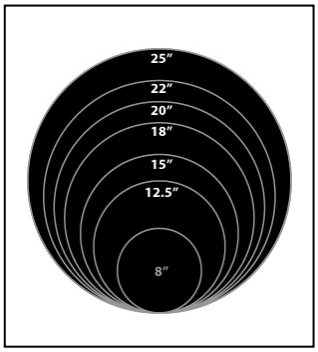
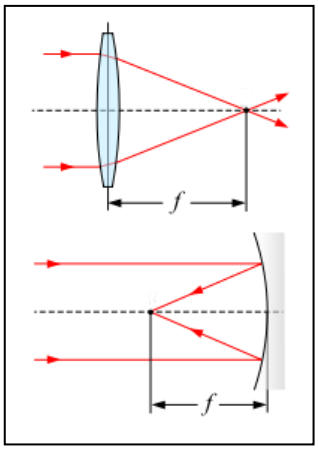


Any optical system, such as a telescope, camera or microscope, can be described by a just few basic numbers.

Aperture is the main lens or mirror that gathers the light to a focus. Aperture diameter, D, is commonly measured in inches, millimeters, centimeters or even meters. The larger the aperture, the more light the system gathers and the finer details it can see. The top figure shows various aperture diameters for telescopes that can be bought.



Focal length is the distance between the center of the aperture and the point in space where distant light rays come to a focus. In the figure, both a lens and a properly-curved mirror can have focal points. The symbol, f, represents the focal length.

F/ number is a measure of the speed and clarity of the optical system. It is the ratio of the focal distance to the aperture size. Fast systems have small F/numbers such as F/1, F/2 or F/3. Slow systems have large F/ numbers such as F/8, F/15 or even F/20. In photography these are also called F-stops.

$$F/ = \frac{f}{D}$$

Problem 1 – An astronomer wants to design a telescope that takes up the least amount of space in a research satellite. The aperture has to be 254 millimeters in order to gather the most light possible and provide the clearest images. The light path between the mirror center and the focus can be folded 3 times between mirrors separated by 500 millimeters. What is the focal length of this system and the F/ number? Is this a fast or slow system?

Problem 2 – An amateur astronomer wants to buy a telescope and has a choice between three different systems that cost about the same:

System 1 : F/2.0		f = 100 mm
System 2 :	D= 10-inches,	f = 1270 mm
System 3 : F/15.0	D = 50 mm	

Fill-in the missing quantities and describe the pros and cons of each system.

Problem 1 – An astronomer wants to design a telescope that takes up the least amount of space in a research satellite. The aperture has to be 254 millimeters in order to gather the most light possible and provide the clearest images. The light path between the mirror center and the focus can be folded 3 times between mirrors separated by 500 millimeters. What is the focal length of this system and the F/ number? Is this a fast or slow system?

Answer: The focal length is 3 x 1500 millimeters = 1500 millimeters, and F/ = 1500/254 = 5.9. It is a slow system because F/ > 3.0.

Problem 2 – An amateur astronomer wants to buy a telescope and has a choice between three different systems that cost about the same:

System 1 :	F/2.0	D=200 mm	f = 100 mm
System 2 :	F/5.0	D= 254 mm	f = 1270 mm
System 3 :	F/15.0	D = 50 mm	f = 750 mm

Fill-in the missing quantities and describe the pros and cons of each system.

Answer: System 1: D = 100 mm x 2.0 = 200 mm. System 2: D = 10 inches x 25.4 mm/inch = 254 millimeters so F = 1270/254 = 5.0; System 3: f = 50 mm x 15.0 = 750 mm.

System 3 is the slowest optical system in the group, and has the smallest aperture, which means that it gathers the least amount of light and so images will appear fainter and show less detail.

System 1 and 2 are very similar in aperture so they gather about the same amount of light, however, System 1 is nearly 3 times faster and so will provide the clearest images. System 1 is also shorter that System 2 (100 mm vs 1270 mm) so it would be easier and lighter to operate.