Bifocal Add: Image Jump and Image Displacement

Basic Optics, Chapter 24

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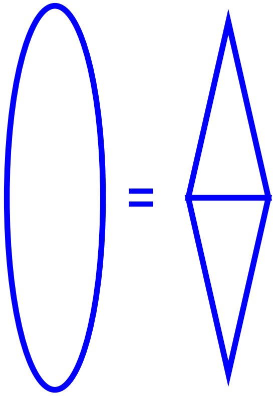
- **Not** an issue with PALs (progressive addition lenses; i.e., no-line bifocals)
- Before delving into jump and displacement, let's talk about some background info:
  - Lenses as prisms
  - Types of bifocal add segments
  - Optical centers
  - Prentice's rule of induced prism

Lenses as Prisms

Spherical lenses come in two basic flavors: *Plus* and *minus*

Lenses as Prisms

Recall that a *plus* lens can be thought of as two prisms **base-to-base**



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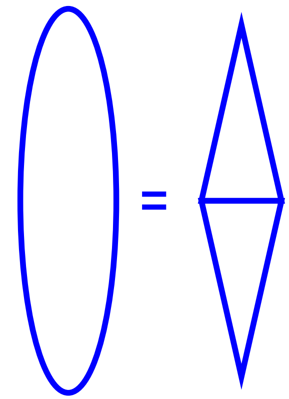

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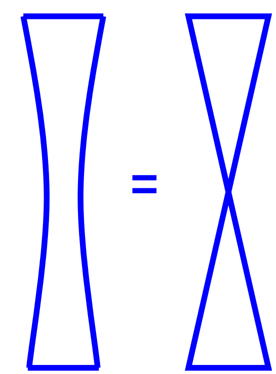
Likewise, a *minus* lens can be thought of as two prisms **apex-to-apex**



Types of Add Segments

Bifocal adds come in two basic flavors: *Round top* and *flat top*

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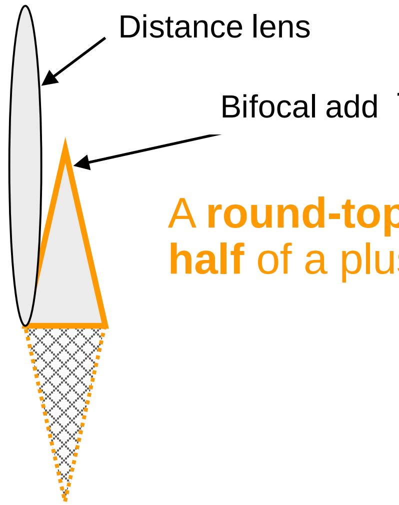

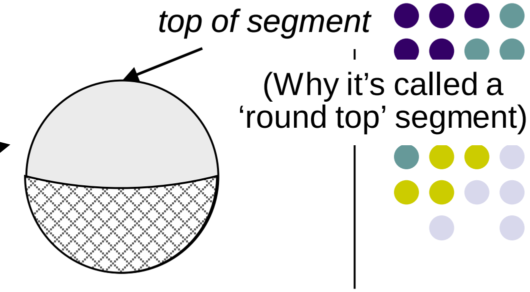

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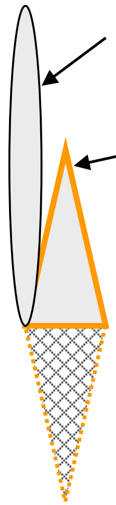

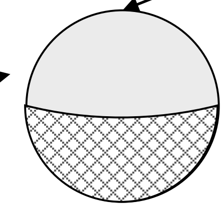

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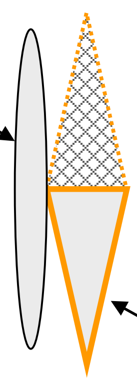
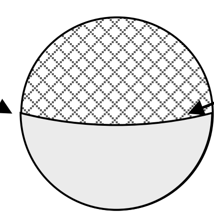
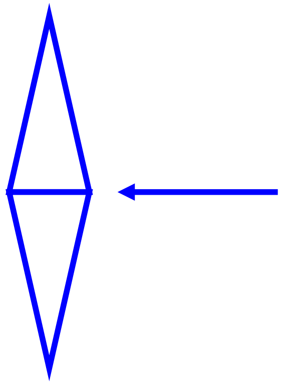


Likewise, a **flat-top** bifocal segment can be thought of as the **bottom half** of a plus lens (i.e., a **base-up** prism)



Lenses: Optical Centers

The optical center of
the **plus** lens is right here,
in the center



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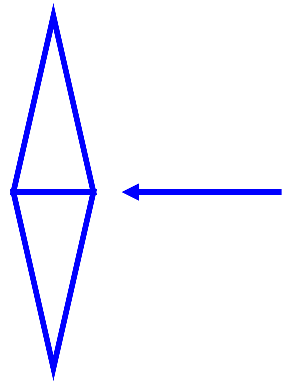

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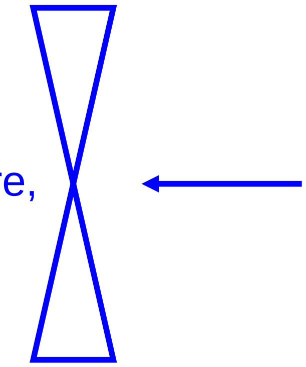

