

TOPICS

- Recap of PHYS110 - *1 lecture*
- Physical Optics - *4 lectures*
 - EM spectrum and colour
 - Light sources
 - Interference and diffraction
 - Polarization
- Lens Aberrations - *3 lectures*
 - Spherical aberrations
 - Coma, astigmatism, field curvature, distortion
 - Chromatic aberrations
- **Instrumental Optics** - *4 lectures*
 - Telescope, microscope
 - Stops, eyepieces**
 - Instruments for the anterior eye
 - Instruments for the posterior eye

Lecture 10: Stops, eyepieces

- Aperture stop
- Entrance, exit pupil
- Field stop
- Eye pieces
 - Ramsdens eyepiece
 - Huygens eyepiece

Stops

- The finite size of lenses limits the amount of light through the optical system.
- In addition, **stops** are usually introduced in the system to control the flow of light.
- A **stop** is an opening in a co-axial system of lenses, centred on the principal axis
- It may be an actual hole, for example the iris in a camera or the eye or it may be a lens itself.

Aperture stop

- For an object point on the axis, the **aperture stop** limits the cone of light forming the image.
- The aperture stop determines the **brightness** of the image

Examples:

For a single lens the aperture stop is the lens itself.

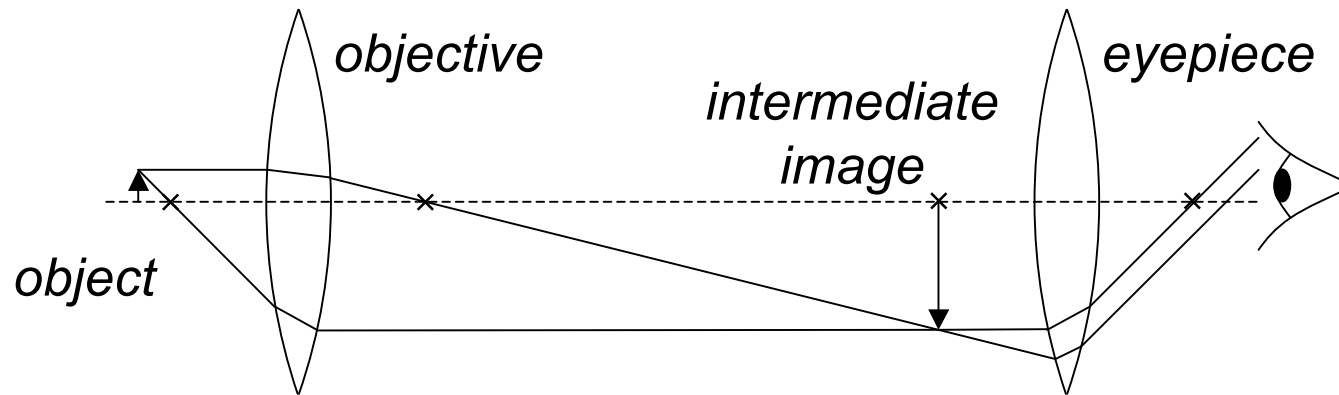
For a camera, the aperture stop is the diaphragm used to control the exposure.

For the eye, the aperture stop is the pupil.

