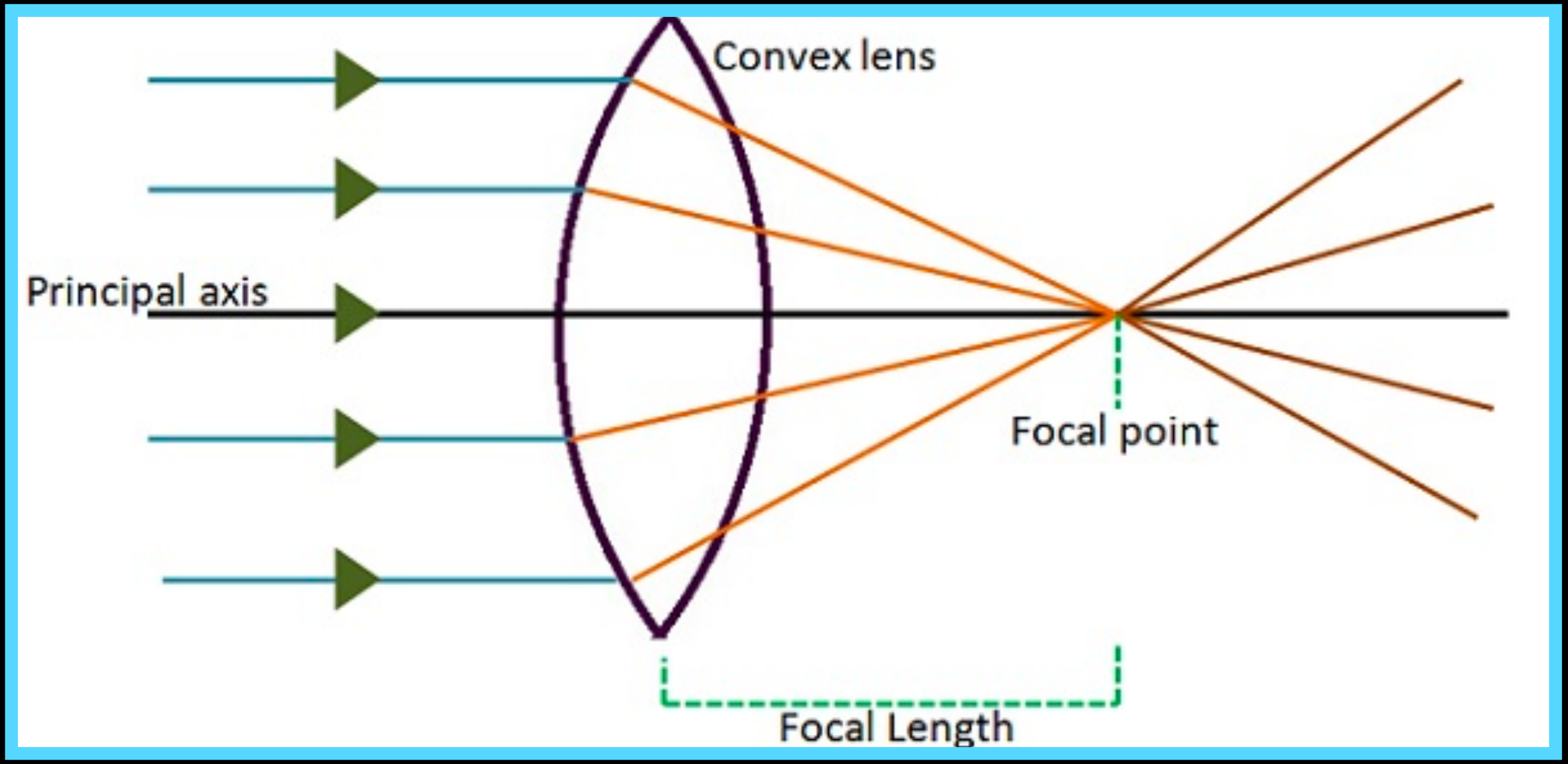
DATE: 6/2; DUE: 27/2 AT THE START OF LAB