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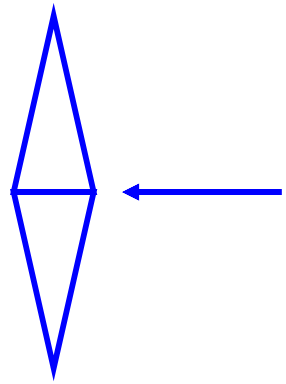

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The optical center of the add is near its base; i.e., near where it would be if the add were a 'whole' plus lens instead of half of one

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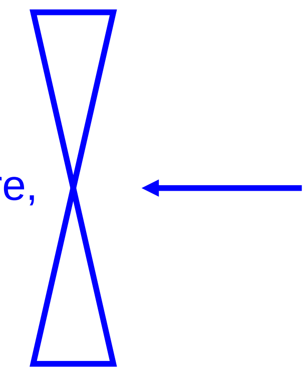

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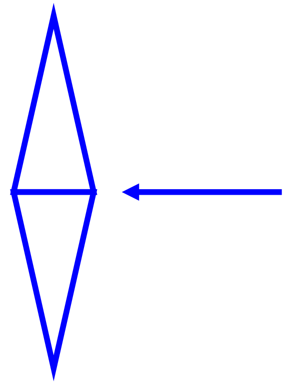

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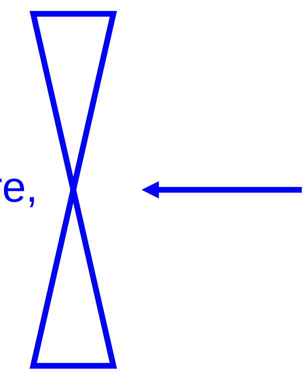

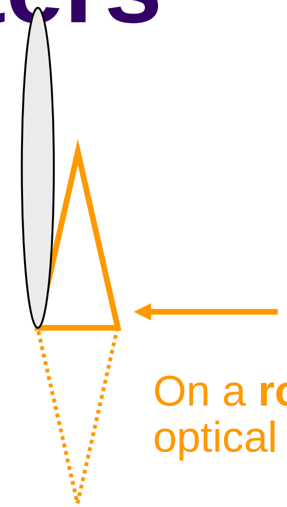

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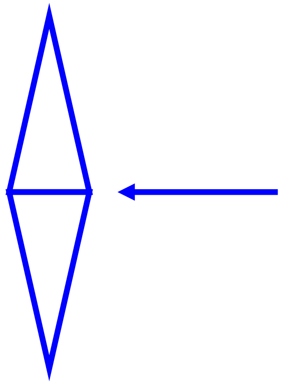

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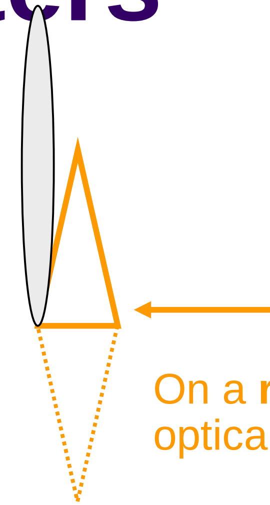
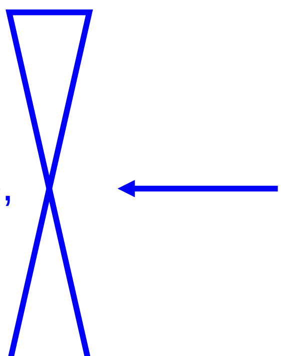


The optical center of the **minus** lens is right here, in the center



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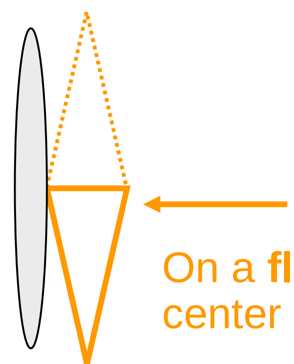

On a **flat-top** add, the optical center of the add is **high**

Prentice's Rule of Induced Prism

Because lenses are fundamentally prisms, it is not surprising that lenses can have prismatic effects. **Prentice's Rule** *states that the amount of prism (in prism diopters,* **PD***) induced by a lens is a function of the distance from the optical center through which one is looking, and the dioptric power of the lens:*

$$PD = hD$$

where **h** *is the distance from the optical center in cm and* **D** *is the dioptric power of the lens.*

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Make sure you take note of this!

