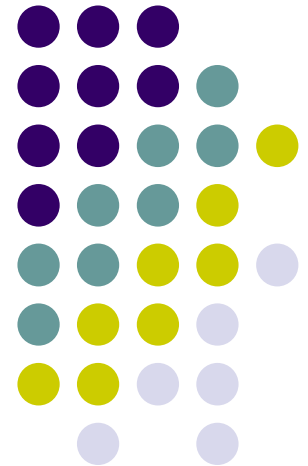
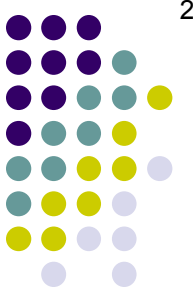


Astigmatic Refractive Error: The Power Cross

Basic Optics, Chapter 15

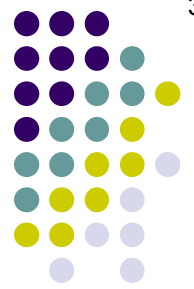


Power Cross

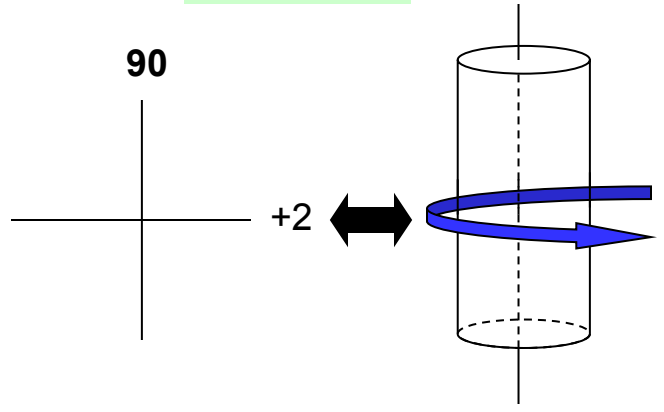


- The power cross is a concise and convenient format for representing astigmatic error (and its correction)
- It's also a source of considerable confusion for ophthalmologists-in-training
- Trust me when I say that, once you understand it, the Power Cross is your friend!

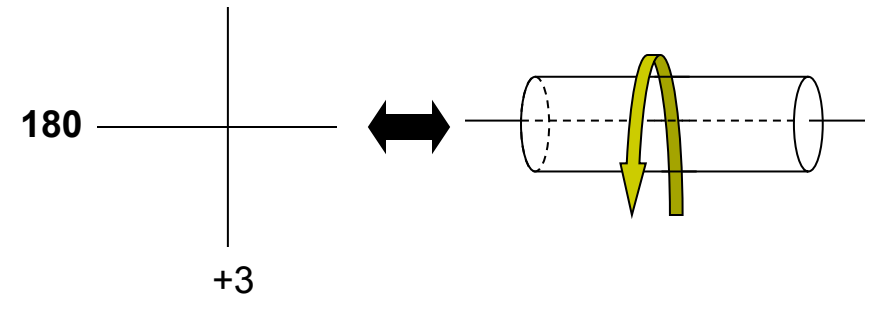
Power Cross



+2 x 090

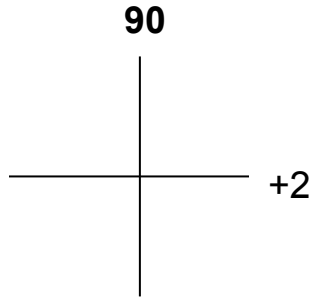


+3 x 180

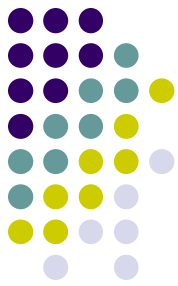
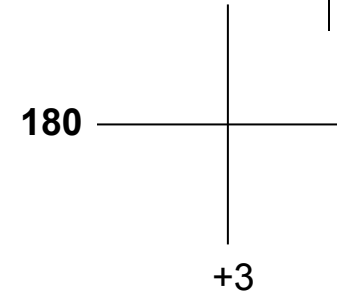


A cylinder can be represented on a power cross. Note the notation conventions: Power is recorded on the *meridian* of power, which is 90° away from the *axis* of power. In this way, a power cross provides an efficient summary of the clinically relevant refractive properties of the cylinder.

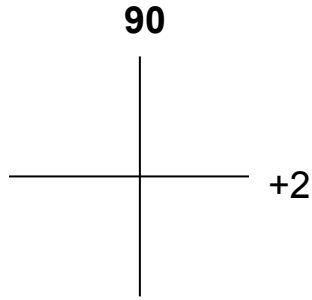
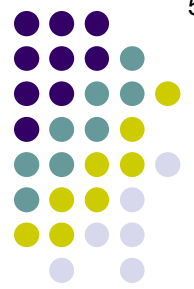
Power Cross



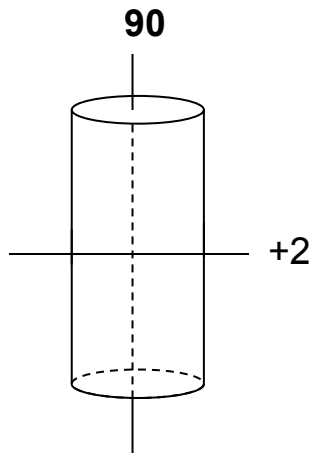
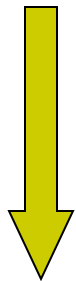
If you have difficulty remembering the conventions of power-cross notation (i.e., that the power is notated at the meridian of power, 90° away from the axis of power)...



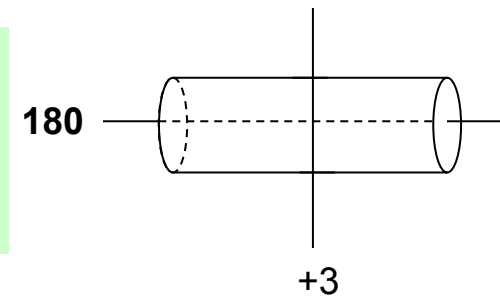
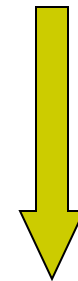
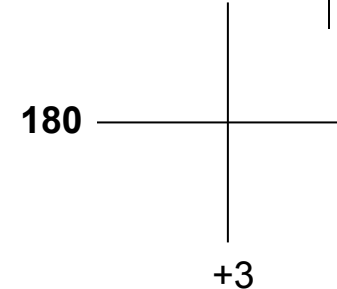
Power Cross



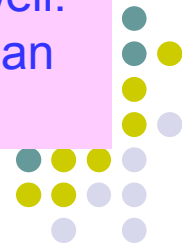
If you have difficulty remembering the conventions of power-cross notation (i.e., that the power is notated at the meridian of power, 90° away from the axis of power)...



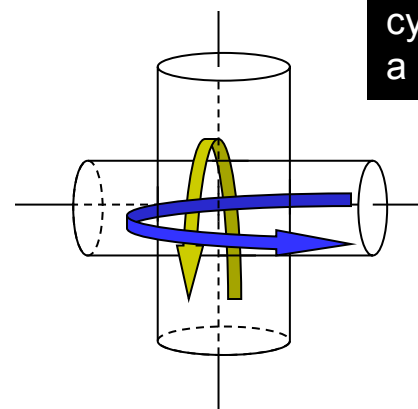
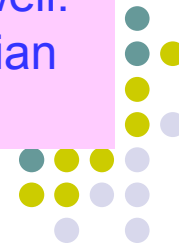
...then picture it **this** way; i.e., as a cylinder oriented along the notated axis of power. Visualized this way, the meridian of power is obvious!



Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90° away from its axis.

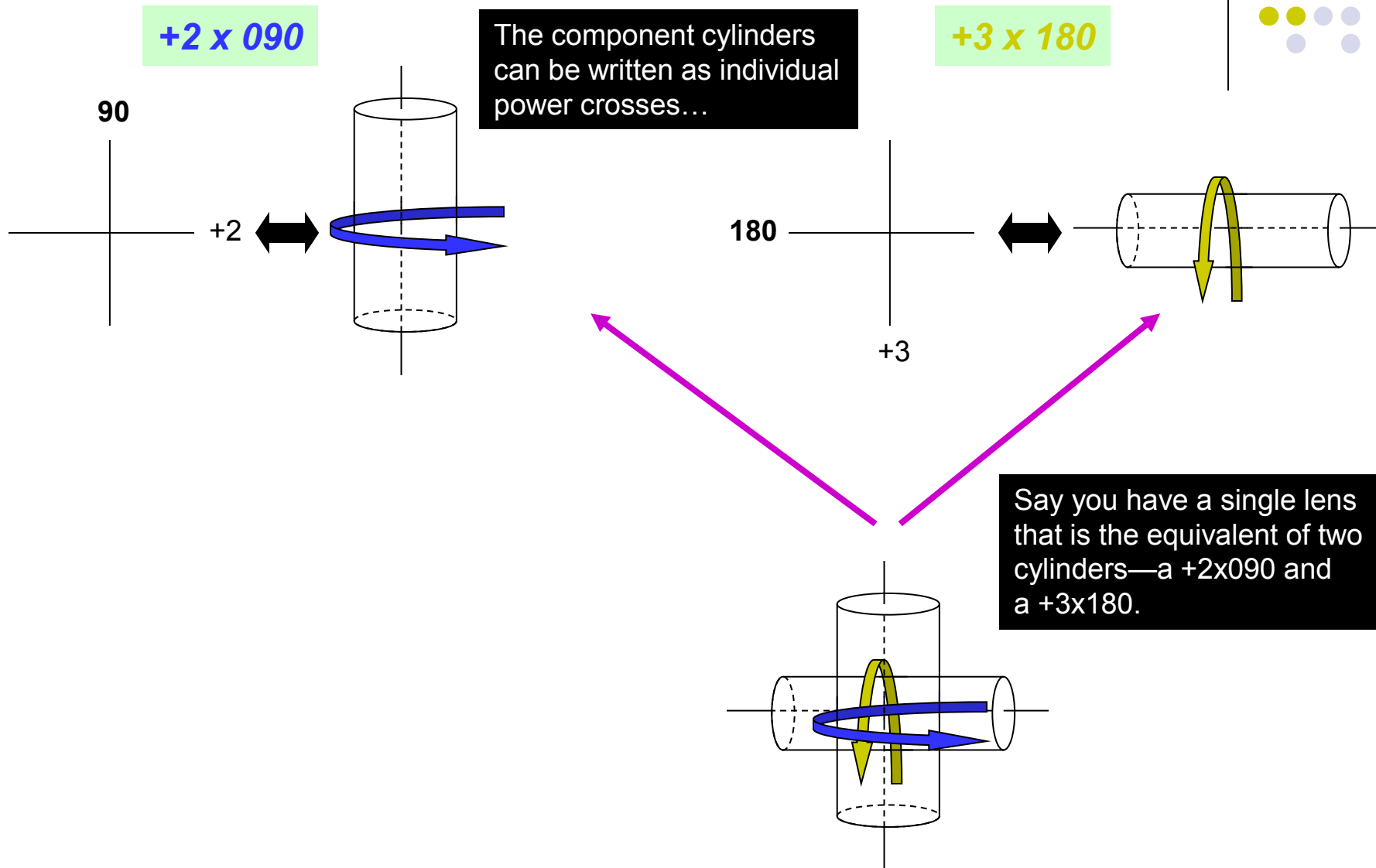


Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90° away from its axis.