SIMPLE TELESCOPE OPTICS

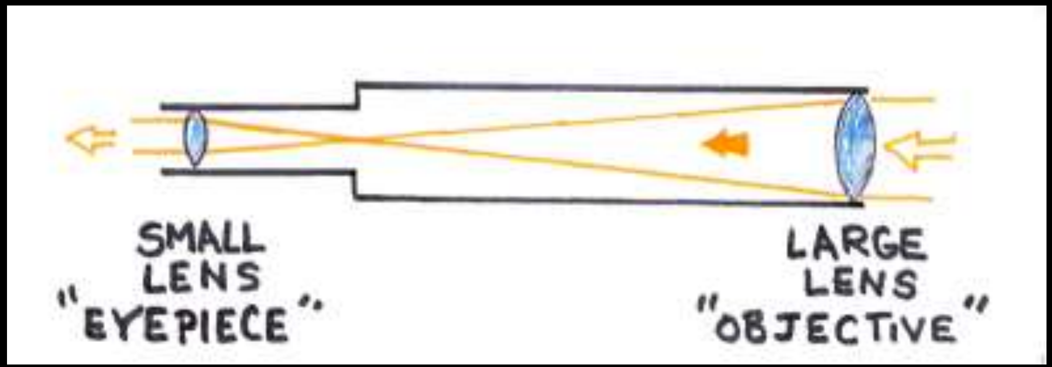
SIMPLE LENS

- We will be using convex lenses in this lab.
- As light passes through a convex lens, the lens bends the light so that it converges at what is called a "focal point".
- The distance between the lens and focal point is called the focal length.
- We can combine multiple convex lenses to create a simple telescope that can magnify objects.

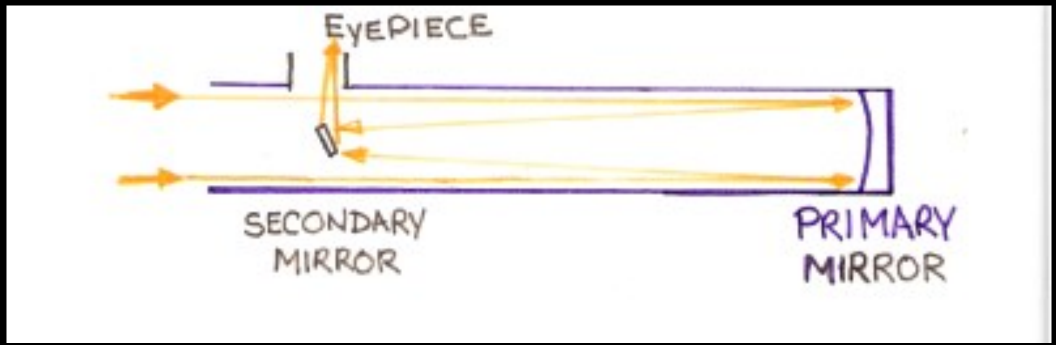


REFRACTORS VS REFLECTORS

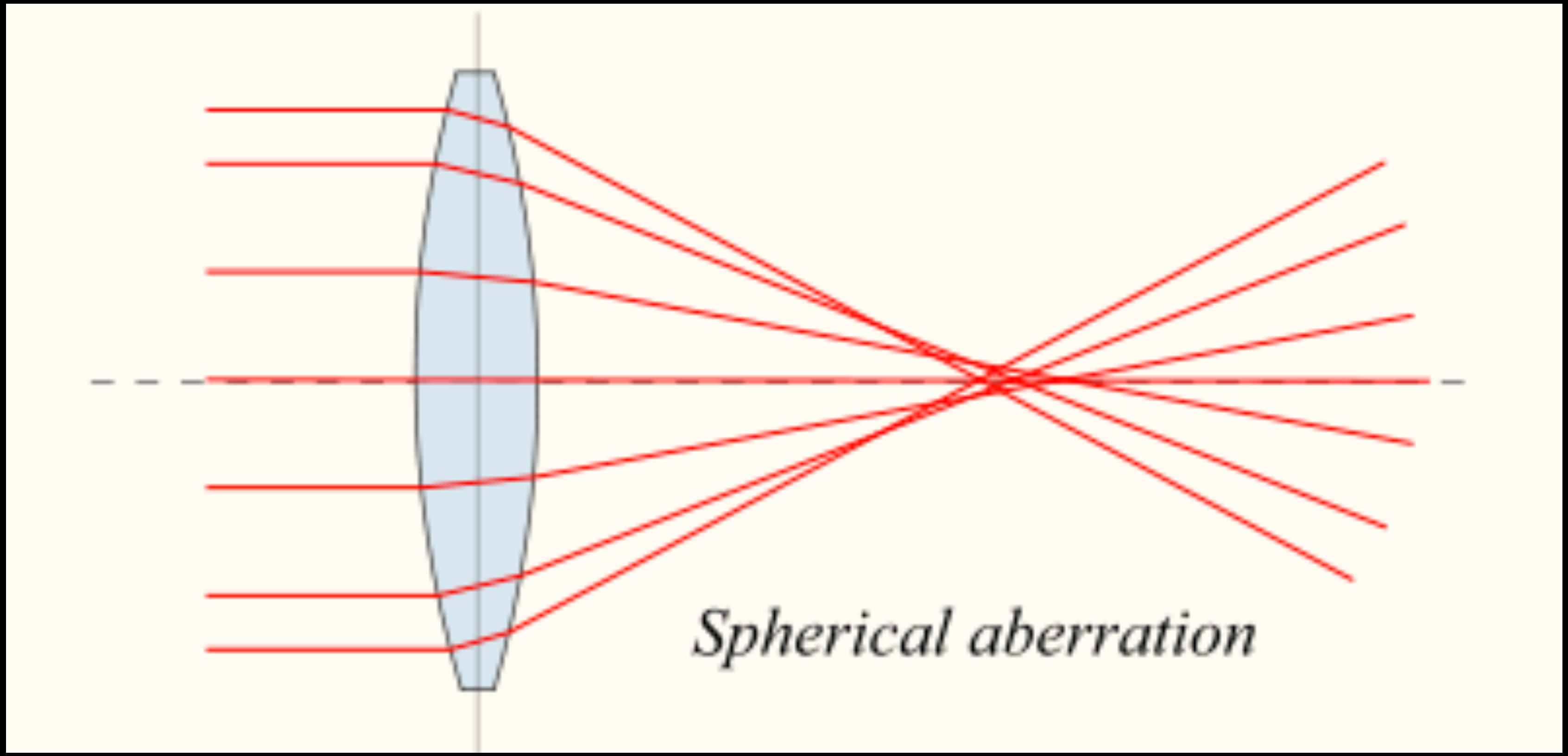
- Refractors: use lenses
  - First telescopes
  - Lenses suffer chromatic aberration
  - Large lenses are extremely expensive and heavy