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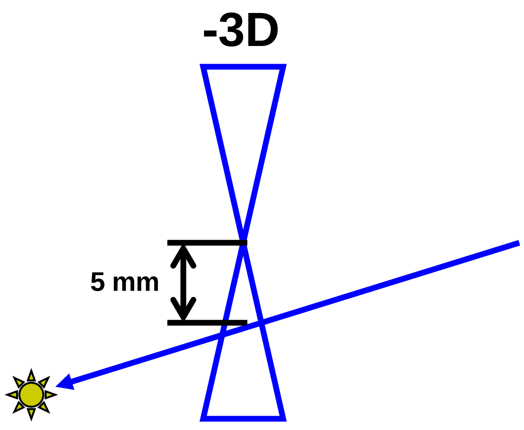

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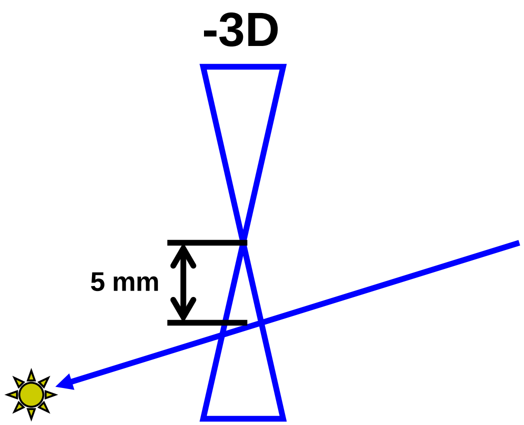

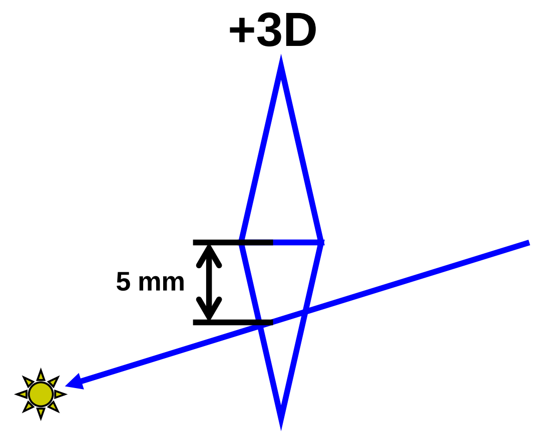

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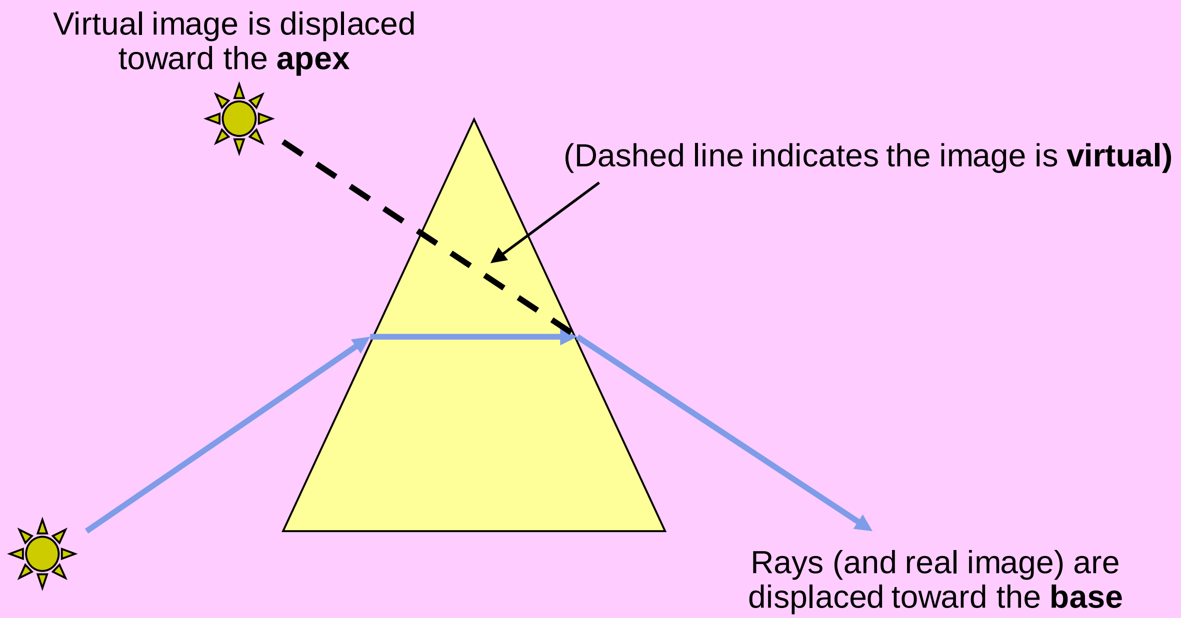

Recall that light rays are bent toward the **base** of a prism, with the result that the image seems to move toward the **apex** of the prism…

Looking 5 mm below the optical center of a -3D lens induces .5 x (-3) = 1.5D of base-**down** prism

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- *Image jump* refers to a **sudden** change in image location that occurs when gaze shifts from the distance lens to the add segment

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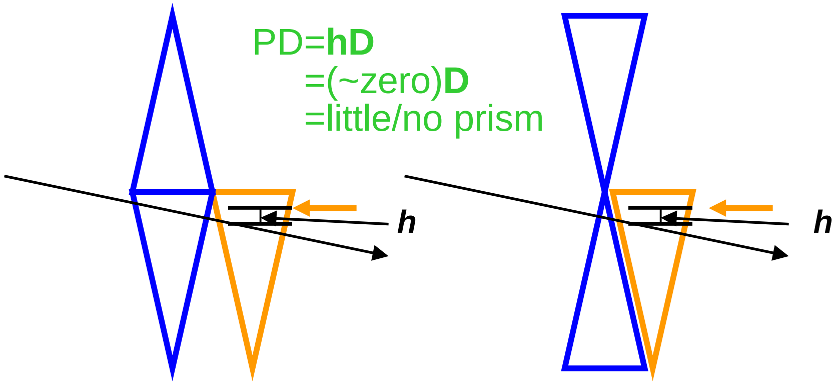
- *Image jump* refers to a **sudden** change in image location that occurs when gaze shifts from the distance lens to the add segment
  - Think of it as a **Prentice's Rule** issue owing to the location of the **optical center** of the add segment

