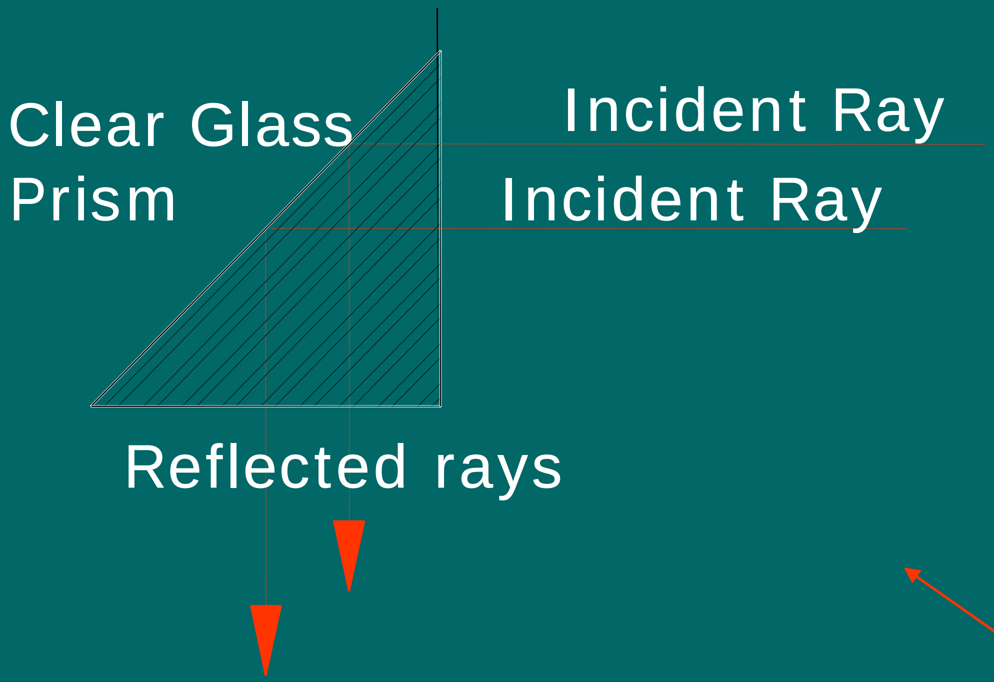
# Optical Principles

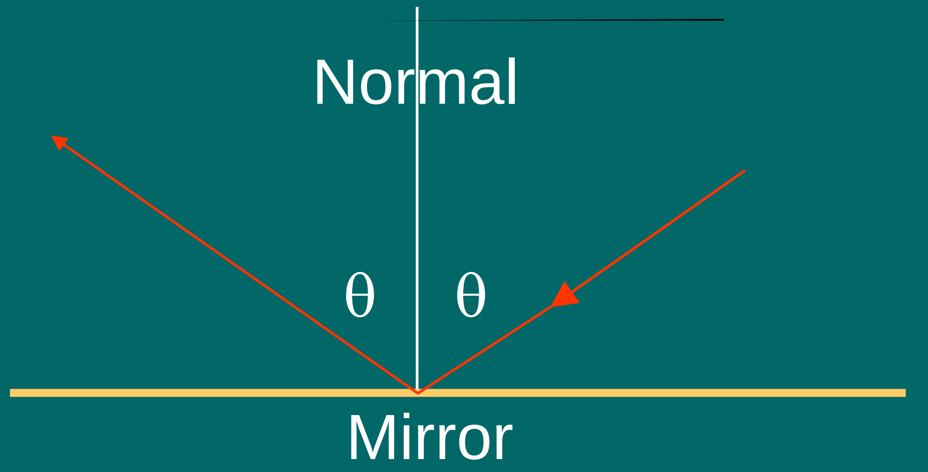
The purpose of this Instruction is to enable you to understand the basic optics of surveying instruments.

