

Chapter 3 Optical Instrumentation

- 3.1 Stops, Pupils, and Windows
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- 3.6 Microscopes
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3.1 Stops, Pupils, and Windows

- Apertures are used to control Image Brightness and limit Field of view.
- Apertures for Controlling Image Brightness : *Aperture stops and Pupils*
 - ↓
 - Determine how bright the image can be, i.e., how much irradiance (W/m^2) reaches the image
 - o *Aperture stop AS*: The real element in an optical system that limits the size of the cone of rays accepted by the system from an axial object point
 - o *Entrance pupil (E_nP)*: The image of the aperture stop formed by the optical elements (if any) that precede it
 - o *Exit pupil (E_xP)*: The image of the aperture stop formed by the optical elements (if any) that follow it

Image Brightness: Aperture stops and Pupils

(a) (b) (c)

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➤ **Aperture stop AS:** The *real* element in an optical system that limits the size of the cone of rays accepted by the system from an axial object point

➤ **AS:** The element that subtends the smallest half-angle from rim to point O

Fig. (a): 2 elements: Aperture (A) and lens
with full angle $\angle MOM'$ and $\angle LOL'$
 $\angle MOM' < \angle LOL'$, so A is the AS

Fig. (b): A is behind of lens, need to find the image of A in lens, which is NN'
2 elements: Lens and NN' (A's image in lens)
with full angle $\angle LOL'$ and $\angle NON'$
 $\angle NON' < \angle LOL'$, so A is the AS

Fig. (c): same as Fig. (a)

Image Brightness: Aperture stops and Pupils

(a) (b) (c)

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➤ **Entrance pupil (E_nP):** The image of the aperture stop formed by the optical elements that *precede* it

Fig. (a): No elements to the left of AS, so it serves also as E_nP

Fig. (b): Lens is to the left of AS, then the image of AS in lens, which is NN' , serves as E_nP

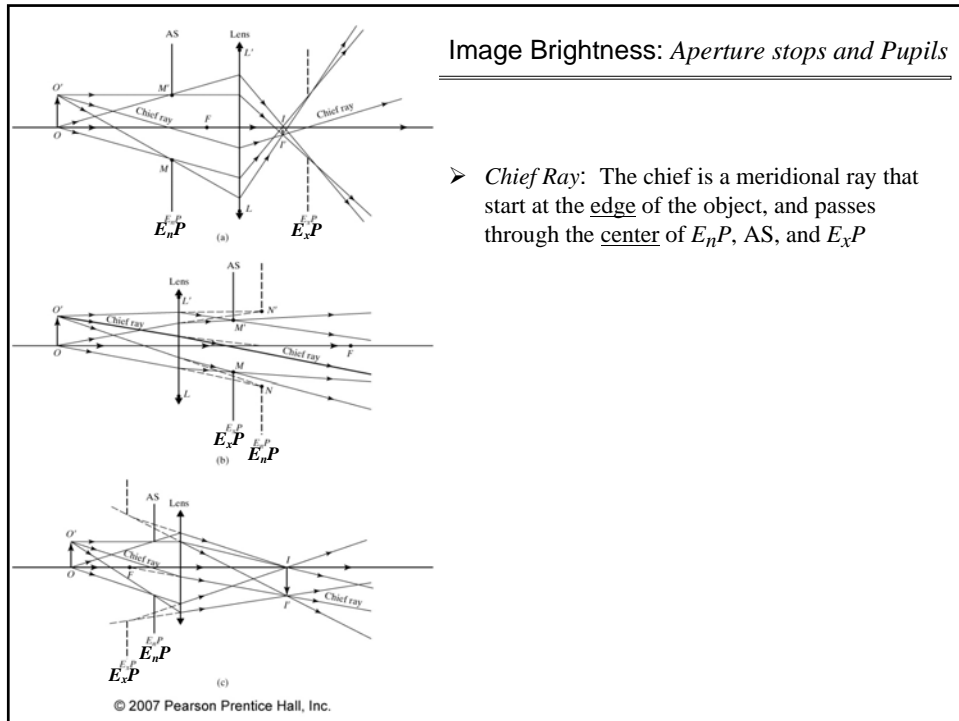
Fig. (c): same as Fig. (a)

➤ **Exit pupil (E_xP):** The image of the aperture stop formed by the optical elements that *follow* it

Fig. (a): Lens is to the right of AS, so the image of AS in lens, will serves as E_xP (see dashed line)