Image Jump

Image jump: *A sudden change in image location occurring when gaze shifts into the bifocal add segment*

Bifocal add:
Flat-Top segment



The optical center of a **flat-top** segment is high. When gaze shifts downward into the add, one is looking through or very near its optical center. Because there is little or no induced prism (i.e., ***h*** is small or zero), images do not seem to jump.

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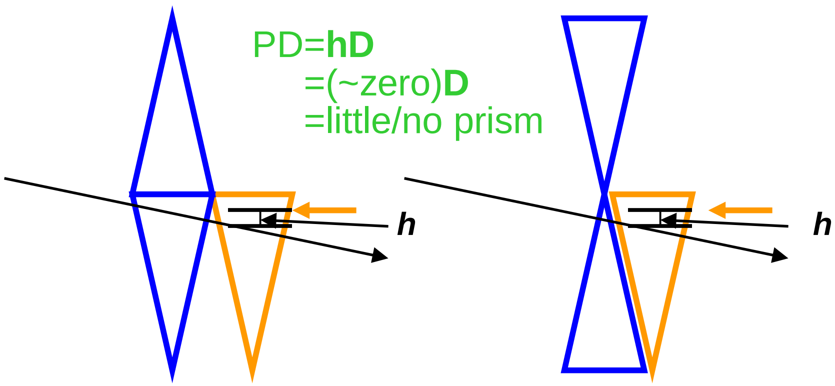

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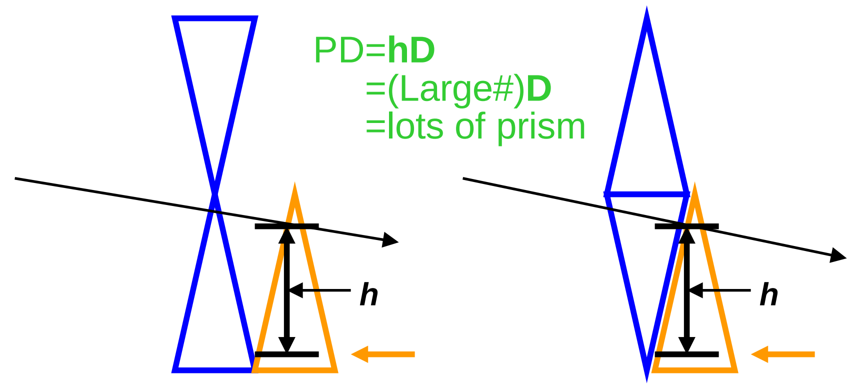
Bifocal add: ***Round-Top*** segment



However, the optical center of a **round-top** segment is low. Therefore, when gaze shifts downward into the add, one is suddenly looking through a lens at considerable distance from its optical center (i.e., ***h*** is large). This abruptly induces a significant amount of prism, and images will seem to jump (*upwards*, toward the apex of the add segment ‘prism’).

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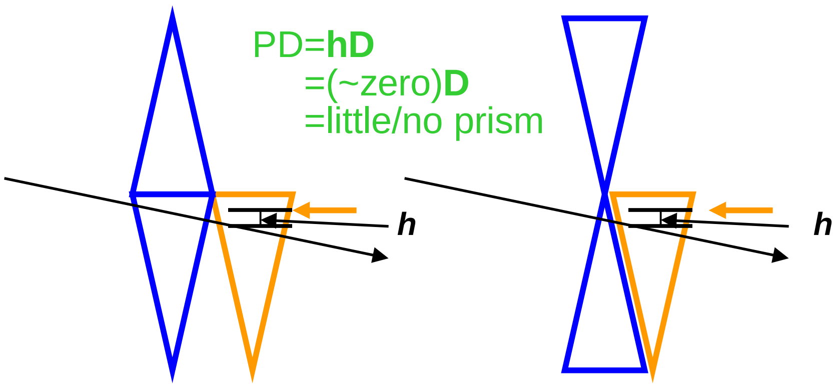
Bifocal add: ***Flat-Top*** segment



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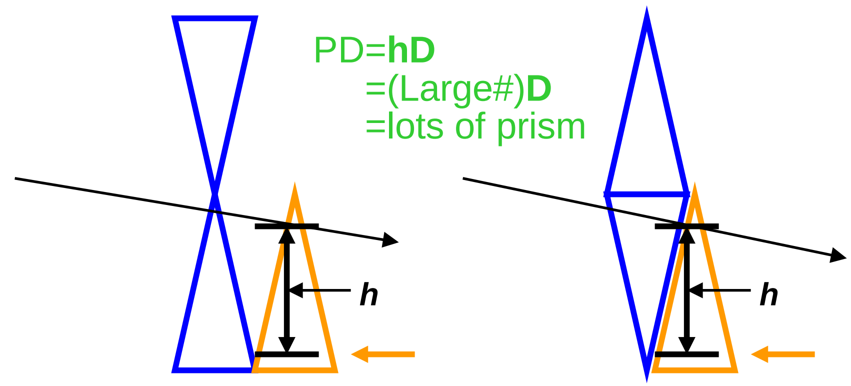