# Contents

# Reflection 1

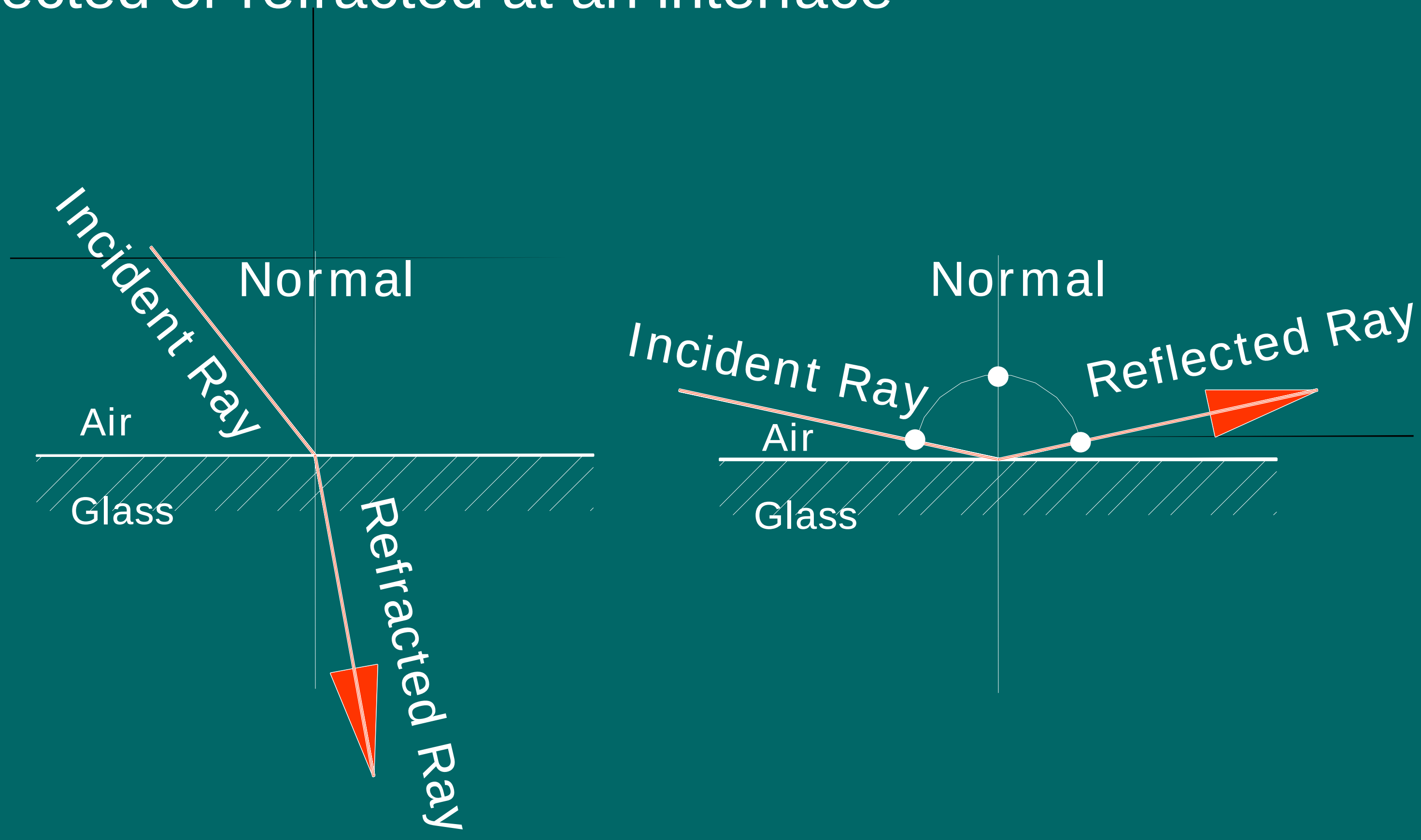
The angle of incidence = the angle of reflection