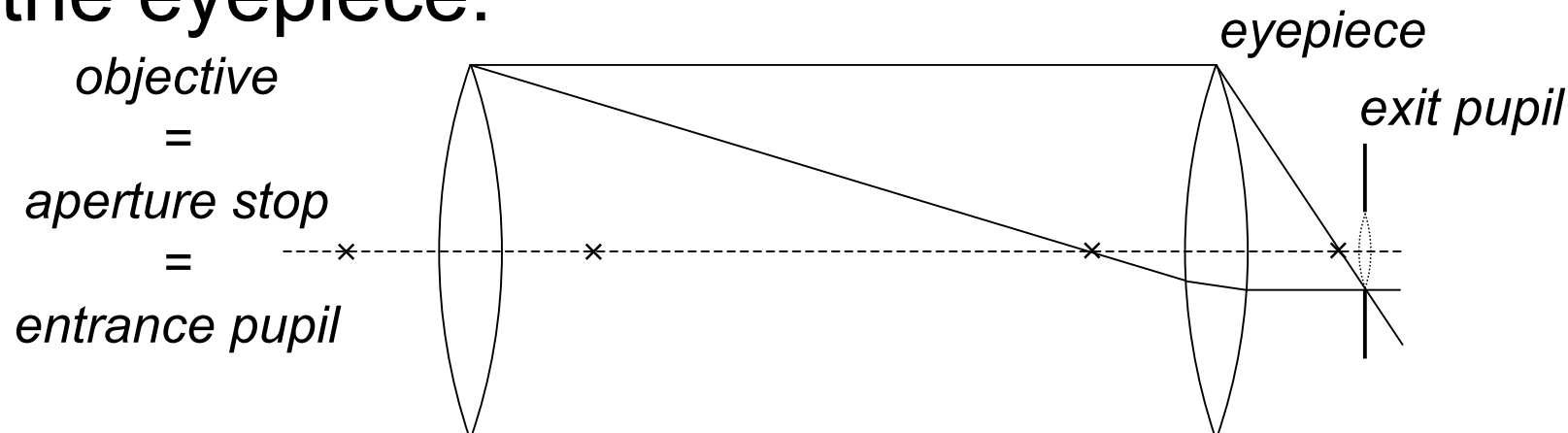
Entrance/exit pupil

- The image of the aperture stop in the lenses preceding it is called the ***entrance pupil***.
 - In a telescope or microscope this is usually the objective lens itself.
- The image of the aperture stop in the lenses that follow is called the ***exit pupil***
 - In a telescope or microscope, this is the image of the objective through the eyepiece.

Entrance/exit pupil of microscope



- Entrance pupil is the objective
- Exit pupil is the image of the objective through the eyepiece:

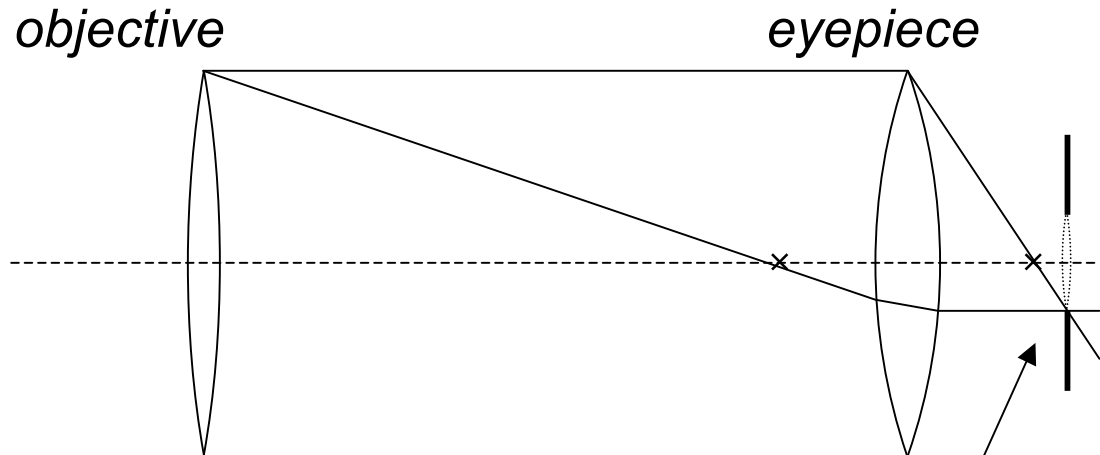


Exit pupil

- When using an optical instrument, the entrance pupil of the eye should coincide with the exit pupil of the instrument.
- If not, the field of view may be reduced
- The distance from the eye piece to the exit pupil is called the **eye relief distance**
- For comfortable viewing, the eye relief distance should be at least 1 cm