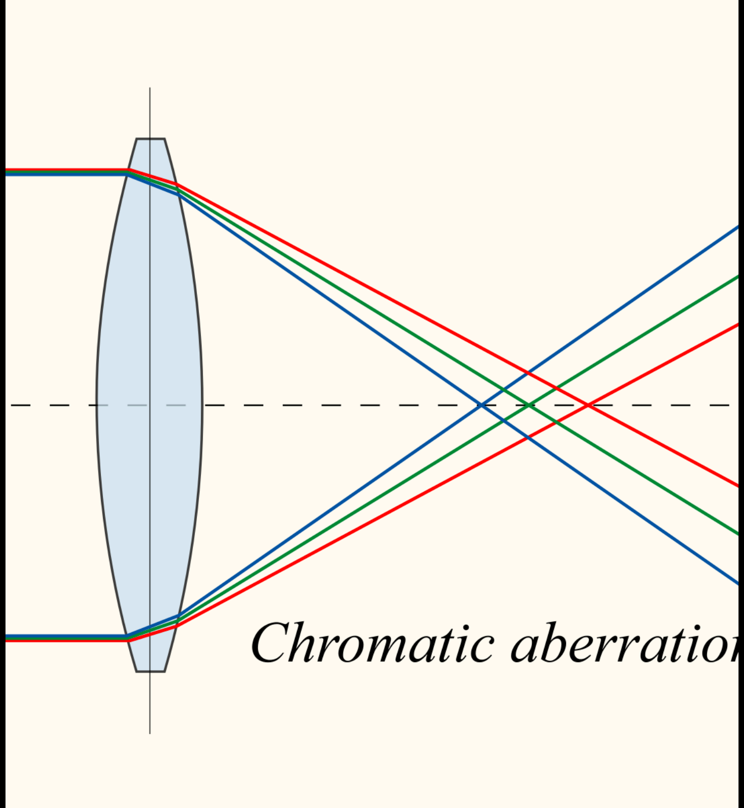


- Reflectors: use mirrors
  - Modern telescopes
  - Does not suffer chromatic aberration
  - Mirrors are lightweight and cheap