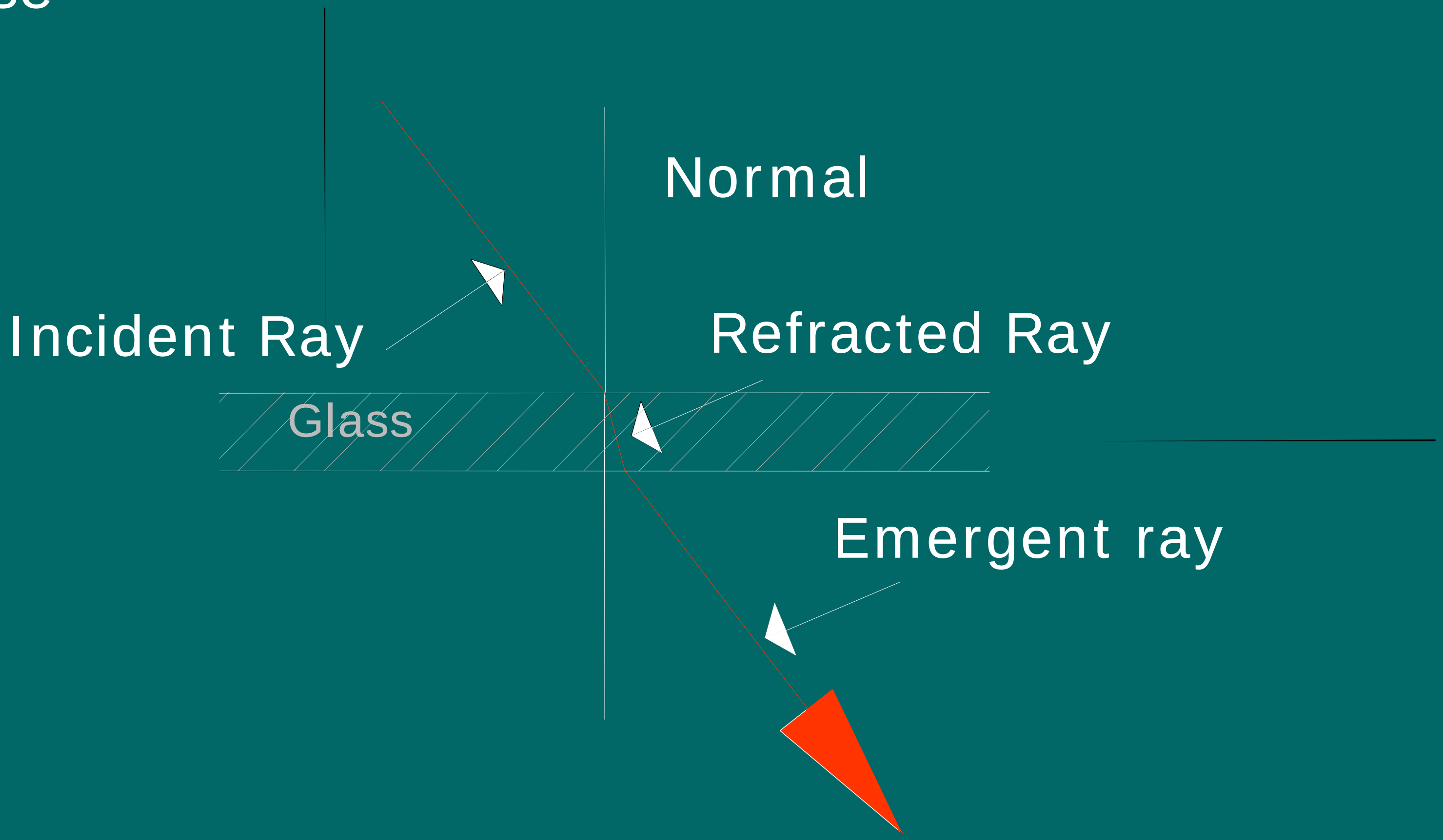
# Reflection 2

The critical angle determines whether a beam is reflected or refracted at an interface