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*Therefore, for both plus and minus lenses, image jump is minimized with a **flat-top** segment*

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- *Image displacement* refers to the total apparent distance between an image viewed through the distance lens versus through the add segment
  - Think of it as owing to **net prismatic effects**
    - The magnitude of image displacement is a function of the **total net prism** acting on the image through the bifocal segment

Image Displacement

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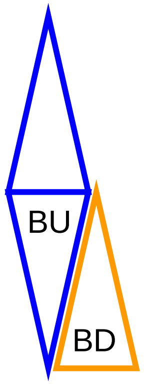
Bifocal adds: ***Plus*** lenses

When a **round-top** segment is placed on a plus lens, note how the prismatic effects work to cancel each other



BU+BD=Little net prism→
little image displacement

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The magnitude of image displacement is a function of the **total net prism** *acting on the image through the bifocal segment*

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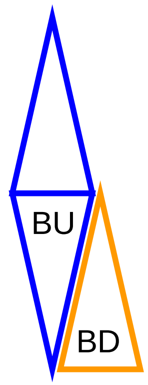

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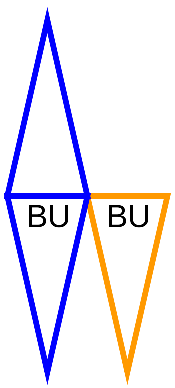

However, when a **flat-top** segment is placed on a plus lens, note how the prismatic effect is amplified

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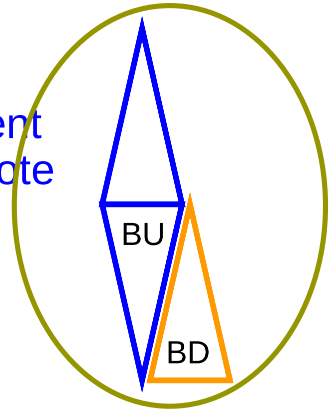

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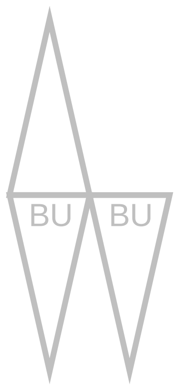

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For a **plus** *lens, image displacement is minimized with a* ***round-top*** *segment*

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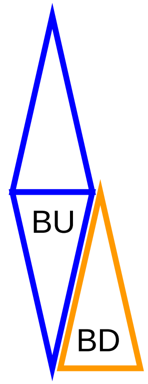

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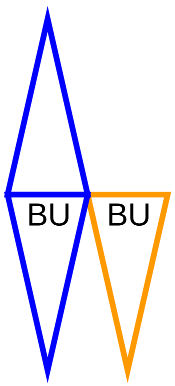

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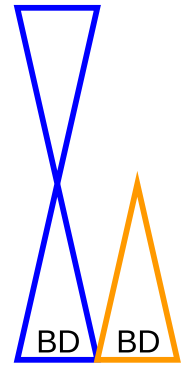

When a **round-top** segment is placed on a minus lens, note how the prismatic effects amplify one another

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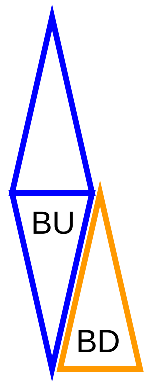

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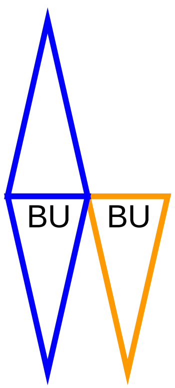

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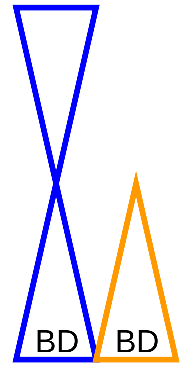

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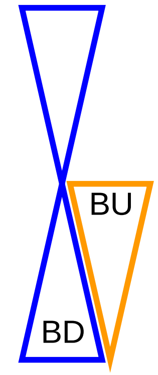
However, when a **flat-top** segment is placed on a minus lens, the prismatic effects work to cancel one another



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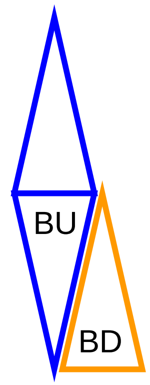

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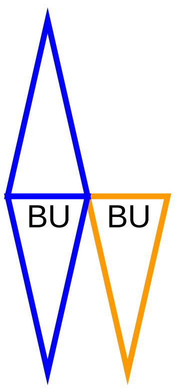

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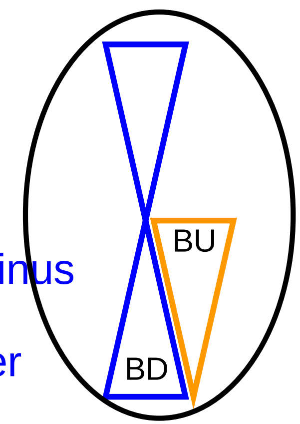
For a **plus** ***lens, image displacement is minimized with a*** ***round-top*** ***segment***