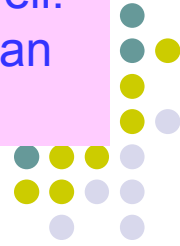


Say you have a single lens that is the equivalent of two cylinders—a +2x090 and a +3x180.

Cylinder ***combinations*** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90° away from its axis.



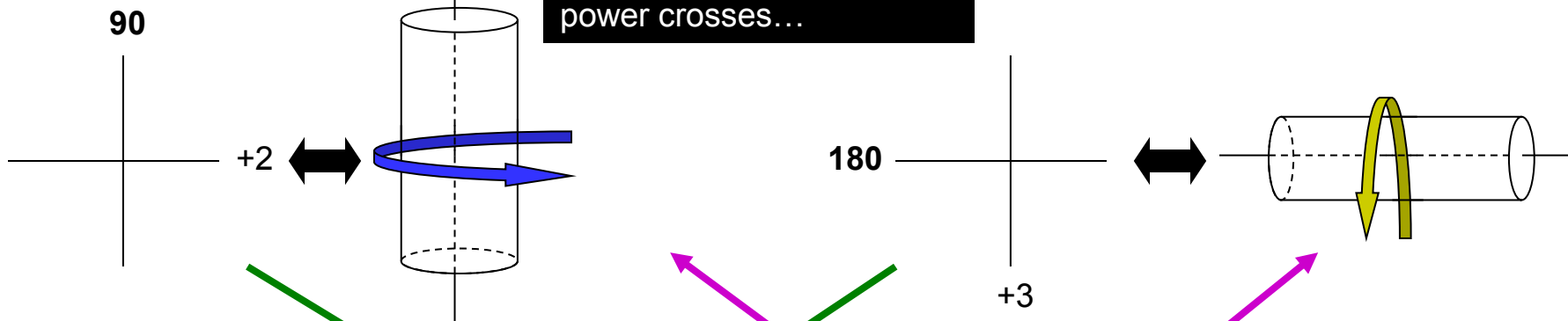
Cylinder **combinations** can be represented on a single power cross as well. As in the single-cylinder case, the power of each is recorded on its meridian of power, 90° away from its axis.



+2 x 090

The component cylinders can be written as individual power crosses...

+3 x 180

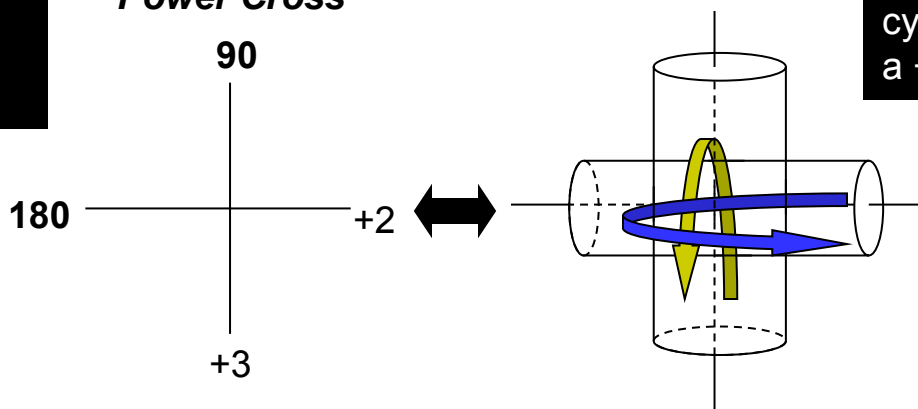


...and the individual power crosses can be combined into a single cross that represents the lens in its entirety.

Power Cross

Say you have a single lens that is the equivalent of two cylinders—a +2x090 and a +3x180.

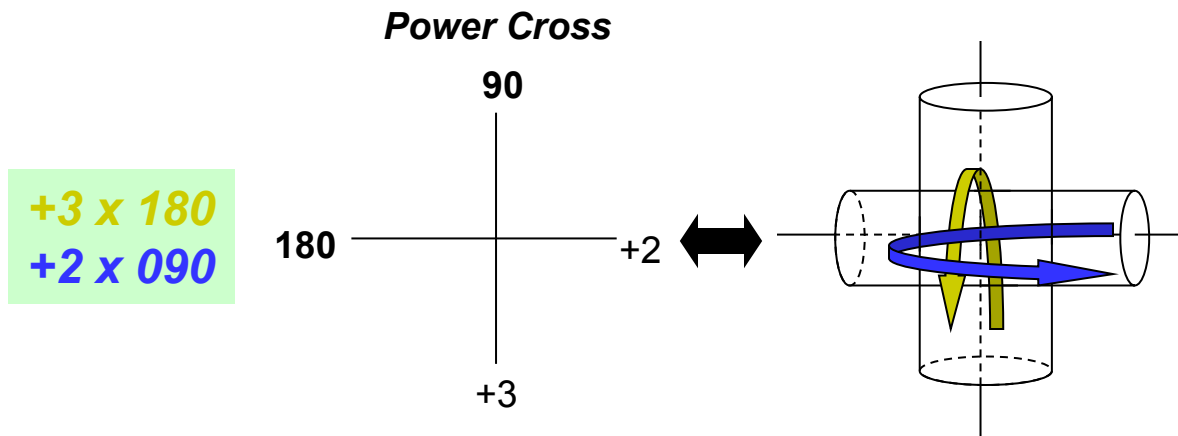
+3 x 180
+2 x 090



Power Cross



Here's where confusion concerning power crosses creeps in. *The most common mistake is to treat the power cross like a spectacle/CL prescription.* In the present example, the power cross could be (mis)interpreted as representing the spectacle correction $+3 +2 \times 090$, or perhaps $+2 +3 \times 180$.



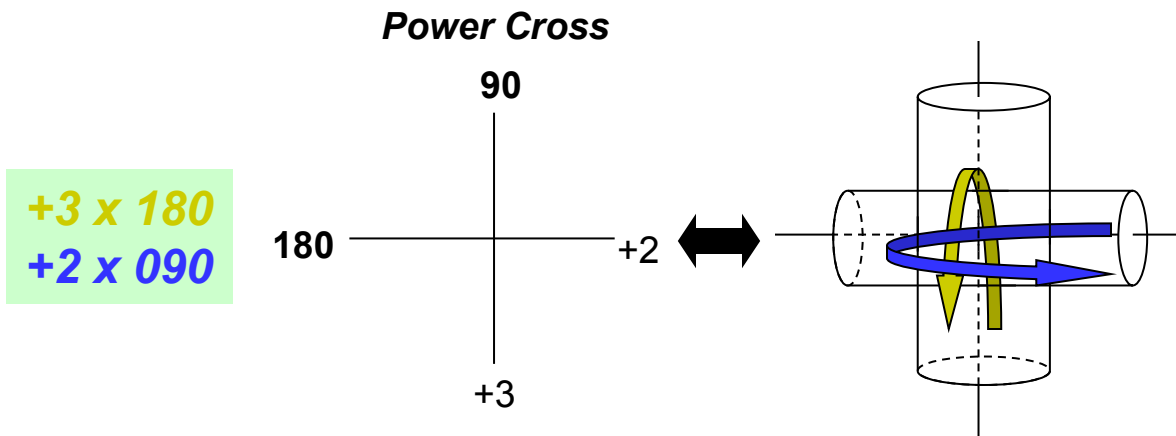
Power Cross



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Note that $+3 +2 \times 090$ and $+2 +3 \times 180$ **cannot** both be correct, as they are not equivalent refractions:

$+3 +2 \times 090$ converts to $+5 -2 \times 180$ (not $+2 +3 \times 180$); likewise, $+2 +3 \times 180$ converts to $+5 -3 \times 090$ (not $+3 +2 \times 090$)

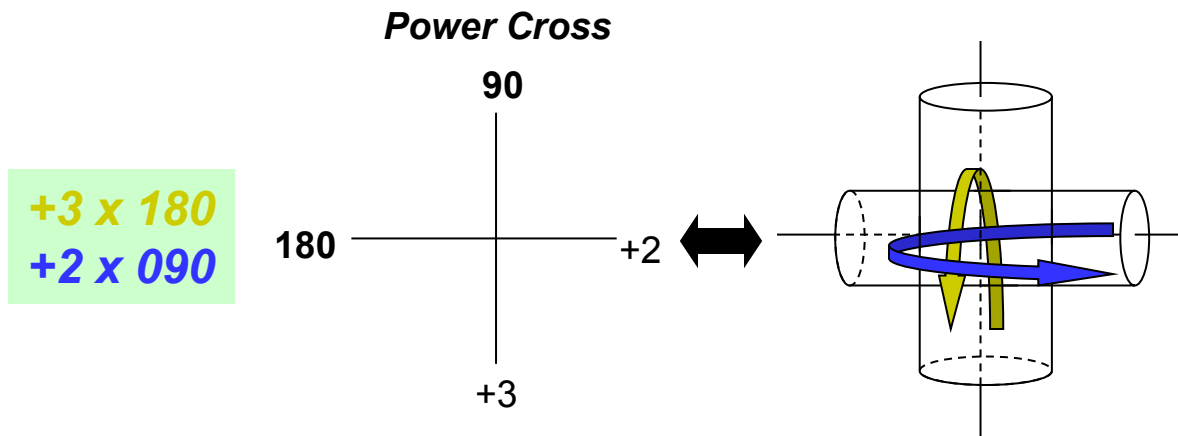


Power Cross



Here's where confusion concerning power crosses creeps in. *The most common mistake is to treat the power cross like a spectacle/CL prescription.* In the present example, the power cross could be (mis)interpreted as representing the spectacle correction $+3 +2 \times 090$, or perhaps $+2 +3 \times 180$.

