeper than a curve with a long radius of curvature.

real image—An image that actually exists and can be projected on a screen or plate.

reflected ray—Ray of light that bounces off the surface of a mirror or other reflective surface.

refracted ray—Light ray that has had its course of travel bent or changed as it passes through a lens or other medium.

refraction—Change in direction of light as it passes obliquely from one medium to another of a different density. The bending of light rays.

refractive error—Condition where parallel light rays entering the eye do not focus on the retina.

retina—Light receptive and innermost tunic of the eye (nervous tunic); represents the terminal expansion of the optic nerve.

single vision—Lens with one focus.

sphere—Lens with one point focus.

strabismus—Condition in which binocular fixation is not present under normal conditions. See heterotropia.

Sturm's Conoid—Circle of least confusion.

suppression—Process of ignoring what one sees.

temporal—Towards the temple.

transparent—Pertains to a medium having the property of transmitting light so that objects can be seen through it.

trauma—Any injury, wound, or shock.

trifocal—Lens with three segments giving three ranges of vision.

tropia—See heterotropia.

velocity (of light)—Speed of light which is dependent on the medium it is passing through. In a vacuum, light travels at approximately 186,000 miles per second.

vergence—Disjunctive movement of the eyes, as in convergence or divergence.

virtual image—An image that has no real existence and cannot be projected on a screen.

visual acuity—Acuteness, distinctness, clearness, or sharpness of vision.

visual field—Area or extent of physical space visible to an eye in a given position.

wavelength—Distance between the crest of one wave and the crest of the next wave. Within the visible spectrum of light, it is directly related to the color of the light.

Abbreviations and Acronyms

5A	standard issue eyewear
ACBRN	aircrew chemical, biological, radiological, nuclear
AFD	Air Force dress
AFE	aircrew flight equipment
AFF	Air Force flight
AFI	Air Force instruction
AFJS	Air Force Joint Service
AH 64	Apache Helicopter
AHLTA	Armed Forces Health Longitudinal Technology Application
ALEP	aircrew laser eye protection
ANSI	American National Standards Institute
AO	American Optical
AOR	area of responsibility
APEL	Authorized Protective Eyewear List
AR	anti-reflective
ASIMS	Aeromedical Services Information Management System
B&L	Bausch & Lomb
BC	base curve
BD	base down
BF	bifocal
BI	base in

BO	base out
BPE	ballistic protective eyewear
BU	base up
CAC	common access card
CBRN	chemical, biological, radiological, nuclear
CC	comfort cables
CCW	counterclockwise
CDC	career development course
CHA	compound hyperopic astigmatism
cm	centimeter
CMA	compound myopic astigmatism
CW	clockwise
D	diopter
DBL	distance between the lenses
DD	Department of Defense
dec	decentration
dm	decimeters
DMDC	Defense Manpower Data Center
DOD	Depatment of Defense
DVO	distant vision only
EAD	extended active duty
FGG	Flight Goggle Gold
FGS	Flight Goggle Silver
FL	focal length
FOC	frame of choice
FOV	field of view
FPD	frame pupillary distance
ft/lbs	foot pounds
ft/sec	feet per second
FTW	full time wear
GMI	gas mask insert
HALO	high altitude/low opening
ID	identification
IVO	intermediate vision only

LES	leave and earnings statement
m	meter
MA	mixed astigmatism
MF	multifocal
mm	millimeter
MPS	miles per second
n	index of refraction
NG	National Guard
nm	nanometers
NOSTRA	Naval Ophthalmic Support and Training Activity
NVA	near visual acuity
NVG	night vision goggles
NVO	near vision only
OC	optical center
OD	right eye or doctor of optometry
OFE	Optical Fabrication Enterprise
OLA	Optical Laboratories Association
OS	left eye
OTC	over the counter
PAL	progressive add lens
PD	pupillary (interpupillary) distance
PL	plano
PPD	patient pupillary (interpupillary) distance
PT	patient
r	radius
ROY G. BIV	red, orange, yellow, green, blue, indigo, and violet
Rx	treatment/prescription
SAAR	system authorization access request
$\overline{sc}$	without correction
SH	simple hyperopia
SHA	simple hyperopic astigmatism
SM	simple myopia
SMA	simple myopic astigmatism
SPH	sphere

SRTS	Spectacle Request Transmission System
SSAN	social security account number
SSN	social security number
ST	straight top
SV	single vision
TBI	traumatic brain injury
TF	trifocal
UCMJ	Uniform Code of Military Justice
UDM	unit deployment manager
UPLC	universal protective lens carrier
USPS	United States Postal Service
UV	ultraviolet
VIP	very important persons

Roots

ab-	away from
ad-	toward
anti-	against
automatic	self-governing
bi-	two
centi-	100
centr-	center
chroma	color
di-, diplo-	two, double
fundus	bottom, deepest
lateral	to the side, away from the midline
milli-	1000
recti-	straight
sub-	under
super-	over
tempora-	temple
tri-	three

Symbols

°	degrees
'	minutes
Δ	prism
"	seconds

Student Notes

AFSC 4V051/S
4V051 03 1704
Edit Code 04