Bifocal adds: ***Minus*** lenses

When a **round-top** segment is placed on a minus lens, note how the prismatic effects amplify one another

BD+BD=Lots of net prism→
lots of image displacement

However, when a **flat-top** segment is placed on a minus lens, the prismatic effects work to cancel one another



BD+BU=Little net prism→
little image displacement

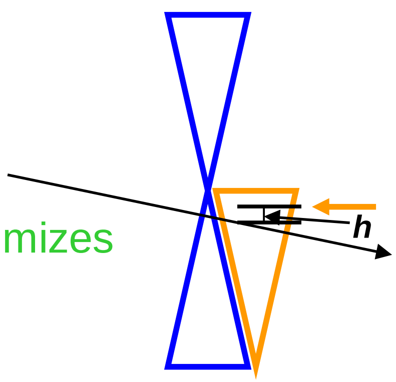
For a **minus** ***lens, image displacement is minimized with a*** ***flat-top*** ***segment***

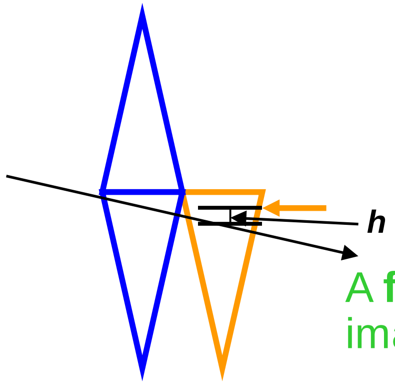
Putting It Together: Which Add Is Best?

Putting It Together: Which Add Is Best?

Bifocal adds:
Minus lenses

A **flat-top** segment minimizes image jump





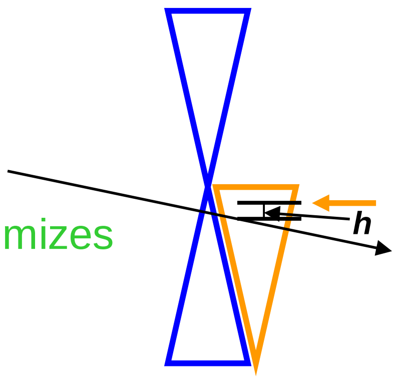
Bifocal adds:
Plus lenses

A **flat-top** segment minimizes image jump

As stated previously, a flat-top segment minimizes image jump for both plus and minus lenses

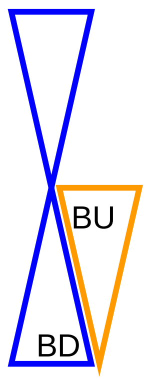
Putting It Together: Which Add Is Best?

Bifocal adds: ***Minus*** lenses



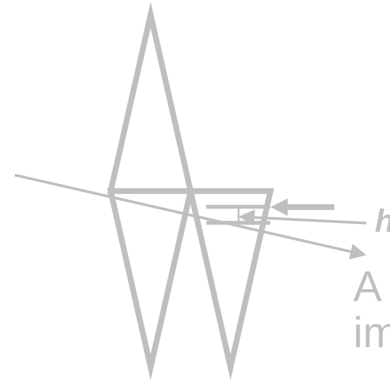
A **flat-top** segment minimizes image jump

When a **flat-top** segment is placed on a minus lens, the prismatic effects work to cancel one another



BD+BU=Little net prism→
***little** image displacement*

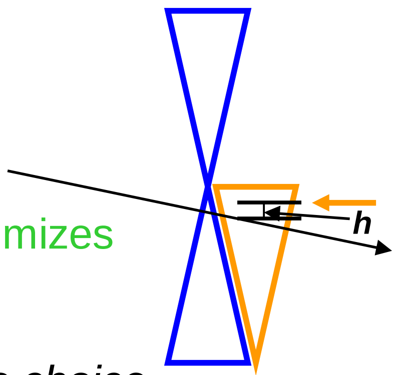
Bifocal adds: ***Plus*** lenses



A **flat-top** segment minimizes image jump

Putting It Together: Which Add Is Best?

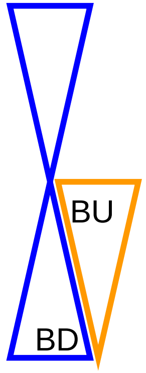
Bifocal adds: ***Minus*** lenses



A **flat-top** segment minimizes image jump

So, for minus lenses the choice of add type is easy: A flat-top minimizes both image jump **and** *displacement*

When a **flat-top** segment is placed on a minus lens, the prismatic effects work to cancel one another



BD+BU=Little net prism→ ***little*** *image displacement*

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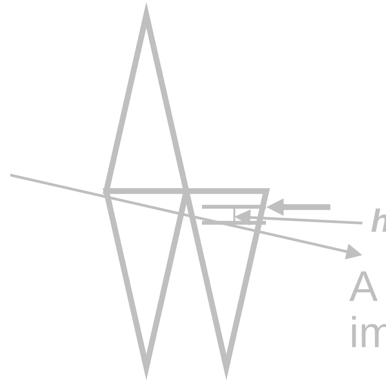
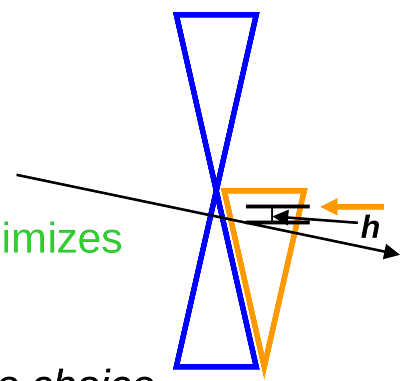


A **flat-top** segment minimizes image jump

Putting It Together: Which Add Is Best?