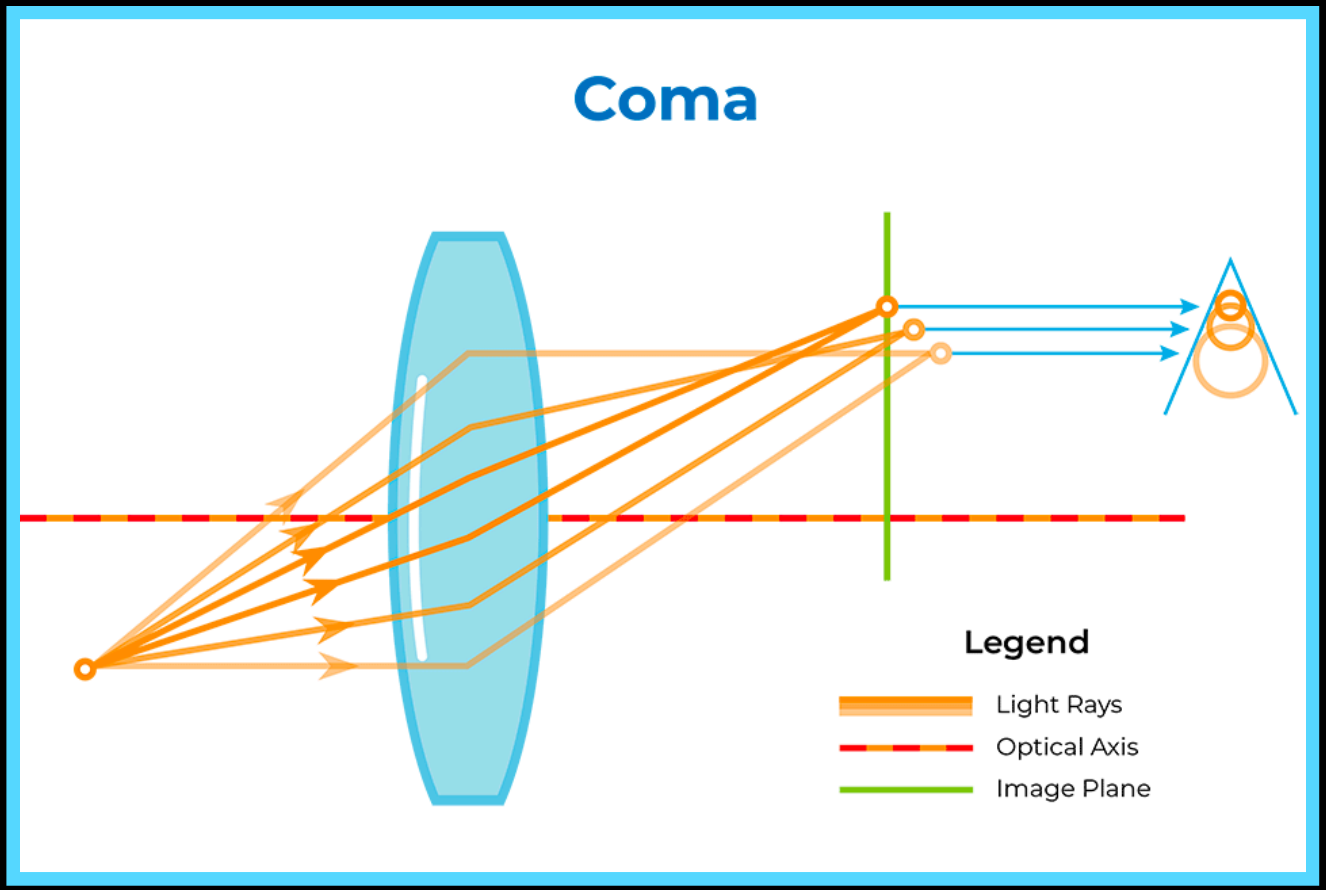
ABERRATION

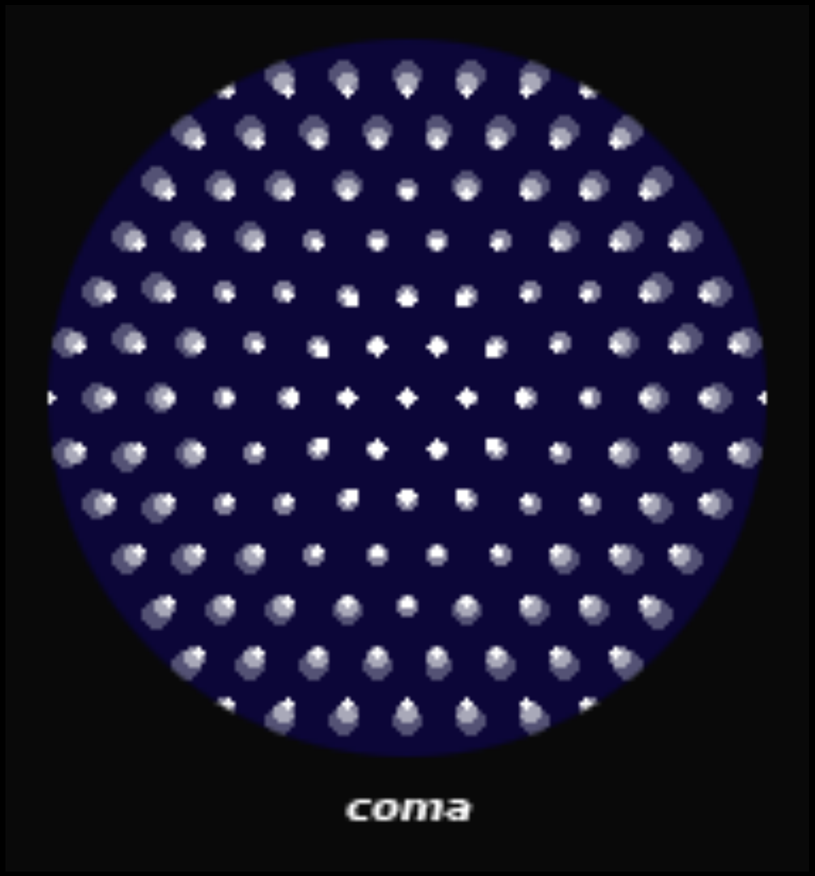




COMA

- **Coma causes "tails" when not centered**
- This makes it harder to see the fine details of an image