What's the difference between a power cross and a prescription? *A prescription is written in **spherocylindrical** form, whereas a power cross is written in **cylinder** form only.* If you break down the word 'spherocylindrical,' you can see that a prescription is composed of a sphere power (the first number) and a cylinder power (the second number, and its axis). In contrast, a power cross simply states the power and axes of two cylinders—no spherical power is implied.

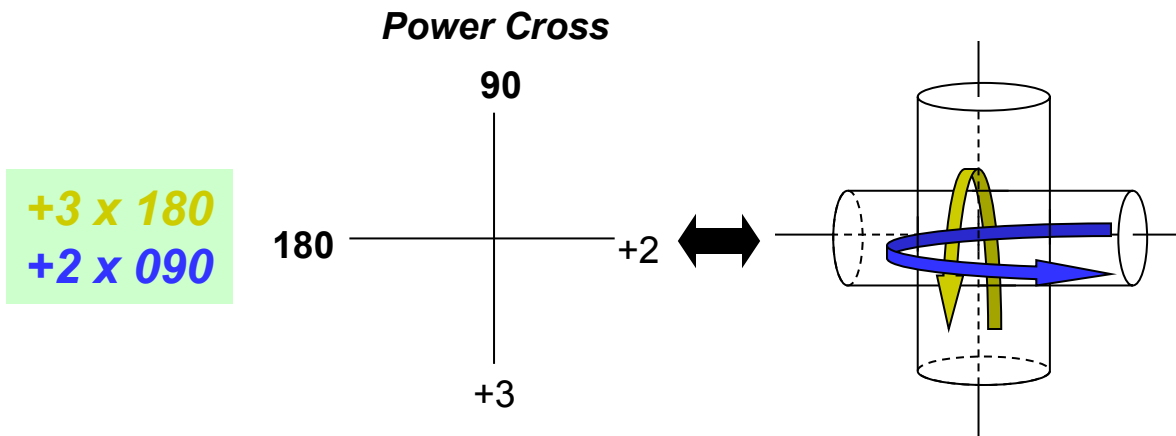




This states 'the entire lens has a base power of +3, and +2 of cylinder power with axis 090 has been added.' (Note that this means the lens has a total of +5D power at axis 090--the base +3 plus the cylindrical +2.)

Here's where confusion concerning power crosses creeps in. The most common mistake is to treat the power cross like a spectacle/CL prescription. In the present example, the power cross could be (mis)interpreted as representing the spectacle correction **+3 +2 x 090**, or perhaps +2 +3 x 180.

What's the difference between a power cross and a prescription? **A prescription is written in spherocylindrical form**, whereas a power cross is written in cylinder form only. If you break that word down, you can see that a prescription is composed of a sphere portion (the first power) and a cylinder portion (the second power, and its axis). In contrast, a power cross simply states the power of two cylinders—no spherical power is implied.





This states 'the entire lens has a base power of +3, and +2 of cylinder power with axis 090 has been added.' (Note that this means the lens has a total of +5D power at axis 090--the base +3 plus the cylindrical +2.)

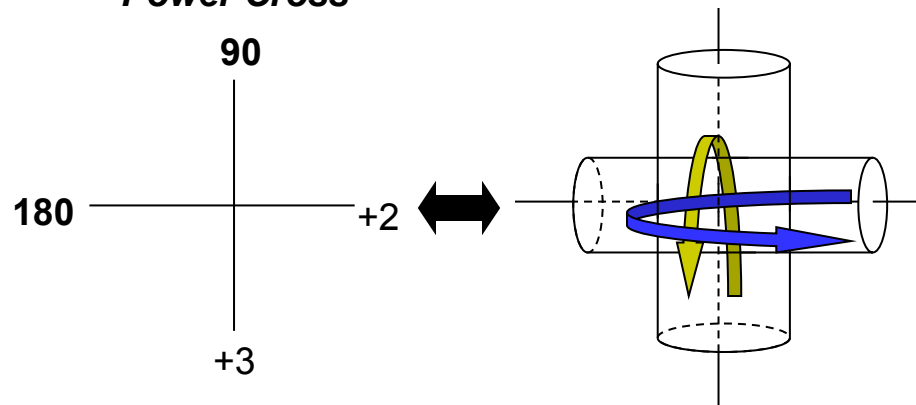
Here's where confusion concerning power crosses creeps in. The most common mistake is to treat the power cross like a spectacle/CL prescription. In the present example, the power cross could be (mis)interpreted as representing the spectacle correction **+3 +2 x 090**, or perhaps **+2 +3 x 180**.

What's the difference between a power cross and a prescription? **A prescription is written in spherocylindrical form**, whereas a power cross is written in cylinder form only. If you break that word down, you can see that a prescription is

composed of a spherical power, a cylindrical power, and an axis. This states 'the entire lens has a base power of +2, and +3 of cylindrical power with axis 180 has been added.' In this version, the lens has a total of +5D power at axis **180** (the base +2 plus the cylindrical +3).

Power Cross

+3 x 180
+2 x 090





This states 'the entire lens has a base power of +3, and +2 of cylinder power with axis 090 has been added.' (Note that this means the lens has a total of +5D power at axis 090--the base +3 plus the cylindrical +2.)

Here's where confusion concerning power crosses creeps in. The most common mistake is to treat the power cross like a spectacle/CL prescription. In the present example, the power cross could be (mis)interpreted as representing the spectacle correction **+3 +2 x 090**, or perhaps **+2 +3 x 180**.

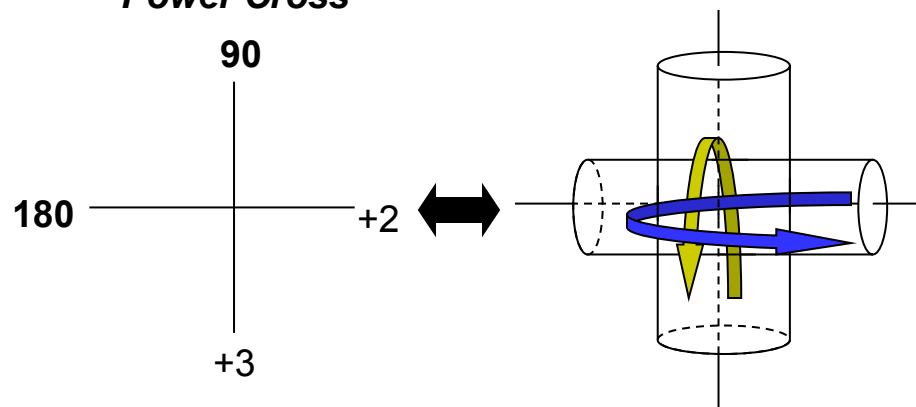
You can see that neither of these is a proper interpretation of the power cross below

What's the difference between a power cross and a prescription is written in spherocylindrical form, whereas a power cross is written in cylinder form only. If you break that word down, you can see that a prescription is

composed of a spherical power, a cylindrical power, and an axis. This states 'the entire lens has a base power of +2, and +3 of cylindrical power with axis 180 has been added.' In this version, the lens has a total of +5D power at axis **180** (the base +2 plus the cylindrical +3).

Power Cross

+3 x 180
+2 x 090



Power Cross

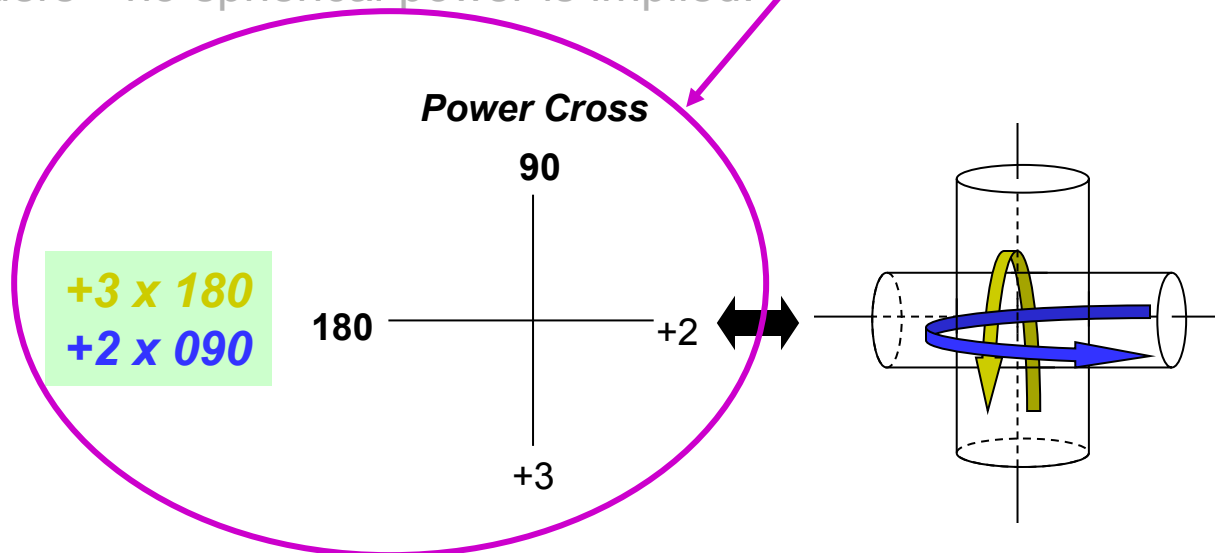


Here's where confusion concerning power crosses creeps in. *The most common mistake is to treat the power cross like a spectacle/CL prescription.* In the present example, the power cross could be (mis)interpreted as representing the spectacle correction $+3 +2 \times 090$, or perhaps $+2 +3 \times 180$.

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composed of spherical power, and cylinders—no spherical power is implied.

In contrast, this is simply stating 'the lens has a power of +2 at axis 090 and +3 at axis 180.'