Entrance/exit pupil of telescope

Astronomical telescope



Galilean telescope

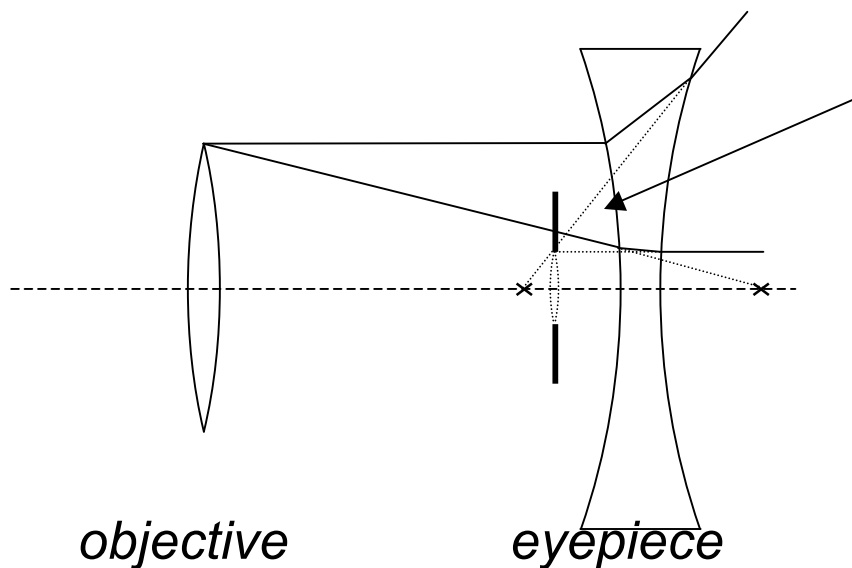


image of the objective = exit pupil

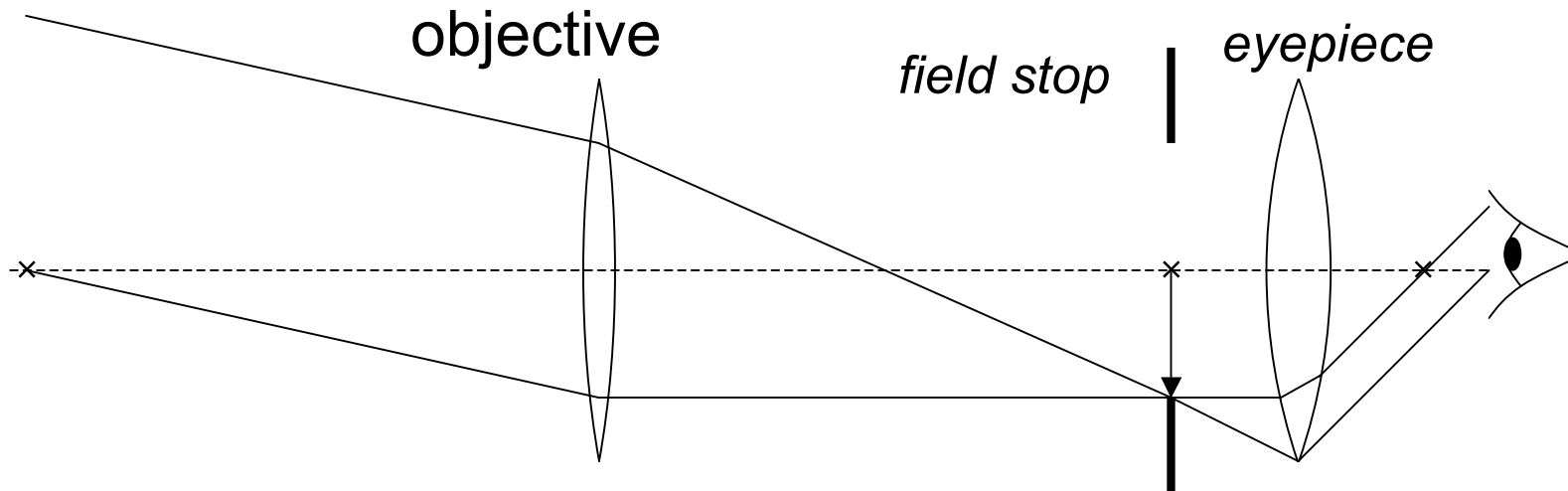
Exit pupil in front of eyepiece
⇒ Impossible to coincide with pupil of the eye
⇒ Reduced field of view