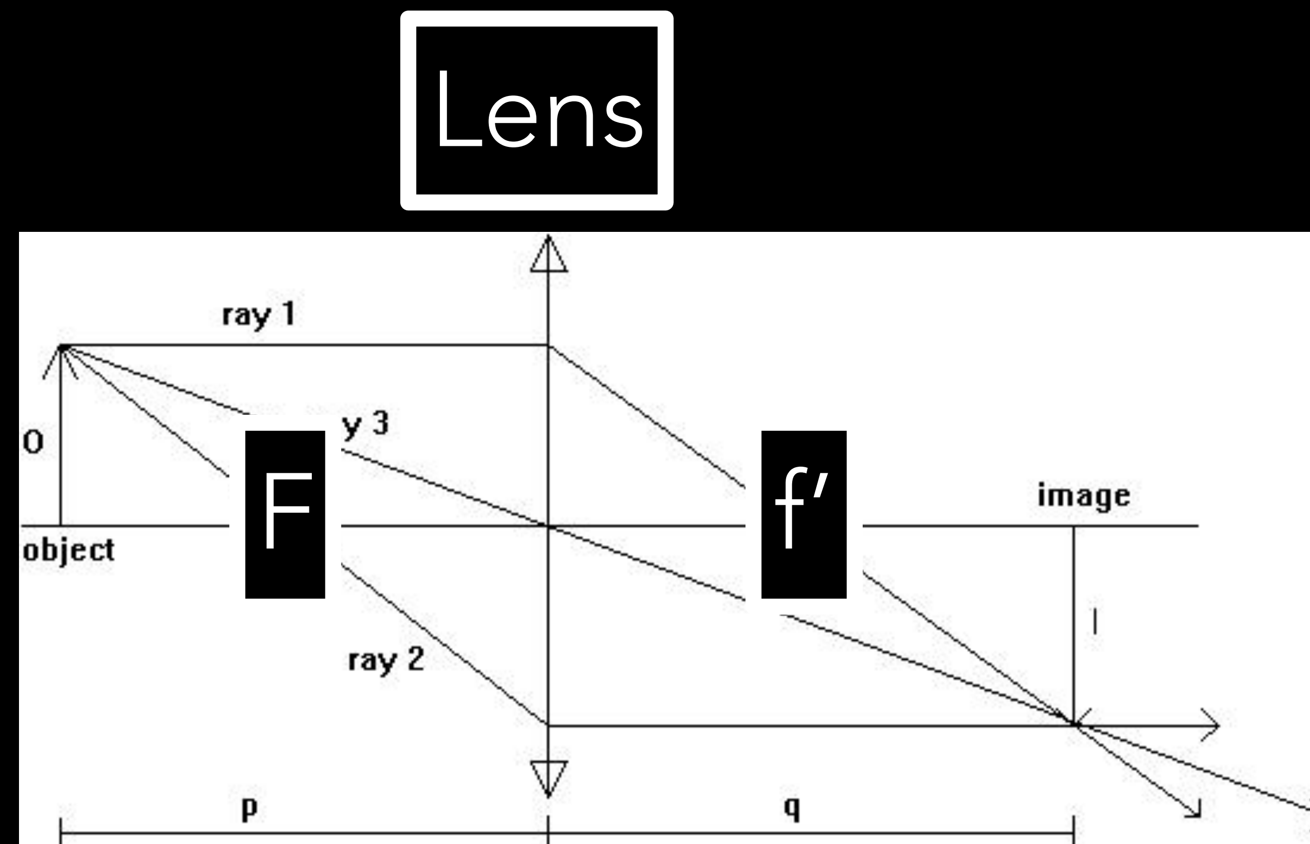




RAY TRACING

Convex lenses will produce a reverse image; height depends on the distances (F) and focal length (f)