Power Cross

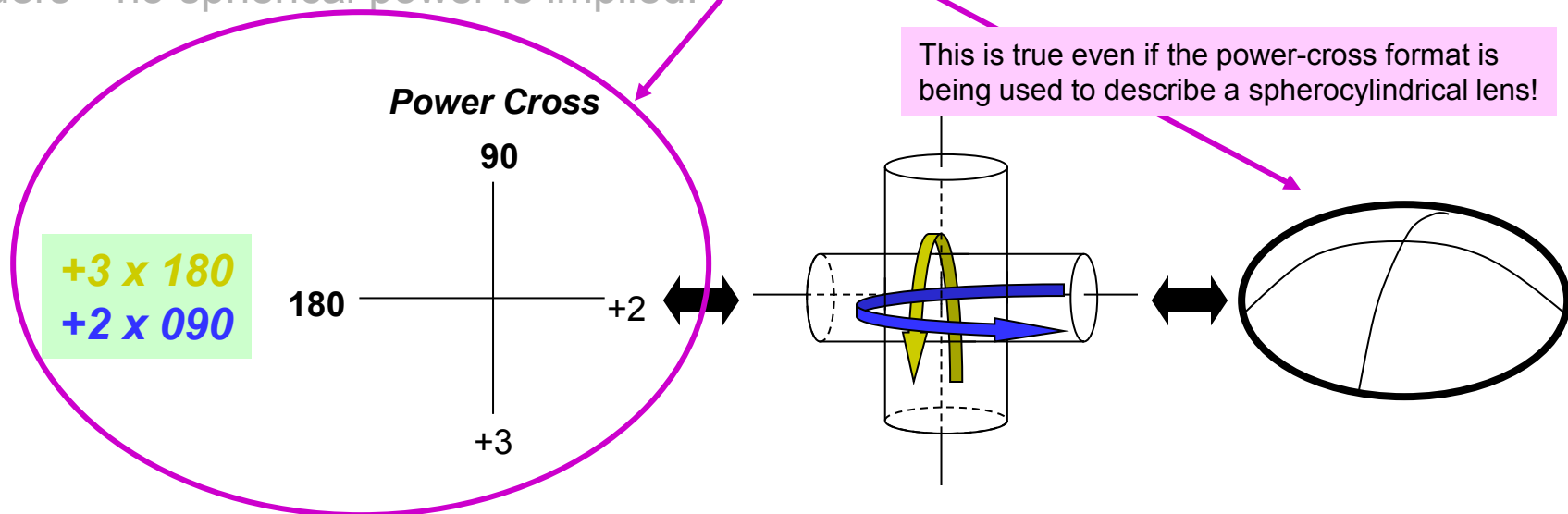


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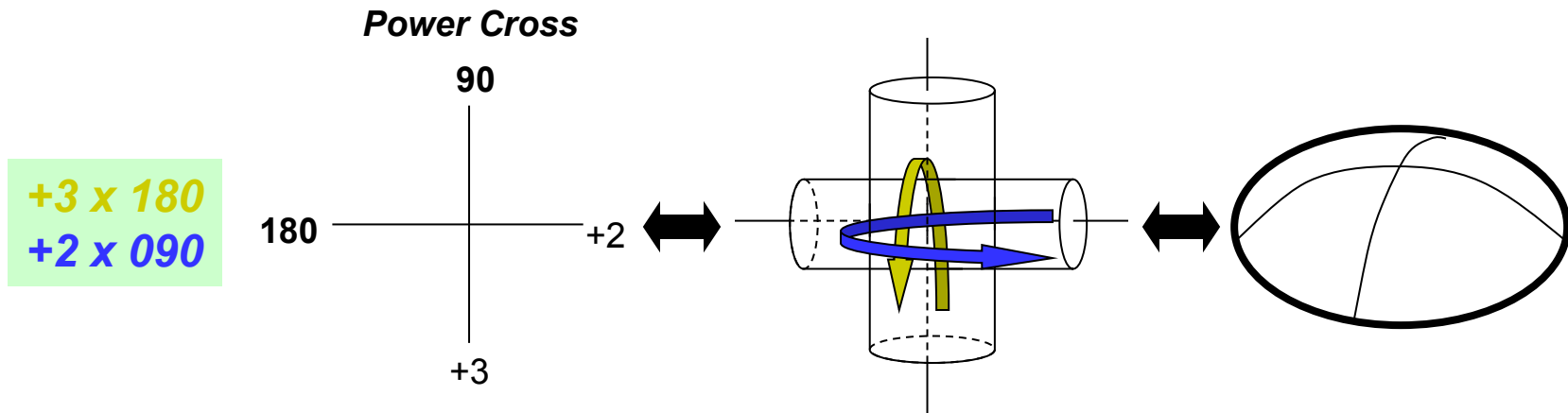
In contrast, this is simply stating 'the lens has a power of +2 at axis 090 and +3 at axis 180.'



Power Cross



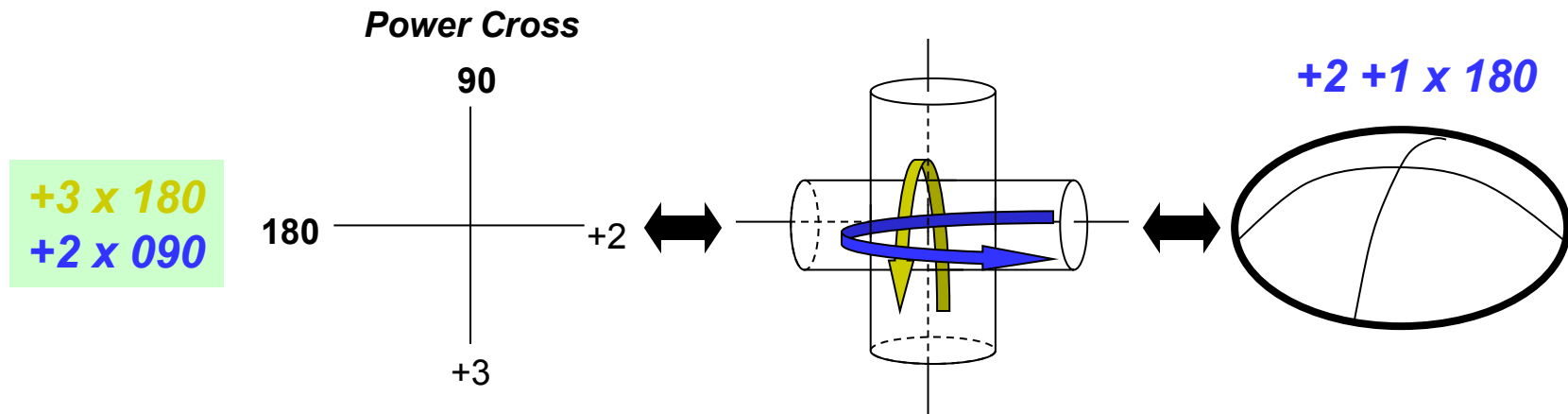
A power cross can easily be converted to its spherocylindrical equivalent. Simply pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.



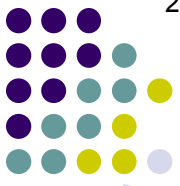
Power Cross



A power cross can easily be converted to its spherocylindrical equivalent. Simply *pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.* For instance, in the present example we could use +2D as our base sphere. The power needed at axis 090 is now in place. What about at 180? Since there is already +2D present there (courtesy of our +2D base sphere), we need an additional +1 x 180 to produce the +3D power needed in this axis. Thus, if using a +2D base sphere lens, the spherocylindrical (prescription) equivalent of our power cross is +2 +1 x 180.

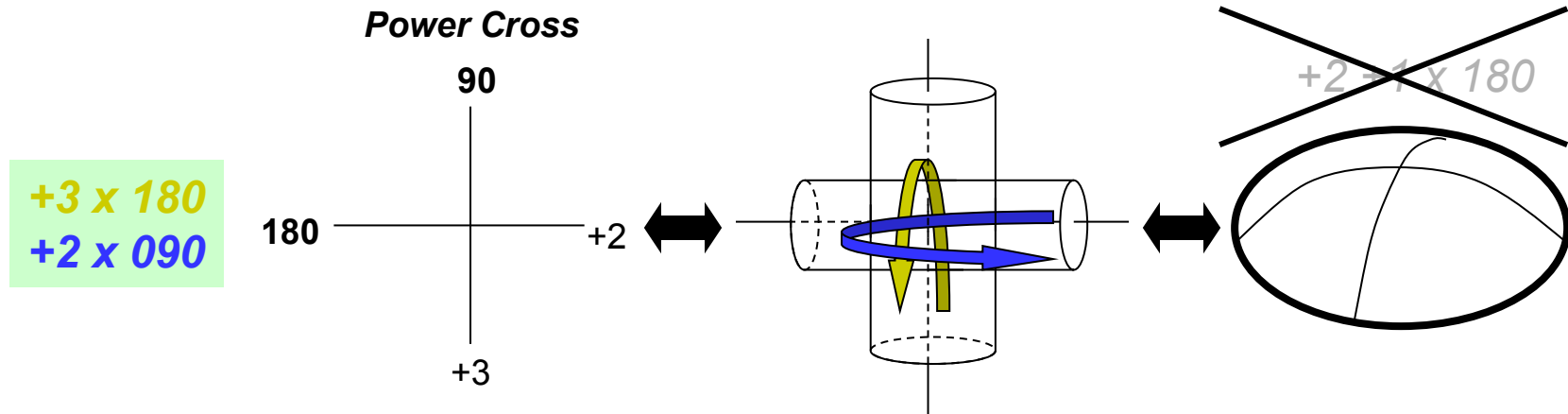


Power Cross



A power cross can easily be converted to its spherocylindrical equivalent. Simply *pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed.* For instance, in the present example we could use +2D as our base sphere. The power needed at axis 090 is now in place. What about at 180? Since there is already +2D present there (courtesy of our +2D base sphere), we need an additional +1 x 180 to produce the +3D power needed in this axis. Thus, if using a +2D base sphere lens, the spherocylindrical (prescription) equivalent of our power cross is +2 +1 x 180.

Or, we could use the +3D cylinder to create our base sphere. Note that this provides 1D of plus more than is needed at axis 090. To offset this excess plus we need -1 x 090 to produce the power needed in this axis. Thus the spherocylindrical (prescription) equivalent would be +3 -1 x 090.