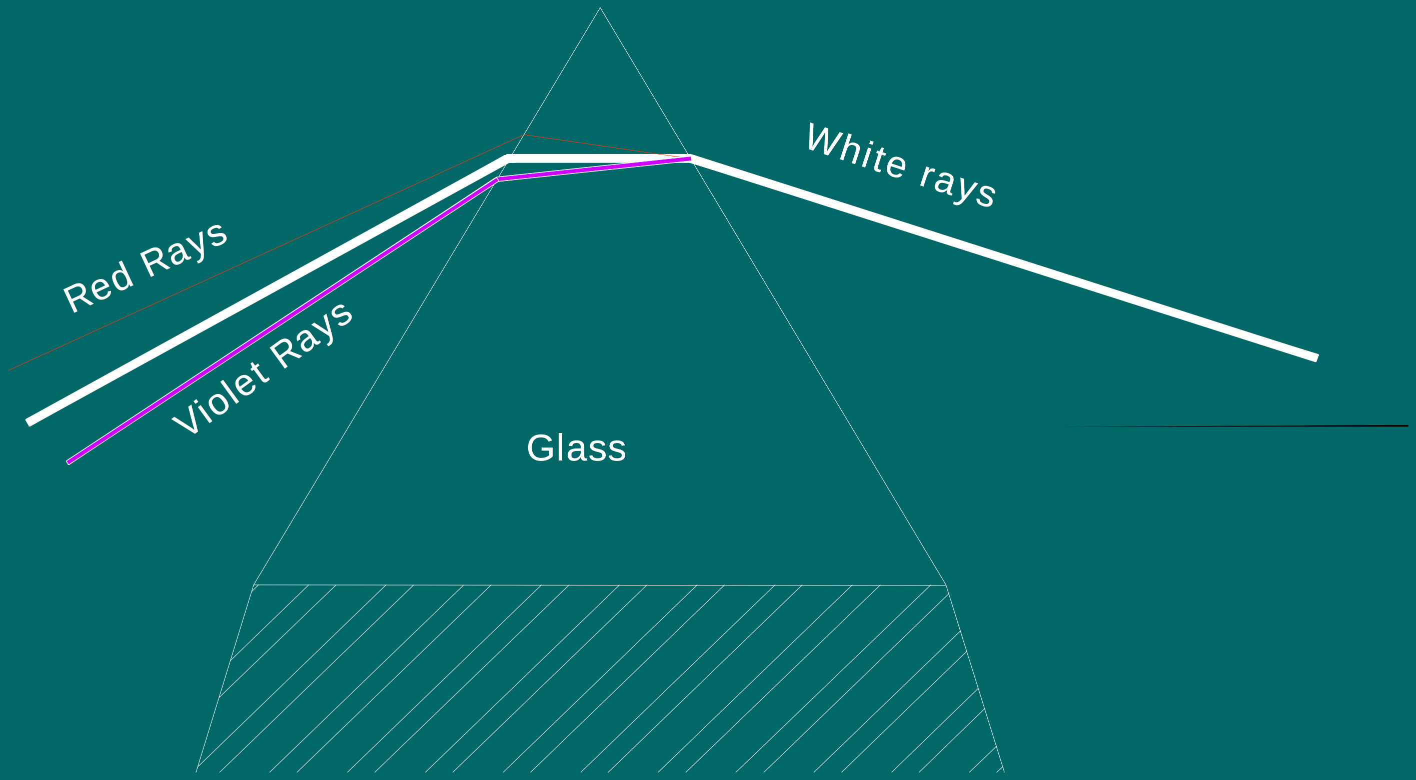
# Refraction 1

The emergent ray is parallel to the incident ray in this case



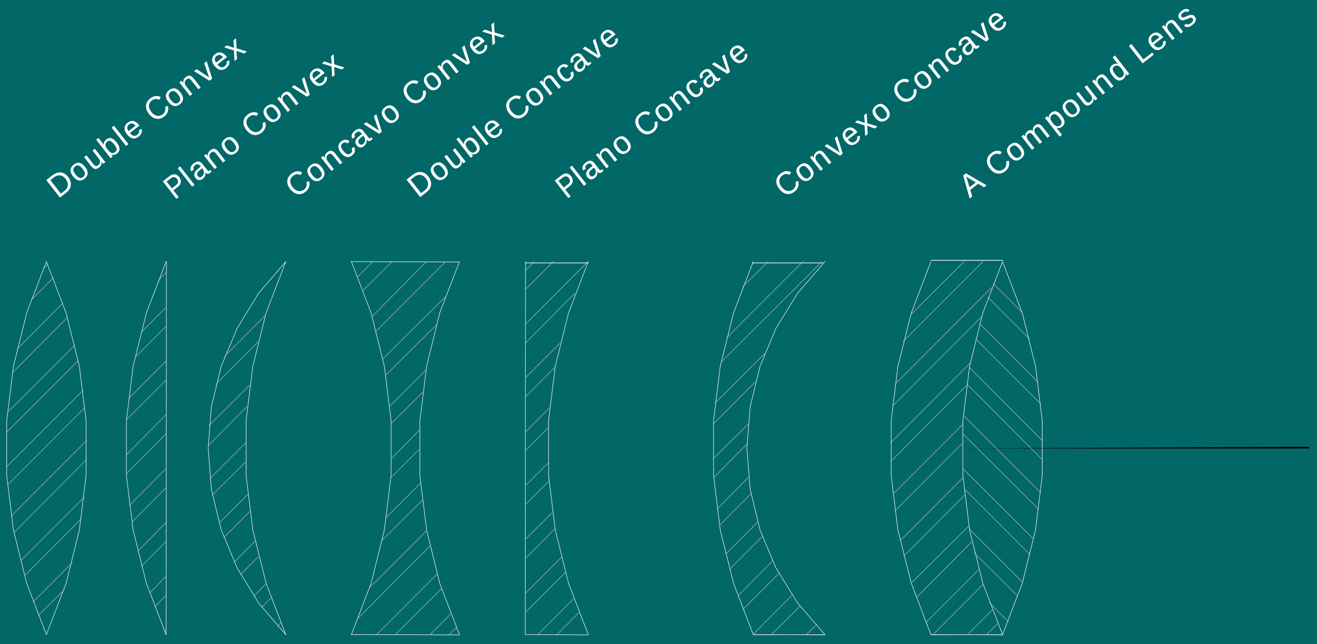
# Refraction 2

## The Prism



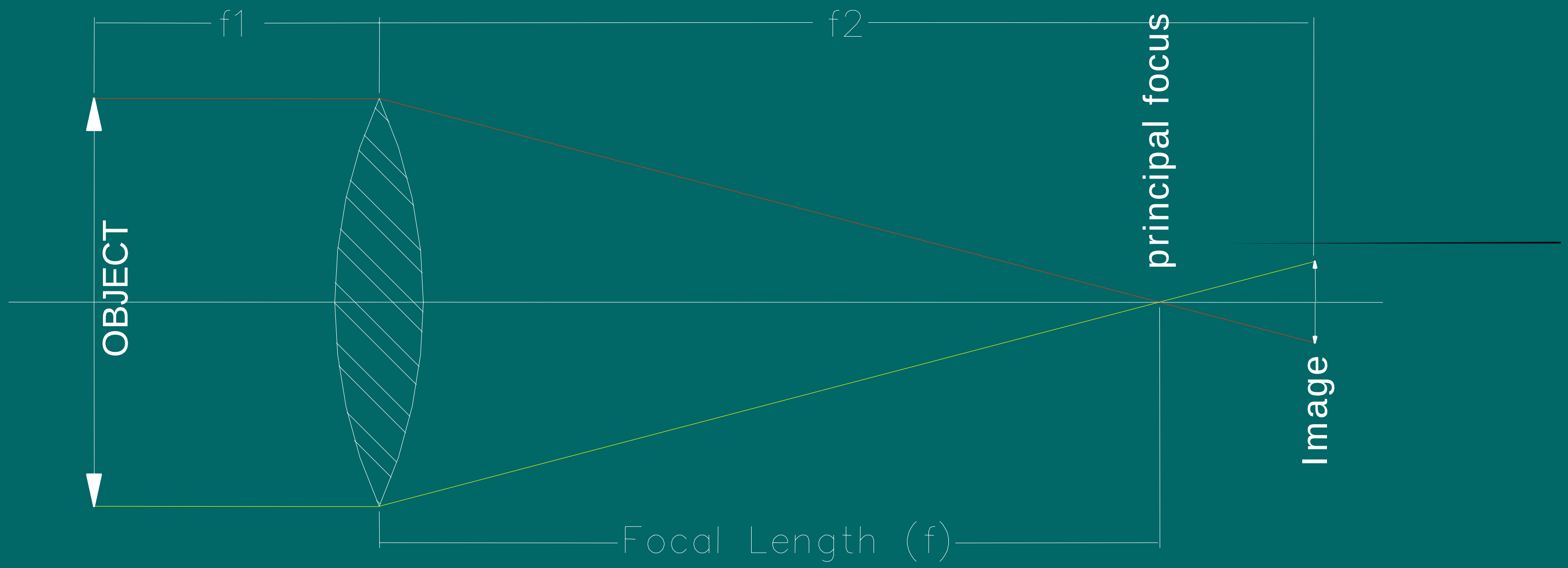
# The lens 1

Types of lenses

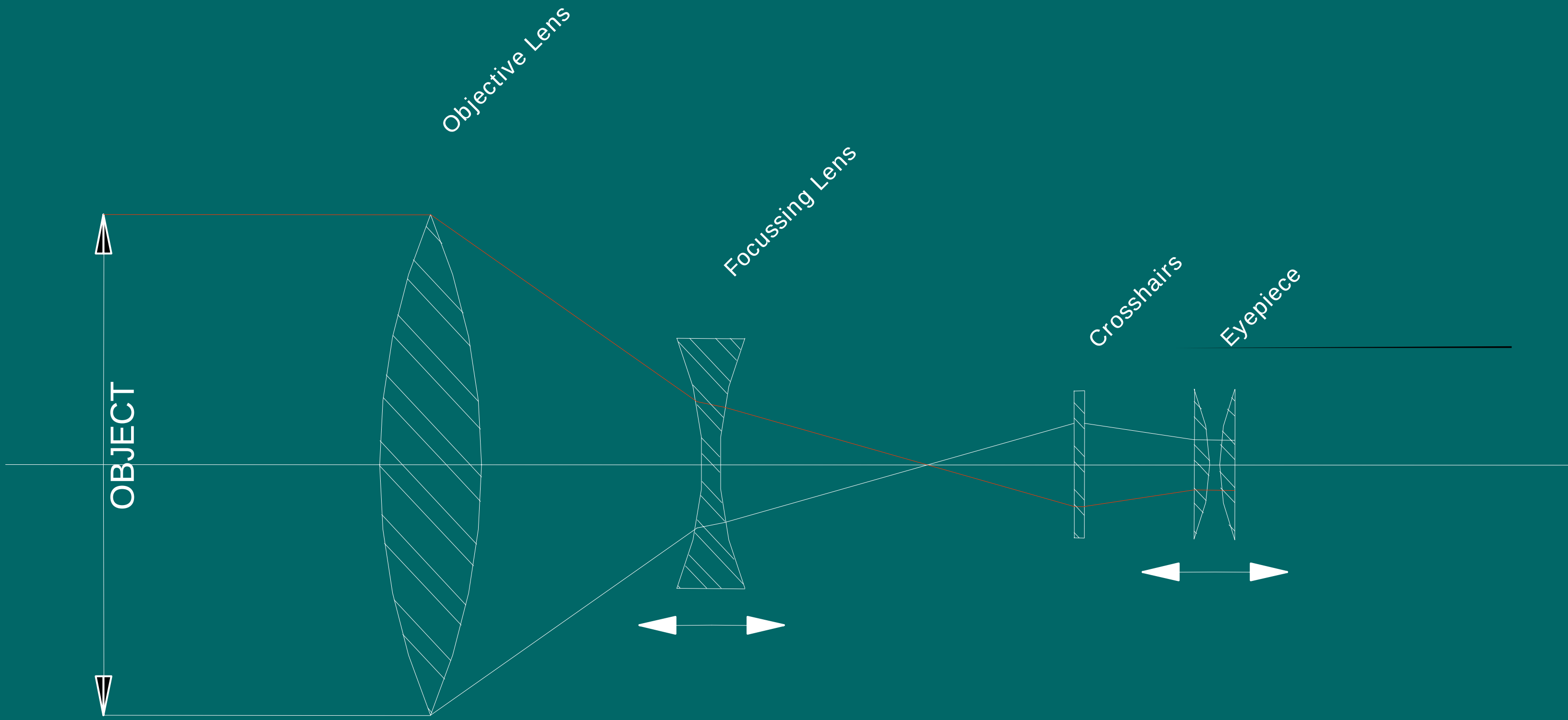


# The lens 2

To calculate the focal length (f), from the conjugate foci f1 and f2: - $1/f = 1/f1 + 1/f2$



# The Telescope



# THE END

**Slide 3**.

- The reflected ray and the incident ray are in one plane with the normal at the point of incidence. The angles of incidence and reflection are equal. So if the reflective surface rotates 1°, the angle between the incident and reflected rays changes by 2°. This is why the 90° arc of a sextant is graduated as 180°.
- The reflecting surface of a mirror is usually on the back for domestic mirrors. This gives the coating a measure of protection from damage. For mirrors requiring better optical quality, the reflective coating is on the front; (e.g. car door mirrors, mirrors internal to optical instruments).