The field stop

- The entrance and exit pupils control the centre of the image.
- The ***field stop*** is relevant for off-axis objects
- It is the stop that limits the field of view
- The field stop is usually an aperture inserted into the system (rather than a lens)
- It ensures the image field has a sharp edge.
 - instead of slowly fading away

Field stop in telescope/microscope

- The eyepiece determines how much of the image is seen
- To produce a sharp edge, a field stop must be placed at the position of the intermediate image:

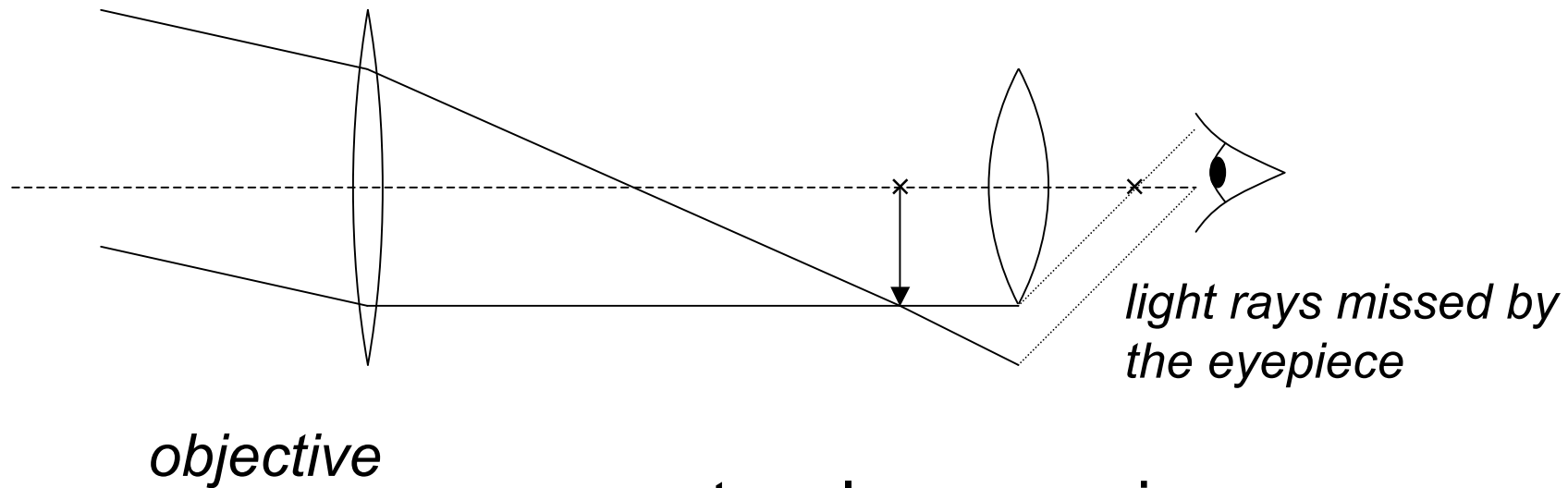


Eyepieces

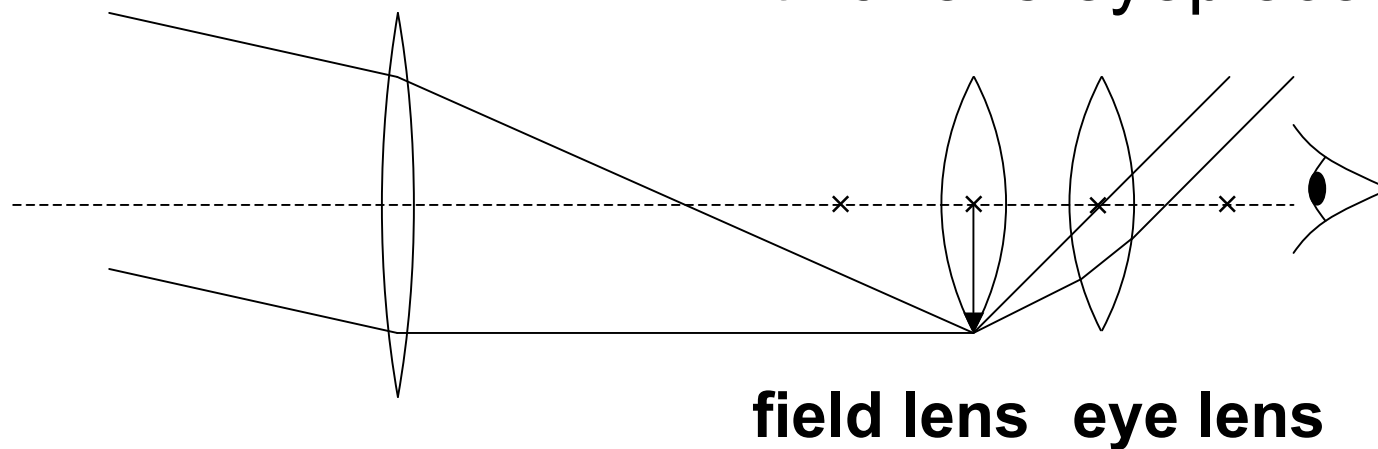
- Adding an extra lens at the position of the intermediate image:
 - does not change the power of the eyepiece
 - increases the field of view of the eyepiece
- The lens nearer the eye is called the **eye lens**. The other is called the **field lens**.