Power Cross

A power cross can easily be converted to its spherocylindrical equivalent. Simply pick one of the cylinders to serve as the basis for the spherical component, then adjust the power of the other cylinder as needed. For instance, in the present example we could use +2D as our base sphere. The power needed at axis 090 is now in place. What about at 180? Since there is already +2D present there (courtesy of our +2D base sphere), we need an additional +1 x 180 to produce

us, if using a +2D base sphere lens, the component of our power cross is

Note the two prescriptions are equivalent:
+2 +1 x 180 converts to +3 -1 x 090, and
+3 -1 x 090 converts to +2 +1 x 180

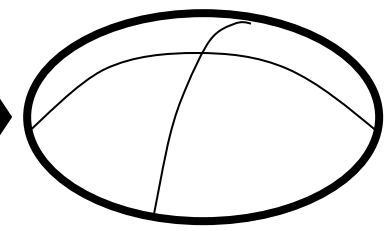
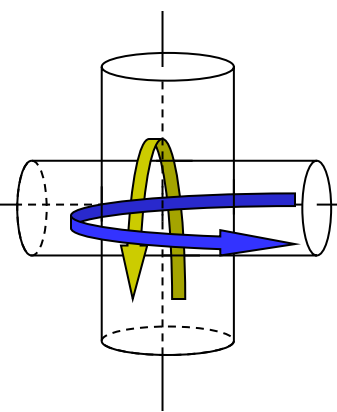
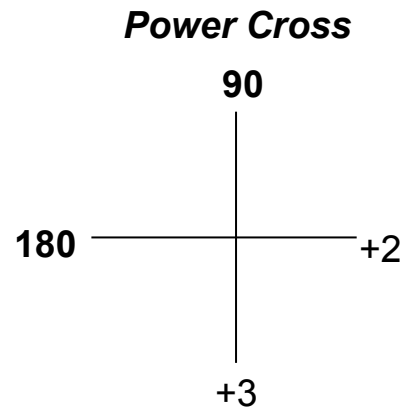
+2 +1 x 180

=

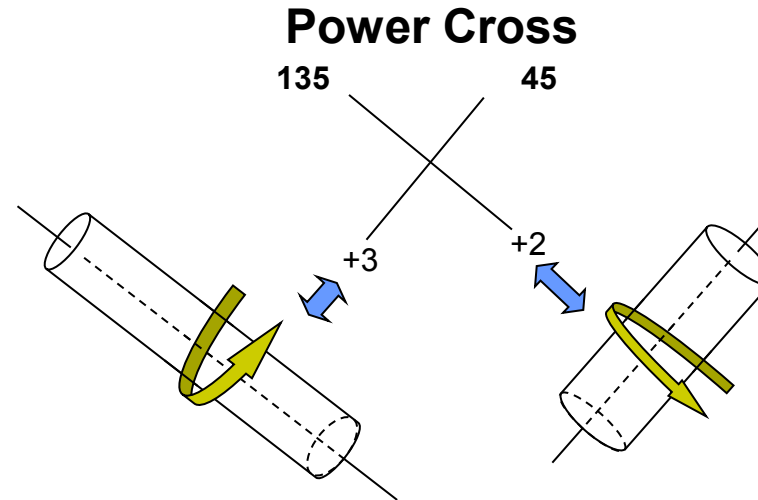
+3 -1 x 090

+3 -1 x 090
=
+2 +1 x 180

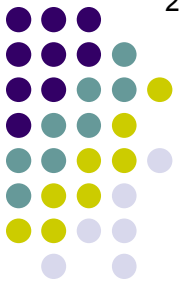
+3 x 180
+2 x 090



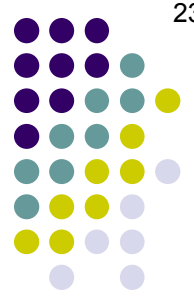
Power Cross



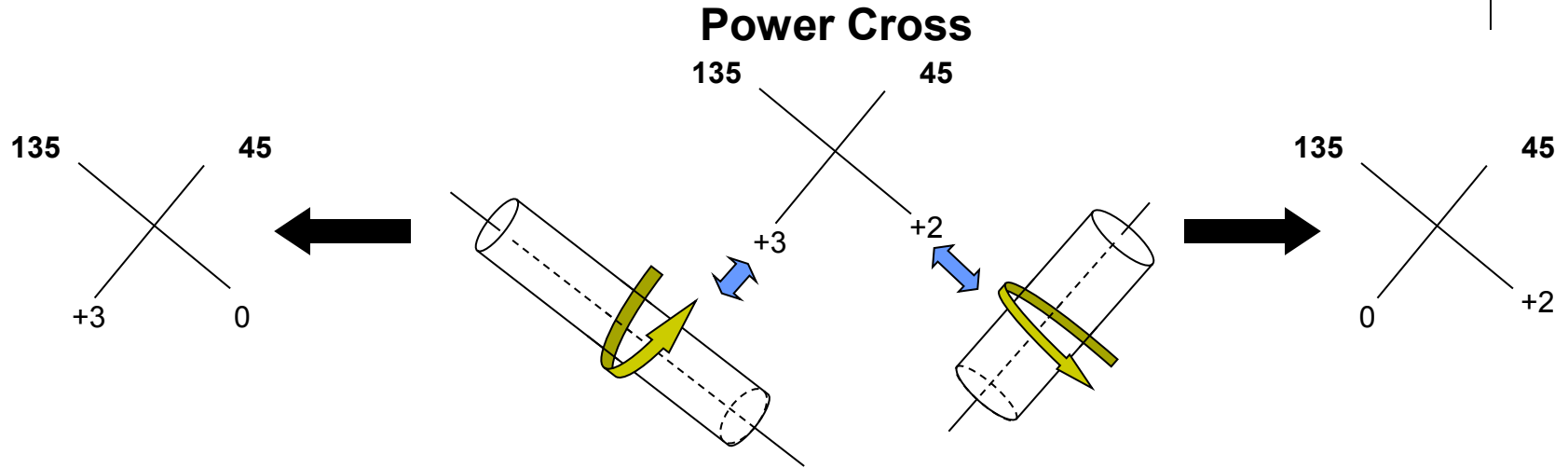
Let's take more of a cookbook approach to the conversion of a power cross to a spherocylindrical correction. Here's how to convert a power cross into a spherocylindrical prescription in four easy steps!

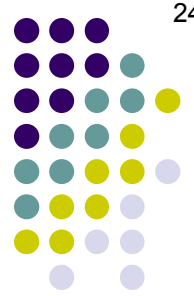


Power Cross



1. Separate the cylinders.



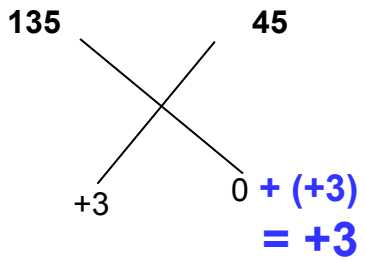
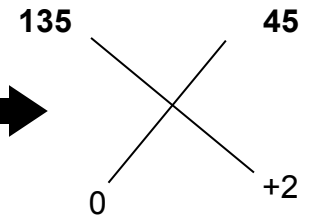
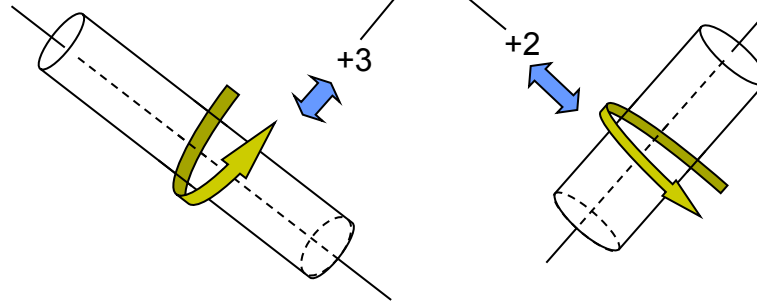
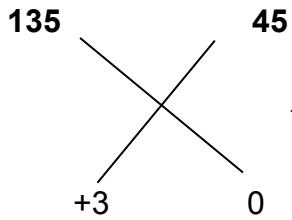


Power Cross

1. Separate the cylinders.

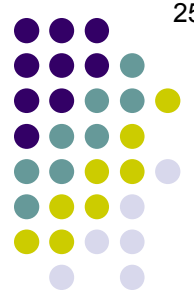
Power Cross

135 45



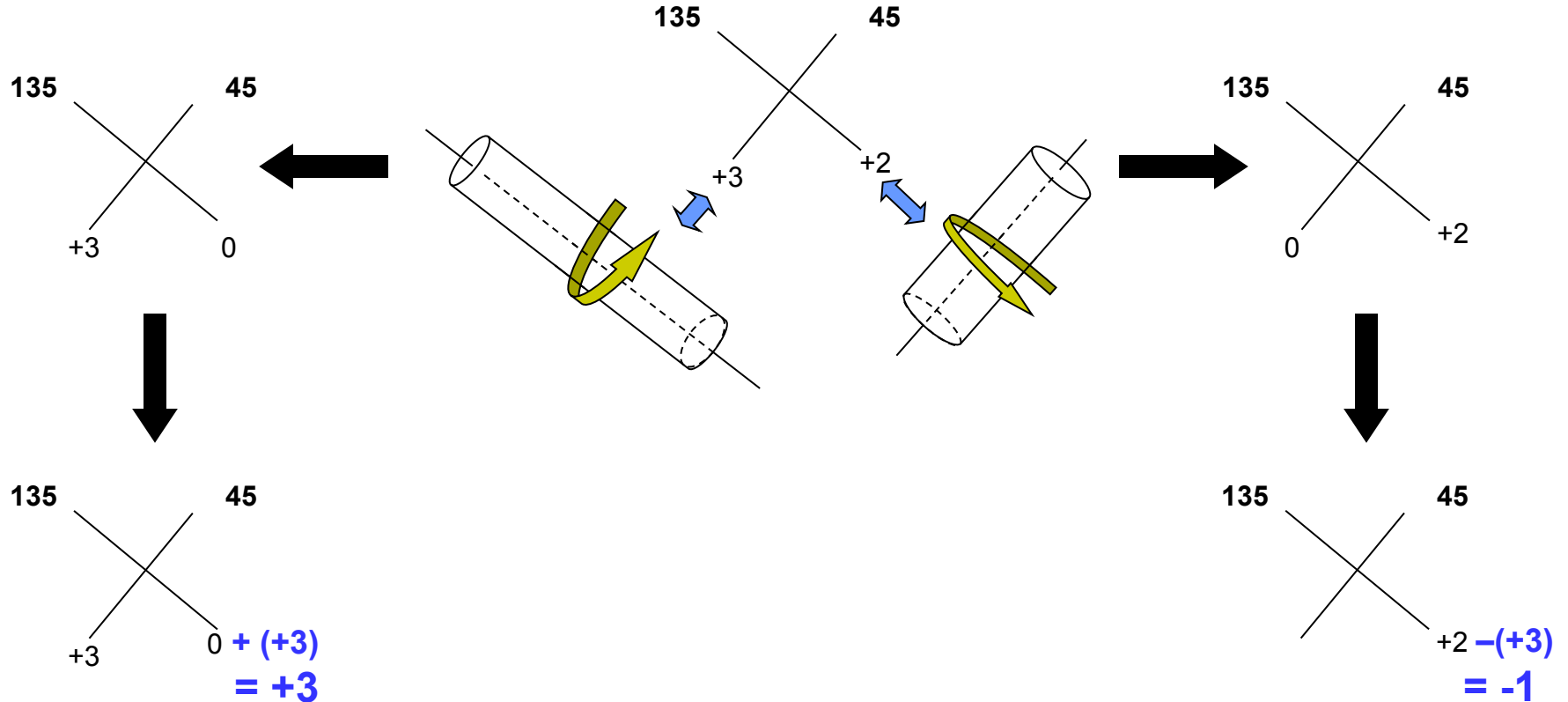
2. Make one cylinder the sphere by adding its power to the other arm.