Bifocal adds: ***Minus*** lenses



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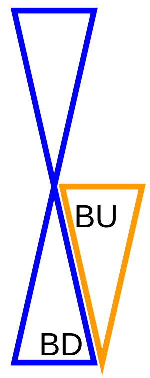
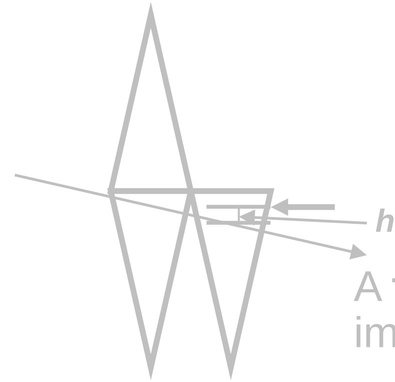


When a **flat-top** segment is placed on a minus lens, the prismatic effects work to cancel one another

BD+BU=Little net prism→
little *image displacement*

For a **minus** *lens, always select a* ***flat-top*** *segment*

Bifocal adds: ***Plus*** lenses



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Putting It Together: Which Add Is Best?

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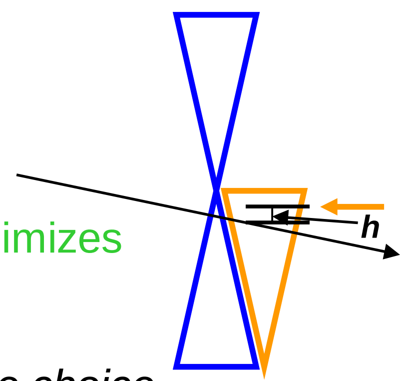

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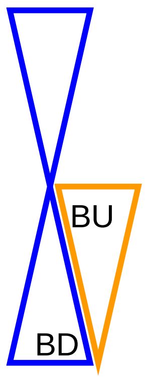

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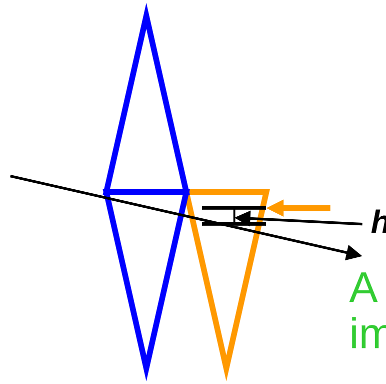
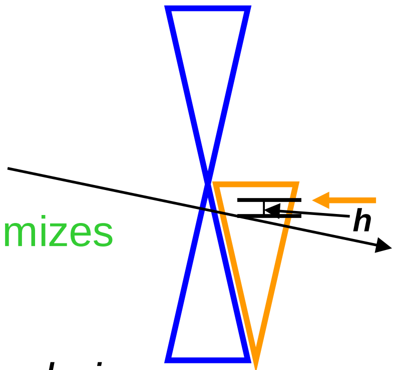


A **flat-top** segment minimizes image jump

For plus lenses, the choice is not as easy: A flat-top will minimize jump…

Putting It Together: Which Add Is Best?

Bifocal adds: ***Minus*** lenses



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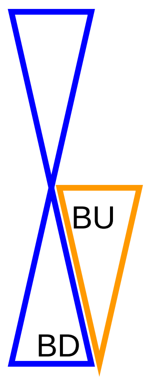

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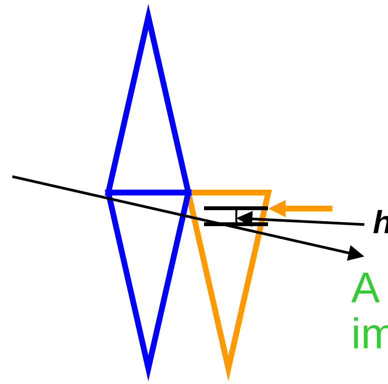
For a ***minus*** *lens, always select a* ***flat-top*** *segment*

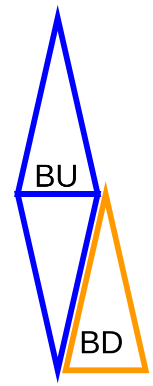
Bifocal adds: ***Plus*** lenses



A **flat-top** segment minimizes image jump

For plus lenses, the choice is not as easy: A flat-top will minimize jump…but a round-top minimizes displacement

When a **round-top** segment is placed on a plus lens, the prismatic effects work to cancel each other



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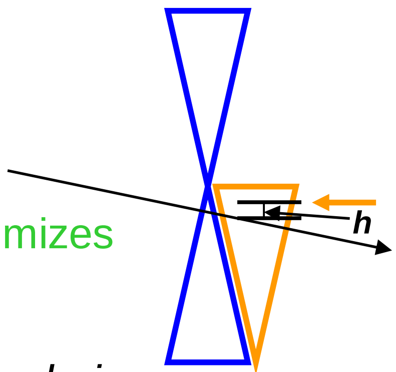
Putting It Together: Which Add Is Best?

