



You have probably seen a telescope before, and wondered how it works!

Telescopes are important in astronomy because they do two things extremely well. Their large lenses and mirrors can collect much more light than the human eye, which make it possible to see very faint things. This is called Light Gathering Ability. They also make distant things look much bigger than what the human eye can see so it is easier to study details. This is called magnification.

The human eye at night is a circle about 7 millimeters in diameter, called the pupil, which lets light pass through its lens and onto the retina. A telescope can have a main mirror or lens that can be many meters in diameter.

How do you figure out how much Light Gathering Ability a telescope has compared to the human eye? Just calculate the area of the two circles and form their ratio!

Problem 1 – The human eye can have a pupil diameter of as much as 7 millimeters. Using the formula for the area of a circle, and a value of $\pi = 3.145$, what is the area of the human pupil in square millimeters?

Problem 2 - The Hubble Space Telescope mirror has a diameter of 2.4 meters, which equals 2400 millimeters. What is the area of the Hubble mirror in square millimeters?

Problem 3 – What is the ratio of the area of the Hubble mirror to the human pupil? This is called the Light Gathering Ability of the Hubble Space Telescope!

Problem 4 - The faintest stars in the sky that the human eye can see are called magnitude +6.0 stars. To see magnitude +11 stars, you need a telescope that can see 100 times fainter than the human eye. What is the diameter of the mirror or lens that will let you see these faint stars?

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Answer: $A = 3.14 (7/2)^2 = \mathbf{0.78 \text{ mm}^2}$

Problem 2 - The Hubble Space Telescope mirror has a diameter of 2.4 meters, which equals 2400 millimeters. What is the area of the Hubble mirror in square millimeters?

Answer: $A = 3.14 (2400/2)^2 = \mathbf{4,521,600 \text{ mm}^2}$

Problem 3 – What is the ratio of the area of the Hubble mirror to the human pupil? This is called the Light Gathering Ability of the Hubble Space Telescope!

Answer: $4,521,600 / 0.78 = \mathbf{5,796,923 \text{ times the human eye}}$

Problem 4 - The faintest stars in the sky that the human eye can see are called magnitude +6.0 stars. To see magnitude +11 stars, you need a telescope that can see 100 times fainter than the human eye. What is the diameter of the mirror or lens that will let you see these faint stars?

Answer: $100 = \pi R^2/0.78$ so $R^2 = 24.8$ and so $R = 5.0$ and $\mathbf{D = 10.0 \text{ millimeters}}$.