Power Cross



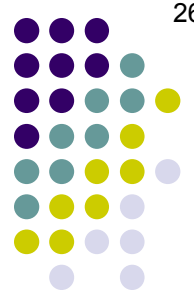
1. Separate the cylinders.

Power Cross



2. Make one cylinder the sphere by adding its power to the other arm.

3. Subtract the same amount from the same arm of the other cylinder.

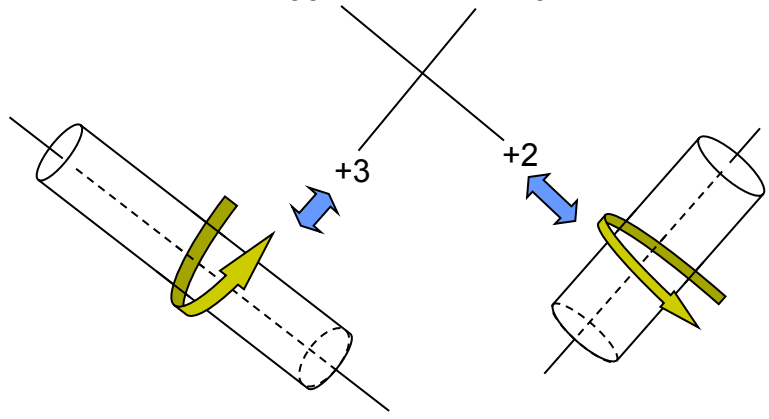


Power Cross

1. Separate the cylinders.

Power Cross

135 45



135 45
+3 0

135 45
0 +2

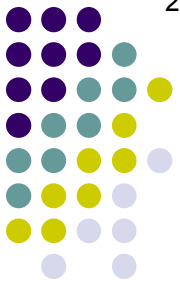
135 45
+3 0 + (+3)
 = +3

4. Combine the two into the spherocylindrical correction:
+3 -1 x 045

135 45
+2 - (+3)
 = -1

2. Make one cylinder the sphere by adding its power to the other arm.

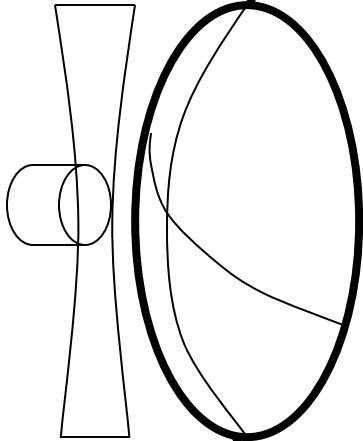
3. Subtract the same amount from the same arm of the other cylinder.



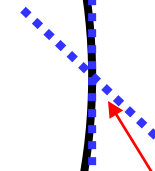
Power Cross

Eye Error:
+1 x 180
+5 x 090

+4x180
-5 Sph



We've seen this slide before:
It was the final result of our
Jackson cross refraction
exercise. Let's use it as a test
of our new-found power cross
skills by checking the final result
against what would be expected
on the basis of the eye error...



*Misleading
figure!*



Power Cross

Check our work...

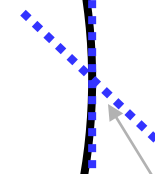
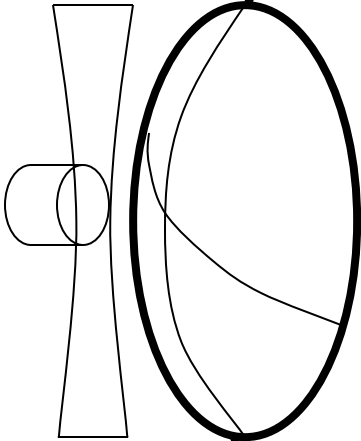
Eye Error:
+1 x 180
+5 x 090

Power cross for correction:

?

(That is, if this is the power cross of the eye error, what would the power cross for the correction be? Disregard vertex distance.)

+4x180
-5 Sph



Misleading figure!

Power Cross



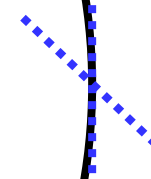
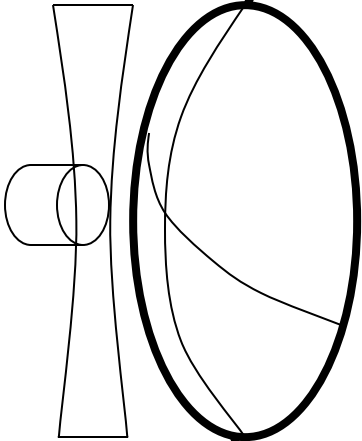
Check our work...

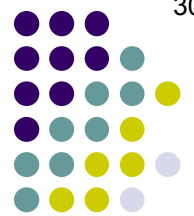
Eye Error:
+1 x 180
+5 x 090

Power cross for correction:

-1 x 180
-5 x 090

+4x180
-5 Sph





Power Cross

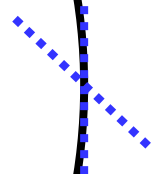
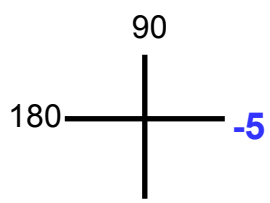
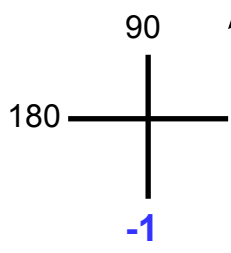
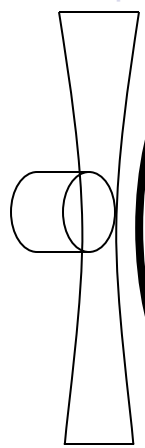
Check our work...

Eye Error:
+1 x 180
+5 x 090

Power cross for correction:

-1 x 180
-5 x 090

+4x180
-5 Sph





Power Cross

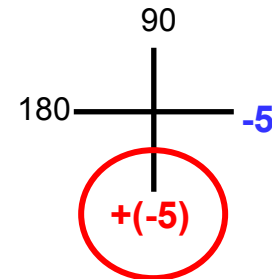
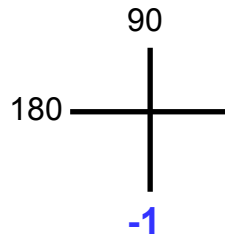
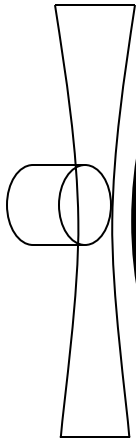
Check our work...

Eye Error:
 $+1 \times 180$
 $+5 \times 090$

Power cross for correction:

-1×180
 -5×090

$+4 \times 180$
 -5 Sph



To combine the power crosses into a spherocylindrical equivalent, first add -5×180 to the -5×090 lens. (This will make -5 the sphere component of the Rx.)



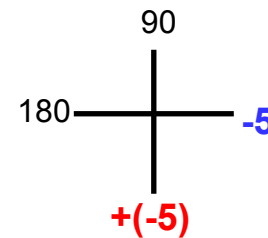
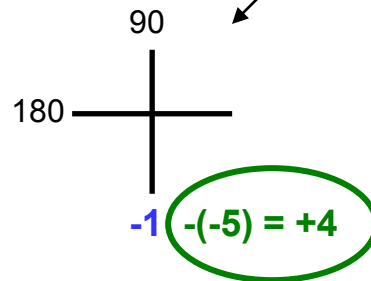
Power Cross

Check our work...

Eye Error:
 $+1 \times 180$
 $+5 \times 090$

Power cross for correction:

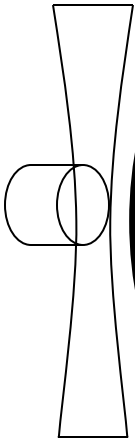
-1×180
 -5×090



To combine the power crosses into a spherocylindrical equivalent, first add -5×180 to the -5×090 lens. (This will make -5 the sphere component of the Rx.)

To keep things in balance, subtract that same -5×180 from the other power cross, resulting in a power of $+4 \times 180$ (remember, minus a minus is a plus).

$+4 \times 180$
 -5 Sph





Power Cross

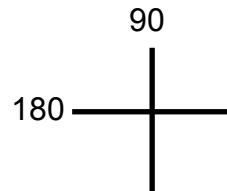
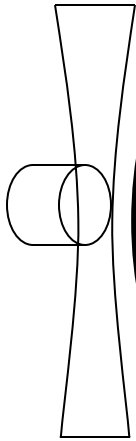
Eye Error:
 $+1 \times 180$
 $+5 \times 090$

Power cross for correction:

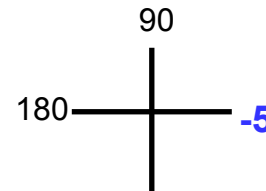
-1×180
 -5×090

Check our work...
Cha-Ching!

$+4 \times 180$
 -5 Sph



$-1 \quad -(-5) = +4$

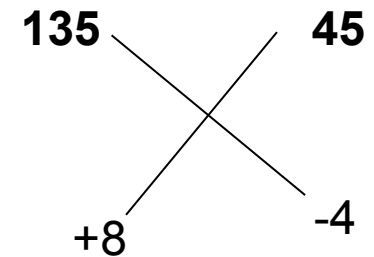
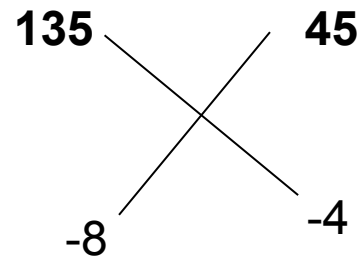
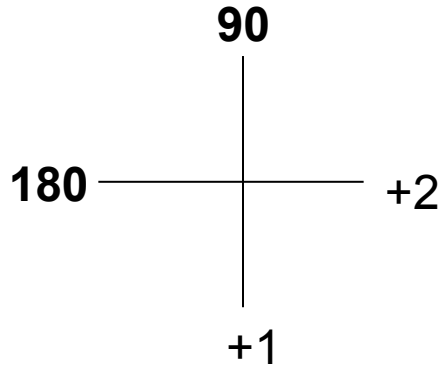
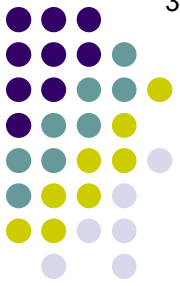


$+(-5)$

So the spherocylindrical correction for this eye error is $-5 +4 \times 180$, which is exactly what we got with the Jackson cross refraction! (This

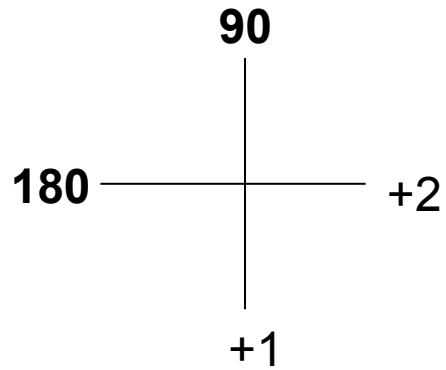
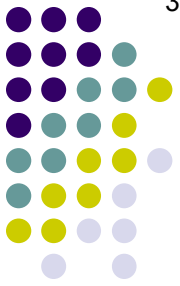
To keep things in balance, subtract that same -5×180 from the other power cross, resulting in a power of $+4 \times 180$ (remember, minus a minus is a plus).