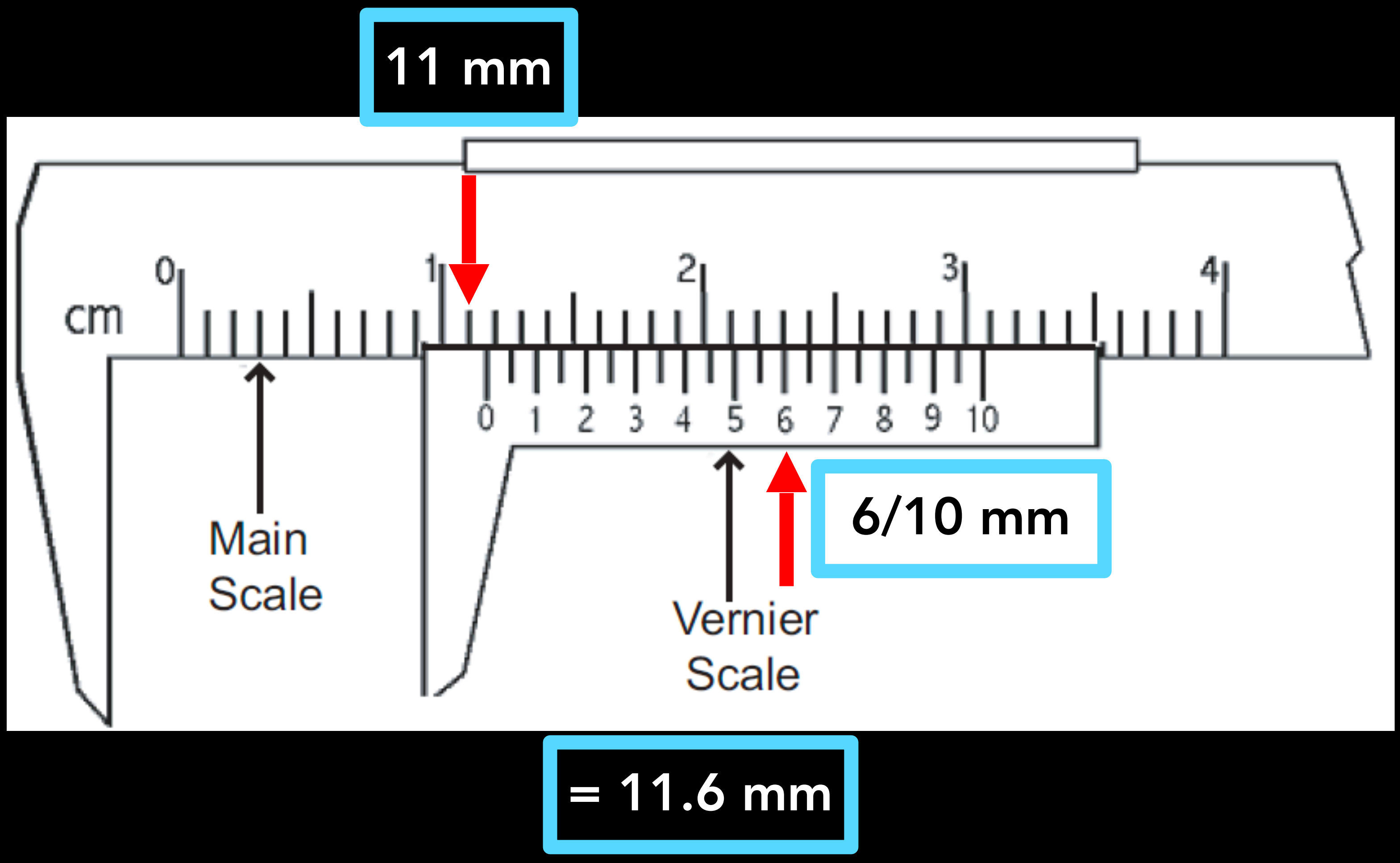
- O: object
- I: image
- F: object distance
- f′: image distance



VERNIER CALIPERS

1. Read the measurement of Main scale to the left of 0
   - Save this number
2. Find the line on the Vernier scale that matches one on the Main scale
   - Divide this number by 10 and add to the previous measurement

What is the reading on this scale?



PART I: IMAGE SCALE

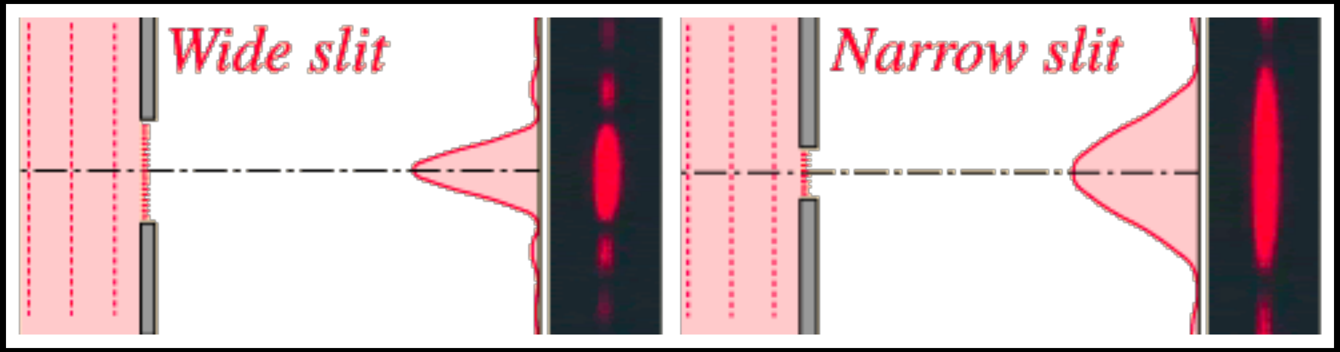
- ***Be careful with the lenses; do not drop them and try not to touch the optical surfaces***
- Measure the focal length (f’) on the optical bench and the image size created using the Vernier caliper for all lenses
- Fill out Table 1
- 3 graphs (use Excel or Python):
  1. Image size vs f’
  2. Image size vs curvature radius
  3. Image size vs diameter
- You will need to extrapolate these graphs for some questions
- Make sure all units are in mm

PART II: SURFACE BRIGHTNESS

1. Visual comparison of surface brightness
   - D1 & D2: same f′
   - F1 & F2: same diameter
2. Calculate the relative brightness using the equation $\text{Brightness} = \left(\frac{d}{f}\right)^2$
3. Calculate the focal ratio (f-ratio) of all lenses
   - f-ratio = f′/diameter

PART III: RESOLVING POWER

- Calculate $\Theta_{theoretical}$ (resolution) for l and d (l = 44 mm, d = 0.51 mm) in arcsec of the metal plate (Q15).
- Based on this value, calculate the spacing that you can resolve using l and d (Q16) at given H.