Fig. (b): No elements to the right of AS, AS serves as E_xP

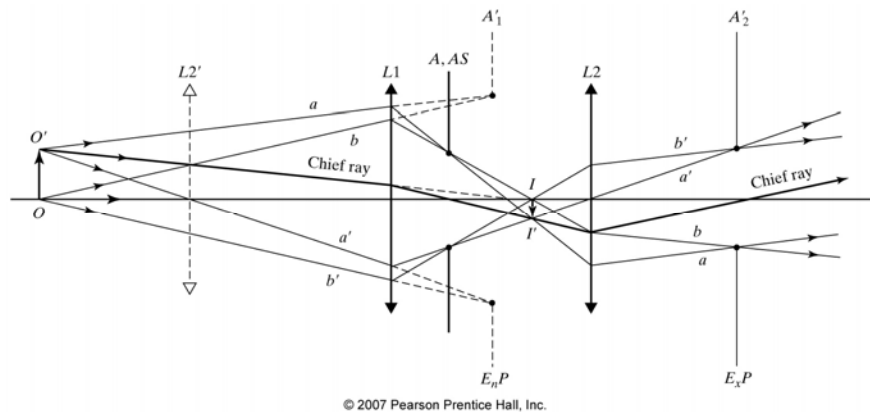
Fig. (c): Lens is to the right of AS, so the image of AS in lens, will serves as E_xP (see dashed line)



3.1 Stops, Pupils, and Windows

Image Brightness: Aperture stops and Pupils

Aperture stop AS, Entrance pupil (E_nP), Exit pupil (E_xP), and Chief Ray



3.1 Stops, Pupils, and Windows

Problem 3-1

An object measures 2 cm high above the axis of an optical system consisting of a 2 cm aperture stop and a thin convex lens of 5-cm focal length and 5-cm aperture. The object is 10 cm in front of the lens and the stop is 2 cm in front of the lens. Determine the position and size of the entrance and exit pupil, as well as the image. Sketch the chief ray and the two extreme rays through the optical system, from the top of the object to its conjugate image point.

3.1 Stops, Pupils, and Windows

Field of View: *Field stops and Windows*

➤ Apertures are used to control *Image Brightness* and limit *Field of view*.

➤ Apertures for Limiting Field of view : *Field stops and Windows*



Determine how much of the surface of a broad object can be seen by looking back through the optical system

- o Field stop FS: The *real* element that limits the angular field of view formed by an optical system
- o Entrance Window (E_nW): The image of the field stop formed by the optical elements that *precede* it
- o Exit Window (E_xW): The image of the field stop formed by the optical elements that *follow* it

(a)

(b)

(c)

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Field of View: *Field stops and Windows*

- The partial shielding of the outer portion of the image by the aperture for off-axis object points is called vignetting.
- **Field stop FS:** The real element that limits the angular field of view formed by an optical system
- **FS:** The element that subtends the smallest half-angle from the center of E_nP (see β)

Fig. (b): Only 1 element – lens, to the right of E_nP , so lens serves as FS and E_nW

(a)

(b)

(c)

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Field of View: *Field stops and Windows*

- **Entrance Window (E_nW):** The image of the field stop formed by the optical elements that precede it
 E_nW : The image of FS in all elements to its left
- **Exit Window (E_xW):** The image of the field stop formed by the optical elements that follow it
 E_xW : The image of FS in all elements to its right
- **Angular field view: α, α'**
 α : the angle subtended by E_nW at the center of E_nP
 α' : the angle subtended by E_xW at the center of E_xP

3.1 Stops, Pupils, and Windows Field of View: *Field stops and Windows*

Problems 3-4

An optical system, centered on an optical axis, consists of (left to right)

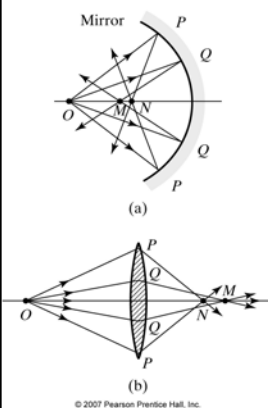
1. Source plane
2. Thin lens L_1 at 40 cm from the source plane
3. Aperture A at 20 cm farther from L_1
4. Thin lens L_2 at 10 cm farther from A
5. Image plane

Lens L_1 has a focal length of $40/3$ cm and a diameter of 2 cm; lens L_2 has a focal length of $20/3$ cm and a diameter of 2 cm; aperture A has a centered circular opening of 0.5-cm diameter

- a. Sketch the system
- b. Find the location of the image plane.
- c. Locate the aperture stop and entrance pupil.
- d. Locate the exit pupil.
- e. Locate the field stop, the entrance window, and the exit window.
- f. Determine the angular field of view.

3.2 A Brief Look at Aberrations

➤ Spherical aberration



➤ Chromatic aberration