Power Cross



Your turn. These are refractive results (not eye errors). Convert each power cross to spherocylindrical spectacle prescriptions in both plus and minus cylinder formats. Then calculate the S.E. (or can you determine the S.E. simply by looking at the power crosses?)

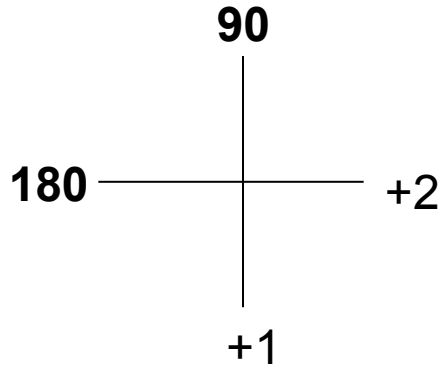
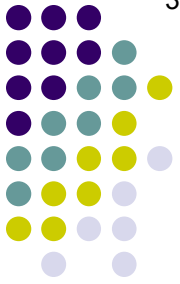
Power Cross



If we let the base sphere be +1D...

+1.0

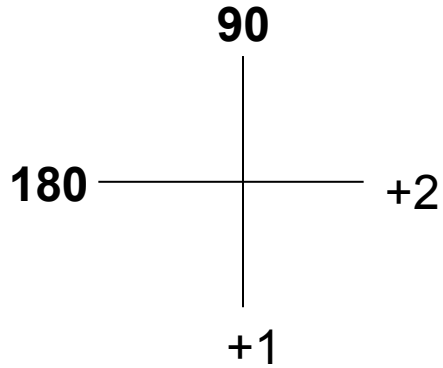
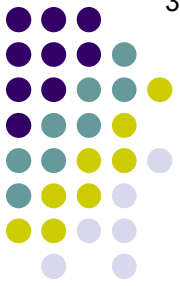
Power Cross



If we let the base sphere be +1D...
we will need an extra +1D at axis 090
to get the +2 power needed there.

Plus cyl: +1.0 +1.0 x 090

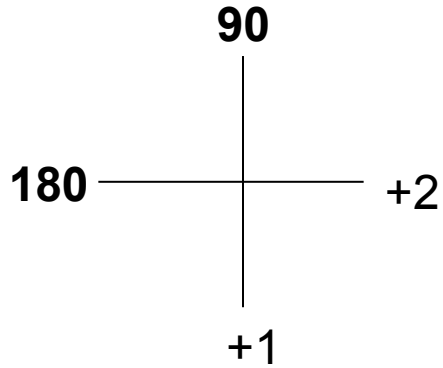
Power Cross



Plus cyl: +1.0 +1.0 x 090
+2.0

If we let the base sphere be +2D...

Power Cross

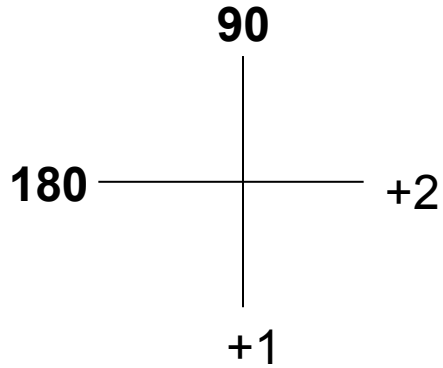
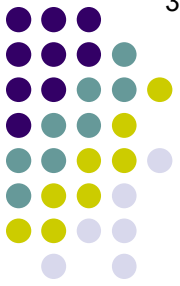


Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 -1.0 x 180

If we let the base sphere be +2D...
 we will need a -1D at axis 180 to
 get the +1 power needed there.



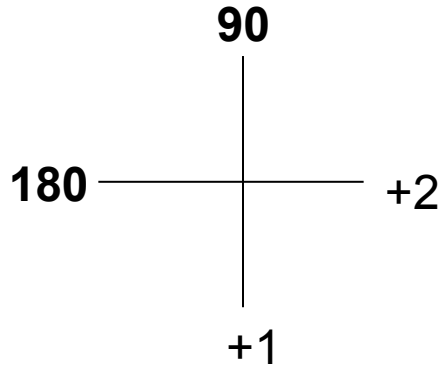
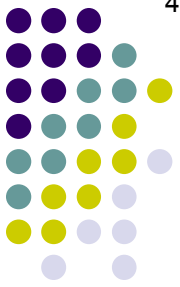
Power Cross



Spherical equivalent = ?

Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 -1.0 x 180

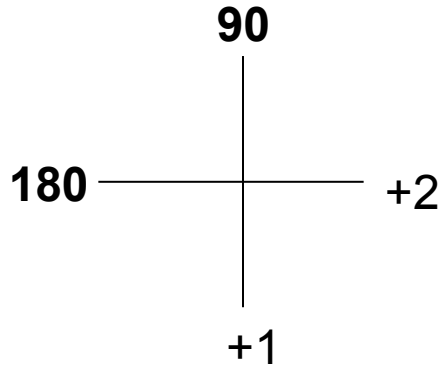
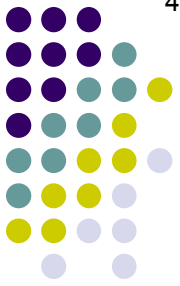
Power Cross



Spherical equivalent = $+1 + (+1)/2 = +1.50$

Plus cyl: $+1.0 +1.0 \times 090$
Minus cyl: $+2.0 -1.0 \times 180$

Power Cross



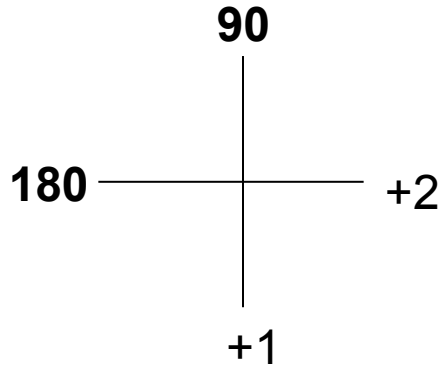
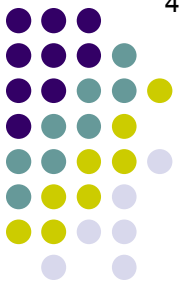
Spherical equivalent = $+1 + (+1)/2 = +1.50$

Plus cyl: $+1.0 +1.0 \times 090$

Minus cyl: $+2.0 -1.0 \times 180$

Spherical equivalent = ?

Power Cross



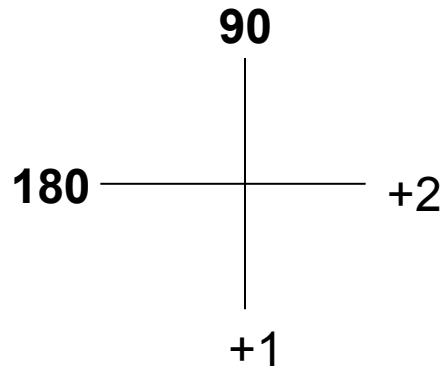
Spherical equivalent = $+1 + (+1)/2 = +1.50$

Plus cyl: $+1.0 +1.0 \times 090$

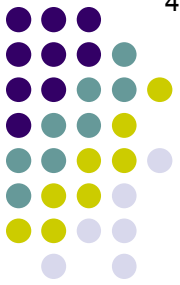
Minus cyl: $+2.0 -1.0 \times 180$

Spherical equivalent = $+2 + (-1)/2 = +1.50$

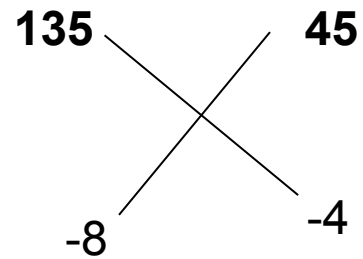
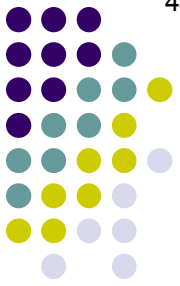
Power Cross



Plus cyl: +1.0 +1.0 x 090
Minus cyl: +2.0 -1.0 x 180
S.E.: +1.50



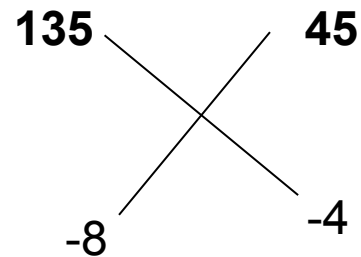
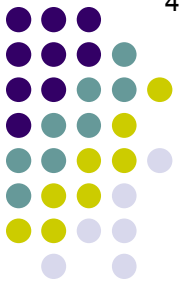
Power Cross



-8.0

If we let the base sphere be $-8D...$

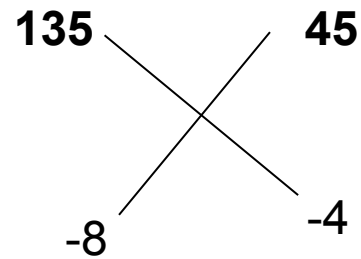
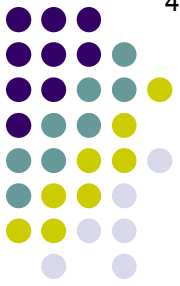
Power Cross



Plus cyl: -8.0 +4.0 x 045

If we let the base sphere be -8D...
we will need an extra +4D at axis 045
to get the -4 power needed there.