**Slide 4**

- The critical angle is that angle where a ray instead of passing through a sheet of glass, becomes reflected.

**Slide 5**

- Refraction means' bending'. A ray emerging from a sheet of glass where both surfaces are parallel is parallel to the incident ray. This is the principal of the 'parallel plate micrometer'.

**Slide 6**

- A prism refracts different wavelengths of light by slightly different angles. As a lens is basically a series of contiguous prisms with different apex angles, this causes objects viewed through a lens to have coloured fringes. This defect is called 'chromatic aberration', and is usually overcome by the use of compound lenses in conjunction with the 'Ramsden Eyepiece', (see slide 9).

**Slide 7**

- Different types of lenses are shown. Their surfaces are usually ground spherically for ease of manufacture, but this results in errors that require correction. Compound lenses usually have their components made of different types of glass to correct some of these and other errors.
- Defects are: -
    1. Chromatic aberration, already mentioned.
    2. Spherical aberration, due to grinding lenses spherically which is easy to manufacture but is not quite the correct shape.
    3. Coma, a type of oblique spherical aberration affecting the margins of the field of view.
    4. Astigmatism, where curvatures vary slightly across the lens.
    5. There are others.
- A convex lens causes convergence; a concave lens causes divergence.

**Slide 8**

- The focal length of a lens is the distance between the lens centre and the principal focus. All rays pass through this point.
- If an object 150mm from the lens is focussed on a screen 300mm on the other side, then 1/f = 1/150 + 1/300. So 1/f = 3/300 = 1/100. So f = 100.
- If a compound lens such as the one on slide 7 has one convex component whose focal length is 75mm, and the other concave component is -300mm, the combined focal length is calculated as above. Then 1/f = 1/75 + 1/-300. So 1/f = 3/300 = 1/100. So f = 100.
- The power of a lens is the reciprocal of the focal length.

**Slide 9**

- The focussing lens can be moved forwards and backwards along the principal axis to focus an image of the object being viewed on the glass plate that carries the crosshairs.
- The eyepiece can also be moved along the principal axis to allow the eye to focus the crosshairs.
- The eyepiece, (Ramsden eyepiece), consists of two plano-convex lenses set apart by 2/3 of the focal length of either of them.
- The magnification of the telescope is the focal length of the objective divided by that of the eyepiece.
- The image brightness is proportional to the lens diameters, and inversely proportional to the magnification. Twenty to thirty times is the usual range for surveying telescopes, up to forty for precision instruments.