Bifocal adds: ***Minus*** lenses



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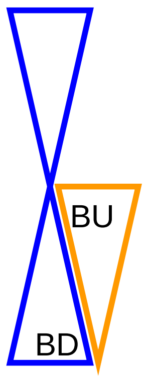

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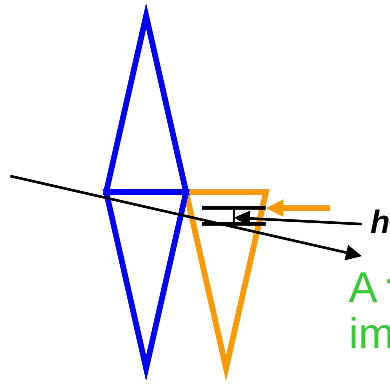

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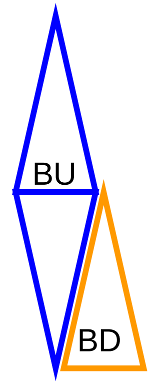


When a **round-top** segment is placed on a plus lens, the prismatic effects work to cancel each other

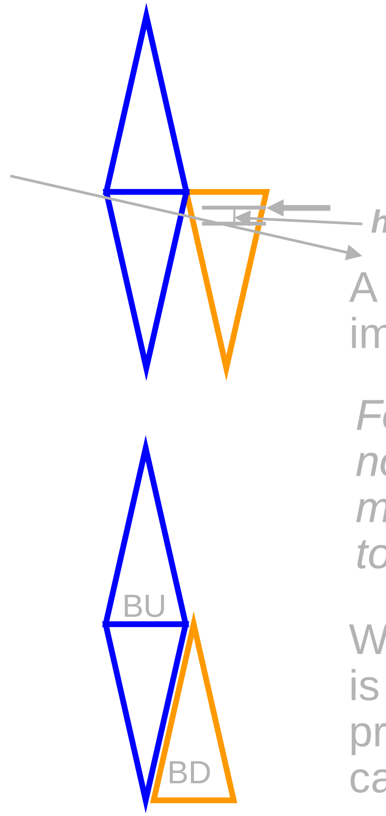
BU+BD=Little net prism→ ***little*** *image displacement*

So which is the best add segment for a ***plus*** *lens?*

Putting It Together: Which Add Is Best?

- The choice of segment type for hyperopic adds depends on whether one needs to minimize jump *vs* displacement

Bifocal adds:
Plus lenses



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  - *Jump* might bother waiters
  - *Displacement* might bother desk workers

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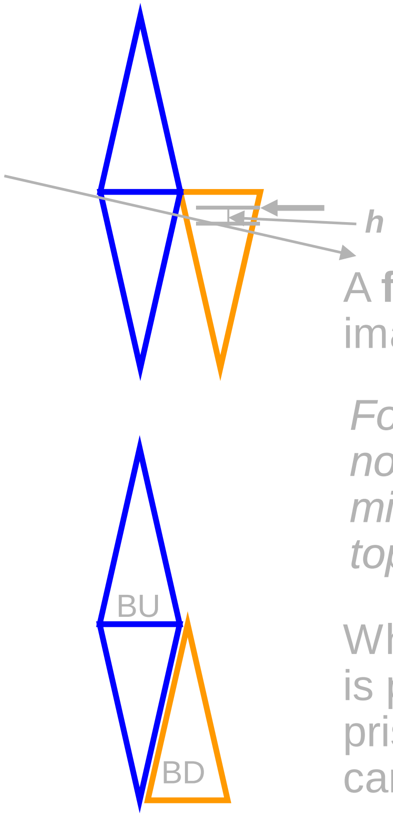

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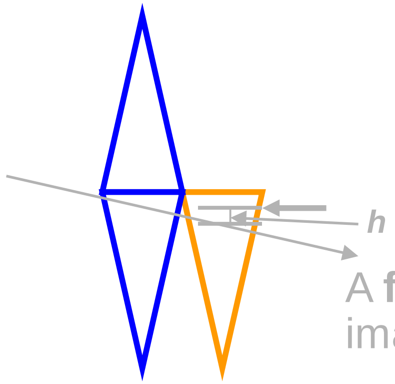
Putting It Together: Which Add Is Best?

- The choice of segment type for hyperopic adds depends on whether one needs to minimize jump *vs* displacement
  - *Jump* might bother waiters
  - *Displacement* might bother desk workers
- In practice, most specs are made with flat-top segs
  - Easier and cheaper to make

Bifocal adds:
Plus lenses



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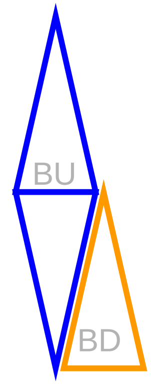

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