Eq 1: arcsec

D = l or d (diameter of telescope) mm

Θ = resolution

$\lambda = 500 \times 10^{-6}$ mm

$$\theta = 206265\frac{(1.22\lambda)}{D}$$

Eq 2: arcsec

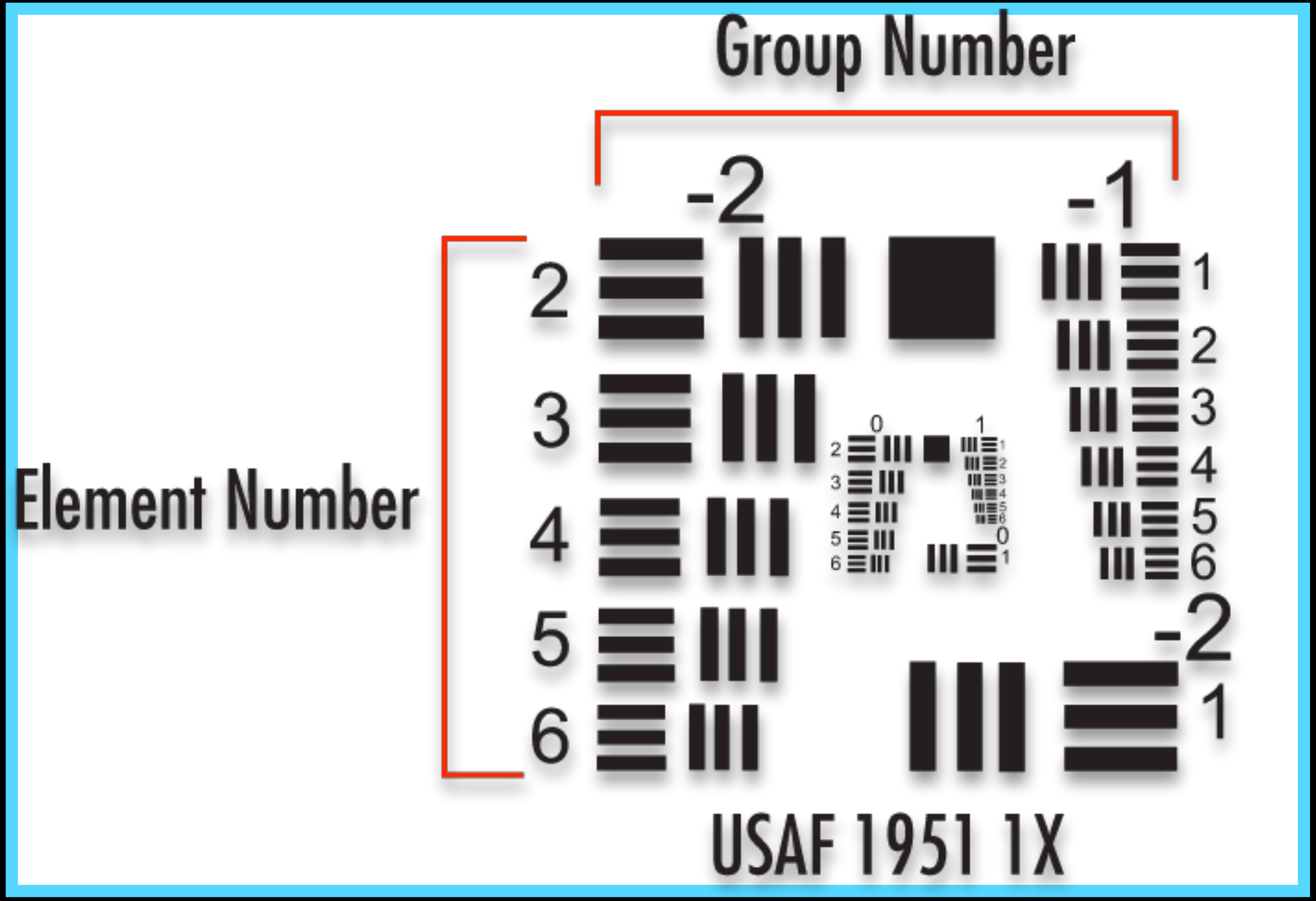
r = spacing mm

H = height mm

$$\theta = 206265\frac{r}{H}$$

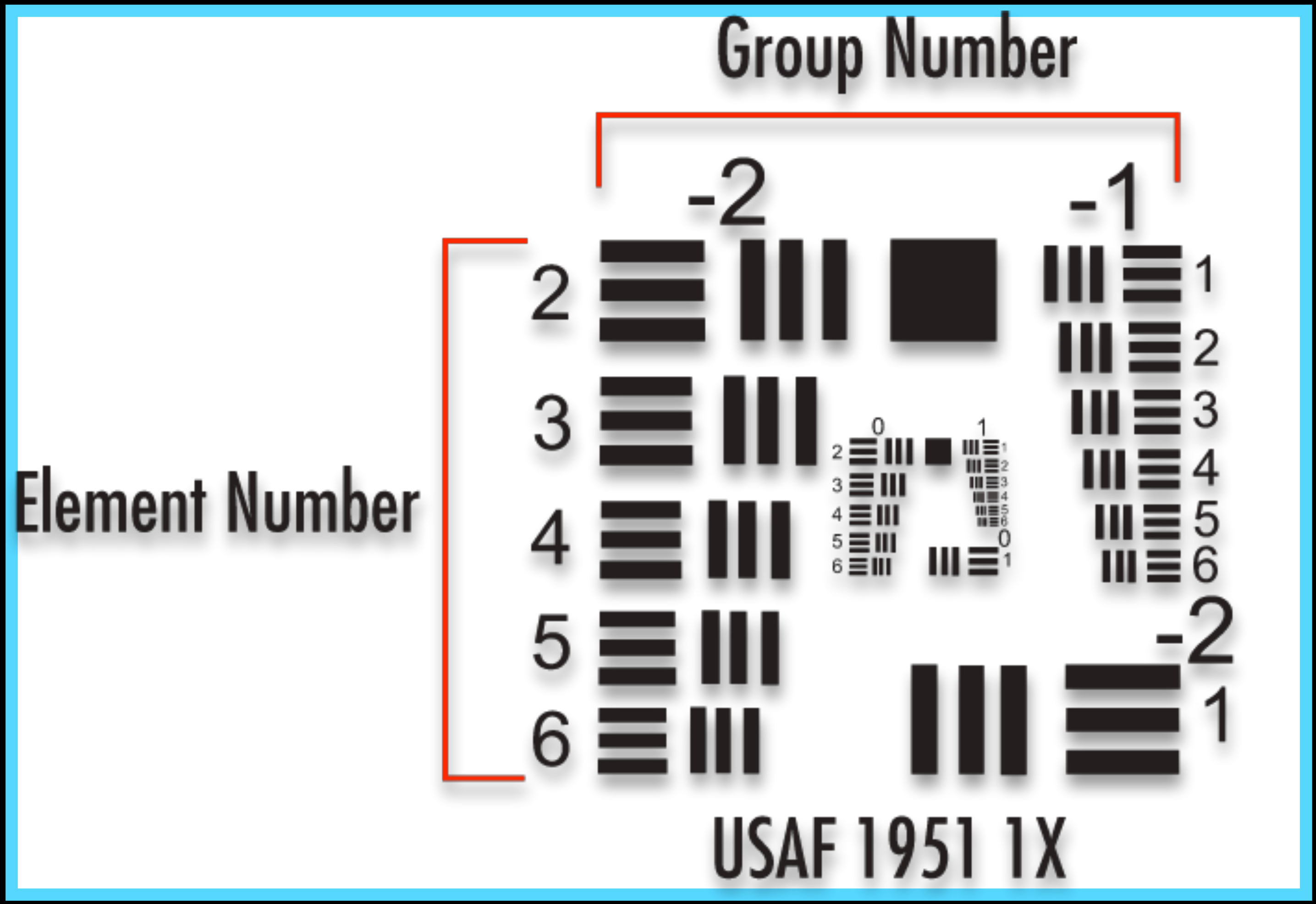
PART III: RESOLVING POWER

- Take a metal plate. Stand above the Resolution Chart (measure H in mm)
- Determine the limiting resolution where you can no longer resolve +2 separate lines
- Record



PART III: RESOLVING POWER

- Go to https://www.edmundoptics.com/knowledge-center/tech-tools/1951-usaf-resolution/ to determine the line pairs per mm
- Calculate spacing: r=1/lines pairs per mm
- Find the angular resolutions (Eq 2) and compare to Q15



HOLDING VERTICALLY	GROUP	ELEMENT	LINE PAIRS PER MM	SPACING (MM)
VERTICAL	****repeat for when holding horizontally****			
HORIZONTAL				

PART IV: SIMPLE TELESCOPE

- Follow the instructions in this section to create a telescope with an objective & eyepiece
- Measure f′ and image height
- Calculate the magnification
  1. $m = \frac{f_o}{f_e}$
  2. Visual comparison
  3. $m = \frac{D_o}{d_{er}}$