Eyepieces

one-lens eyepiece

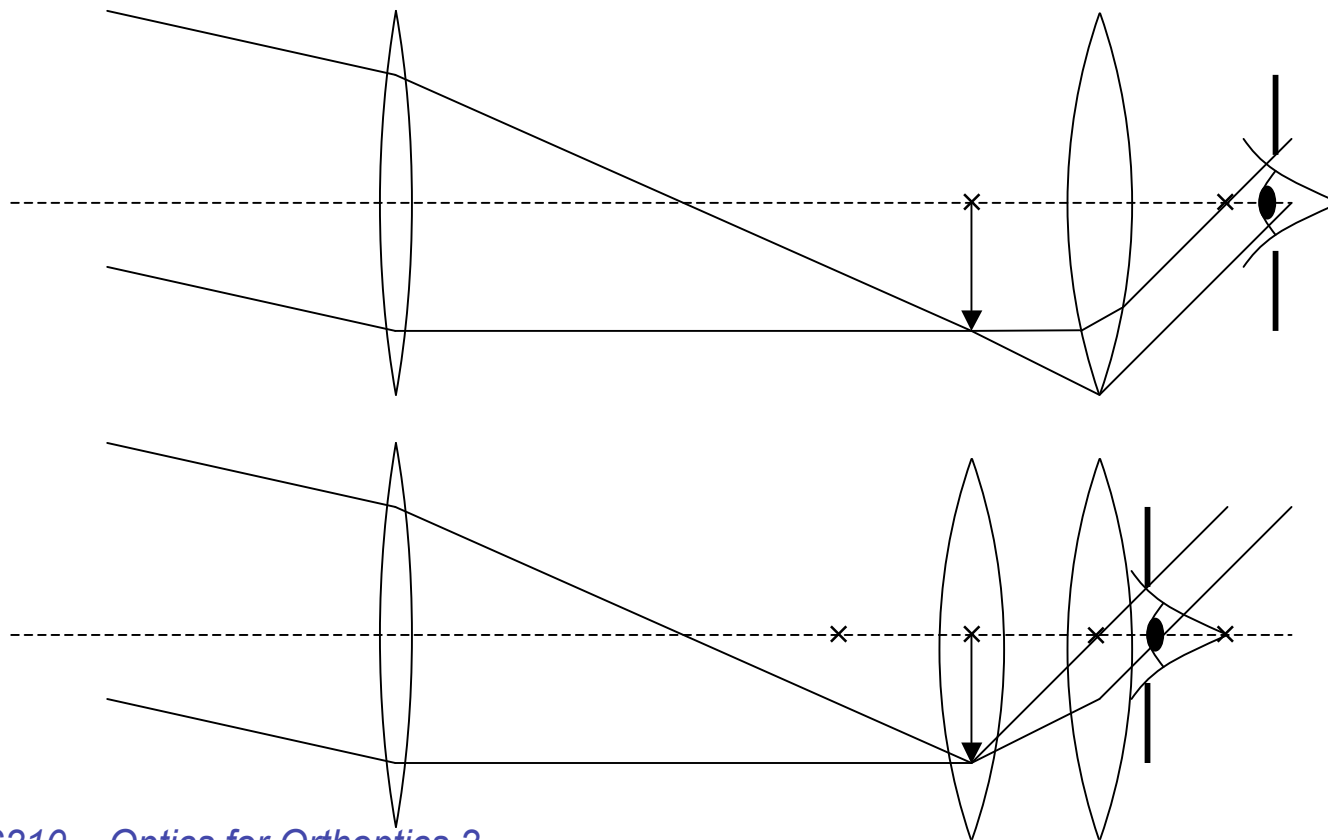


two-lens eyepiece



Eyepieces

- The field lens brings the exit pupil closer to the eyepiece
 - Its power cannot be too high to keep the eye relief distance larger than 1 cm

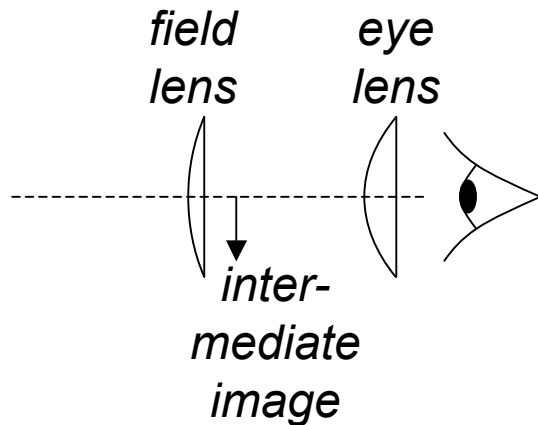


Huygens/Ramsdens eyepiece

- Having the field lens exactly at the position of the intermediate image has the disadvantage that dust and scratches will focus on the final image
 - The field lens is moved either forward or backward of the intermediate image
- **Huygens eyepiece**: the field lens is moved towards the objective of the instrument
- **Ramsdens eyepiece**: the field lens is moved towards the eye lens of the instrument

Huygens/Ramsdens eyepiece

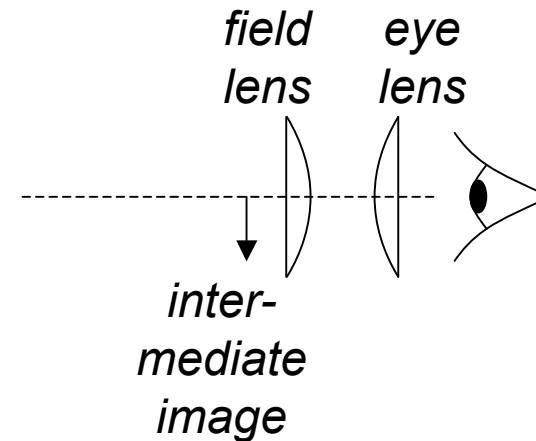
Huygens eyepiece



The intermediate image sits between the field lens and the eye lens

- Better control of aberrations

Ramsdens eyepiece



The intermediate image sits in front of the field lens.

- Can be used as a simple magnifying glass
- Allows external graticule