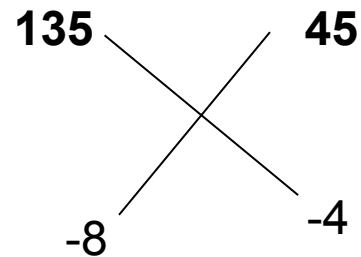
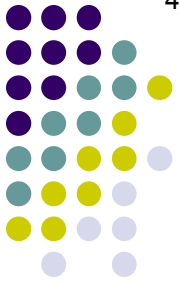
Power Cross



Plus cyl: -8.0 +4.0 x 045
-4.0

If we let the base sphere be -4D...

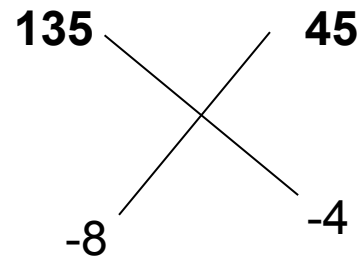
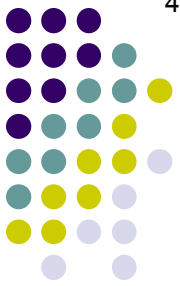
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135

If we let the base sphere be -4D...
 we will need an extra -4D at axis 135
 to get the -8 power needed there.

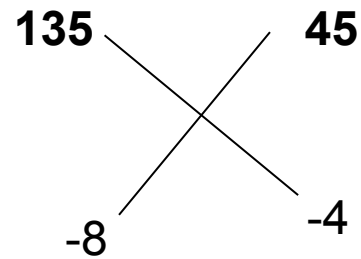
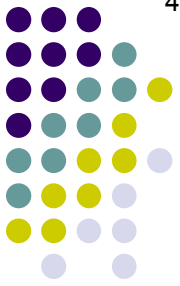
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135

Spherical equivalent = ?

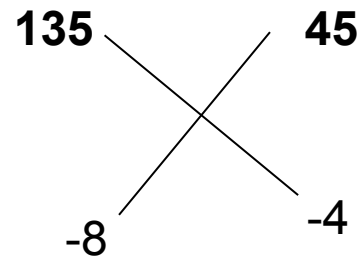
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135

Spherical equivalent = $-8 + (+4)/2 = -6.0$

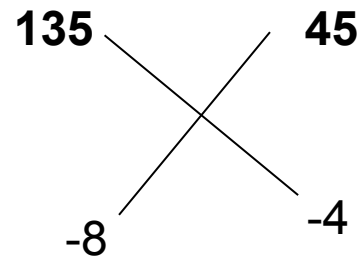
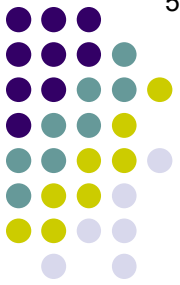
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135

Spherical equivalent = ?

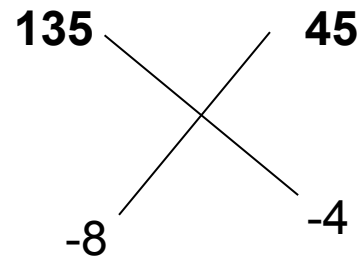
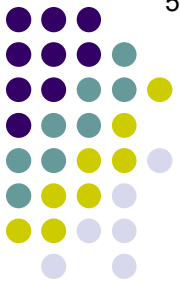
Power Cross



Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135

Spherical equivalent = $-4 + (-4)/2 = -6.0$

Power Cross

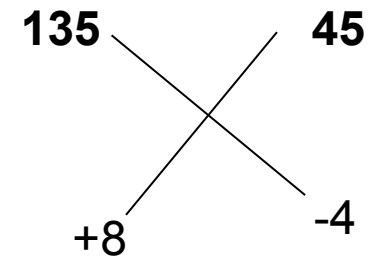


Plus cyl: -8.0 +4.0 x 045
Minus cyl: -4.0 -4.0 x 135
S.E.: -6.0

Power Cross

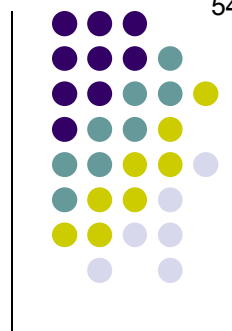


If we let the base sphere be $-4D...$

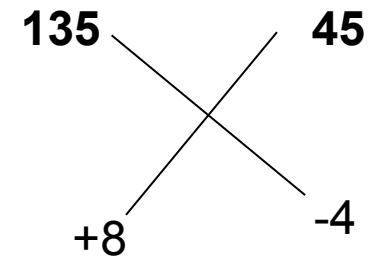


-4.0

Power Cross

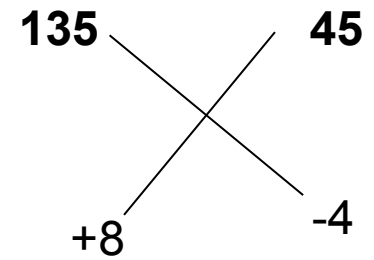
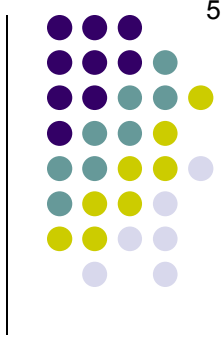


If we let the base sphere be -4D...
we will need an extra +12D at axis 135
to get the +8 power needed there.



Plus cyl: -4.0 +12.0 x 135

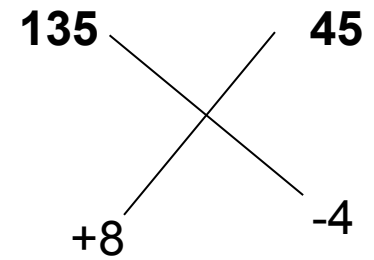
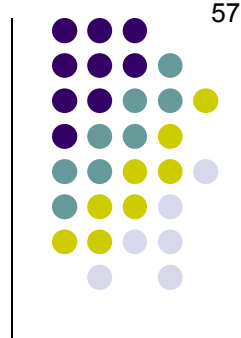
Power Cross



Plus cyl: -4.0 +12.0 x 135
+8.0

If we let the base sphere be +8D...

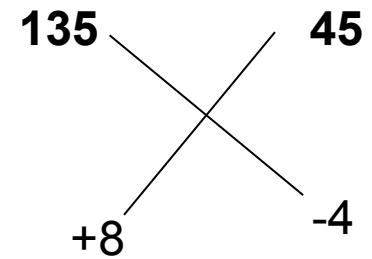
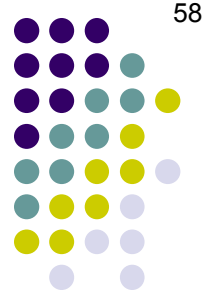
Power Cross



Spherical equivalent = ?

Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 -12.0 x 045

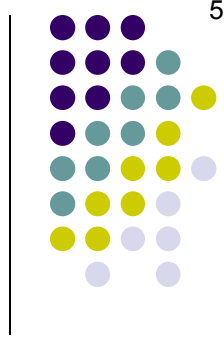
Power Cross



Spherical equivalent = $-4 + (+12)/2 = +2.0$

Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 -12.0 x 045

Power Cross

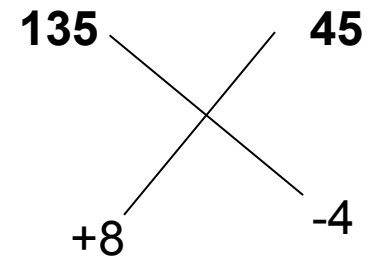
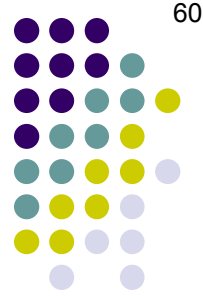


135 45
+8 -4

Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 -12.0 x 045

Spherical equivalent = ?

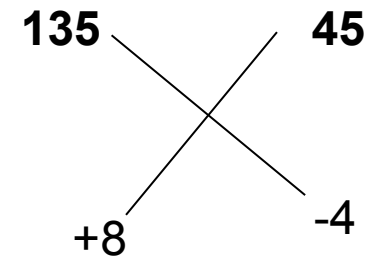
Power Cross



Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 -12.0 x 045

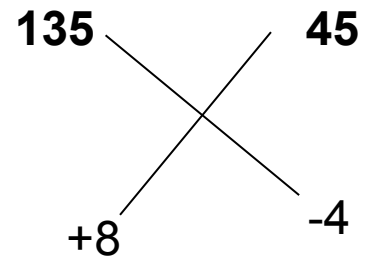
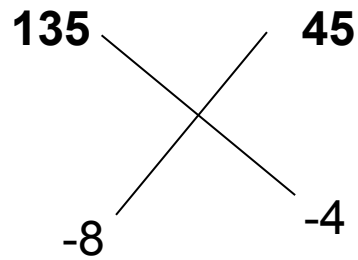
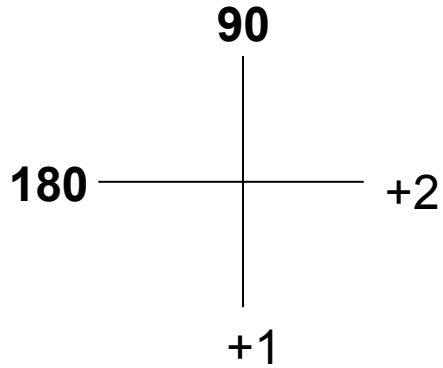
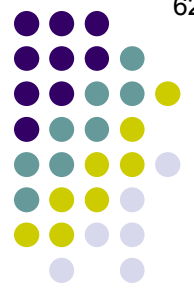
Spherical equivalent = $+8 + (-12)/2 = +2.0$

Power Cross



Plus cyl: -4.0 +12.0 x 135
Minus cyl: +8.0 -12.0 x 045
S.E.: +2.0

Power Cross

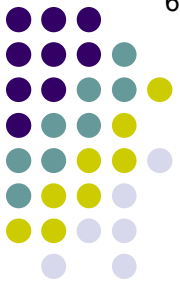


Plus: +1.0 +1.0 x 090
Minus: +2.0 -1.0 x 180
S.E.: +1.50

Plus: -8.0 +4.0 x 045
Minus: -4.0 -4.0 x 135
S.E.: -6.0

Plus: -4.0 +12.0 x 135
Minus: +8.0 -12.0 x 045
S.E.: +2.0

Note that the S.E., being at the 'dioptric center' of the conoid of Sturm, is simply the halfway point between the two cylinder powers. This can be determined by averaging the cylinder powers—converting to spherocylindrical form first is unnecessary.



*At this juncture, you should assess your Optics knowledge by taking Quiz 3 (slide-set BO29). **After that, resume the tutorial with slide-set BO16.***