Bifocal Add: Image Jump and Image Displacement

Basic Optics, Chapter 24
Jump and Displacement

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- **Not** an issue with PALs (progressive addition lenses; i.e., no-line bifocals*)

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Jump and Displacement

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*Be aware that, because they aren’t limited to two focal distances, the appellation *no-line bifocals* is technically incorrect (not to mention a contradiction in terms). The point being, if an OKAP question asks about ‘presbyopia-correcting lenses,’ then PALs are in play. **But if the question refers to “bifocals” specifically, the answer is never PALs (cuz they ain’t bifocals).**
Jump and Displacement

- Image jump and image displacement are phenomena associated with bifocal additions.
- **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*
Recall that a *plus* lens can be thought of as two prisms *base-to-base*.

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

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

**Spherical lenses** come in two basic flavors: *Plus* and *minus*.
Types of Add Segments

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**Types of Add Segments**

A **round-top** bifocal segment can be thought of as the **top half** of a plus lens (and thus like a **base-down** prism).

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

**Bifocal adds** come in two basic flavors: *Round top* and *flat top*.
The optical center of the **plus** lens is right here, in the center.

**Spherical lenses** come in two basic flavors: *Plus* and *minus*.
Lenses: Optical Centers

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

The optical center of the **minus** lens is right here, in the center
Lenses: Optical Centers

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

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

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.
Lenses: Optical Centers

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

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

On a **round-top** add, the optical center of the add is **low**.

*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.*
Lenses: Optical Centers

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

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

On a **round-top** add, the optical center of the add is **low**.

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.

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

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

\[ \text{PD} = hD \]

where \( h \) is the distance from the optical center in cm and \( D \) is the dioptric power of the lens.
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PD = hD
\]

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

Make sure you take note of this!
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:

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

Looking 5 mm below the optical center of a -3D lens induces \(.5 \times (-3) = 1.5D\) of base-down prism.
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Looking 5 mm below the optical center of a +3D lens induces \( .5 \times (3) = 1.5 \)D of base-\textbf{up} prism
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Looking 5 mm below the optical center of a +3D lens induces \( .5 \times (3) = 1.5 \)D of base-up prism.

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…

Rays (and real image) are displaced toward the base

Virtual image is displaced toward the apex

(Dashed line indicates the image is virtual)
Image Jump

- *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

Bifocal add: 

*Flat-Top* segment

The optical center of a *flat-top* segment is high*.

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

*Per the BCSC *Optics* book, the optical center of a typical flat-top is 3 mm from the top of the segment.*
Image Jump

Bifocal add:
\textbf{Flat-Top} segment

The optical center of a \textbf{flat-top} segment is high. When gaze shifts downward into the add, one is looking very near its optical center. Because there is little induced prism (i.e., $h$ is small), images do not seem to jump.
**Image Jump**

**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 very near its optical center. Because there is little induced prism (i.e., \( h \) is small), images do not seem to jump.

\[
PD = hD = (~\text{zero})D = \text{little/no prism}
\]

**Round-Top** segment

However, the optical center of a **round-top** segment is low*.

\[
PD = hD = (~\text{large})D = \text{lots of prism}
\]

*The *Optics* book does not offer a specific value for the typical segment-top-to-optical-center distance on a round-top.*

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

**Bifocal add:**

- **Flat-Top** segment
  - $PD = hD$
  - $(~\text{zero})D$
  - little/no prism

The optical center of a **flat-top** segment is high. When gaze shifts downward into the add, one is looking very near its optical center. Because there is little induced prism (i.e., $h$ is small), images do not seem to jump.

- **Round-Top** segment
  - $PD = hD$
  - $(\text{Large#})D$
  - lots of prism

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’).

**Image jump:** A sudden change in image location occurring when gaze shifts into the bifocal add segment.
Therefore, for both plus and minus lenses, image jump is minimized with a flat-top segment.
A final note related to image jump…
There is a third, rarely dispensed bifocal flavor:
The Executive or Franklin* type

*Yes, that Franklin
Executive/Franklin bifocals are not created by affixing a flat- or round-top segment to a base distance lens.
Instead, they are created by replacing the entire bottom half of the distance lens with the entire bottom half of an ‘add’ lens.
Instead, they are created by replacing the entire bottom half of the distance lens with the entire bottom half of an ‘add’ lens.
This construction also means the optical center of the add is at the very top of the near segment. Put another way: For the Executive/Franklin bifocal, $h = 0$. 

Distance lens (hyperope)

Executive/Franklin add optical center

Executive/Franklin add

Distance lens (myope)

Executive/Franklin add optical center

Executive/Franklin add
This construction also means the optical center of the add is at the very top of the near segment. Put another way: For the Executive/Franklin bifocal, $h = 0$. And because $h = 0$, $hD$ must also $= 0$, and thus no prism is induced.
This construction also means the optical center of the add is at the very top of the near segment. Put another way: For the Executive/Franklin bifocal, \( h = 0 \). And because \( h = 0 \), \( hD \) must also = 0, and thus no prism is induced.

The takeaway point: *Executive/Franklin bifocals produce no image jump.*
Image *Displacement*

- *Image displacement* refers to the total apparent distance between an image viewed through the distance lens versus through the add segment.
**Image Displacement**

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

$BU + BD = \text{Little net prism} \rightarrow \text{little image displacement}$
Image Displacement

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

\[ BU + BD = \text{Little net prism} \rightarrow \text{little image displacement} \]

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

\[ BU + BU = \text{Lots of net prism} \rightarrow \text{lots of image displacement} \]

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

Bifocal adds: \textit{Plus} lenses

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For a \textit{plus} lens, image displacement is minimized with a \textit{round-top} segment.

The magnitude of image displacement is a function of the \textbf{total net prism} acting on the image through the bifocal segment.
Image Displacement

Bifocal adds: **Plus** lenses

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![Diagram showing prismatic effects canceling each other]

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

- BU + BU = Lots of net prism  \(\rightarrow\) lots of image displacement

**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

![Diagram showing prismatic effects amplifying each other]

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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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For a plus lens, image displacement is minimized with a \textit{round-top} segment.

When a \textit{round-top} segment is placed on a minus lens, note how the prismatic effects amplify one another. However, when a \textit{flat-top} segment is placed on a minus lens, the prismatic effects work to cancel one another. Bifocal adds: \textbf{Minus} lenses

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**Image Displacement**

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

The magnitude of image displacement is a function of the **total net prism** acting on the image through the bifocal segment.
Putting It Together: Which Add Is Best?
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Bifocal adds: **Minus** lenses

A flat-top segment minimizes image jump

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

Bifocal adds: **Plus** lenses

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

Bifocal adds: Minus lenses

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

BD+BU=Little net prism \rightarrow little image displacement

Bifocal adds: Plus lenses

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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

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Bifocal adds: **Plus** lenses

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Putting It Together: Which Add Is Best?

Bifocal adds: *Minus* lenses

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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

\[ BD + BU = \text{little net prism} \]  
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*For a minus lens, always select a flat-top segment*
Putting It Together: Which Add Is Best?

Bifocal adds: **Minus** lenses

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

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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…
Putting It Together: Which Add Is Best?

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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.

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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?

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

**So which is the best add segment for a plus lens?**
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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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
  - **Jump** might bother waiters
  - **Displacement** might bother desk workers

Bifocal adds: 

**Plus** lenses

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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

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

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

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.

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