

The Earth and the Moon

How far away is the Moon?

Space is very empty, and even our nearest neighbor, the Moon, is nearly 400,000 km away. These activities help demonstrate the relative sizes of the Earth and the Moon and the distance between them.

Equipment: an Earth globe (any reasonable size), small balloons (preferably round rather than oblong), and a long spool of twine or string.



Earth and Moon:

Take a standard Earth Globe (no smaller than 10 cm diameter — 20 to 40 cm diameter is best). Give each pair of students a balloon and ask them to blow it to be the size of the Moon relative to your globe. To check their answers, take a piece of string or twine and wrap it once around the Earth's circumference, and cut it (one piece per pair of students). That gives you the circumference of the Earth, about 40,000 km. Now, fold the piece of twine in half twice (giving, yes, 1/4 of the distance). That is roughly the circumference of the Moon. Does the balloon just fit inside the circle made from the twice-folded twine? (Praise the groups which got the closest).

Your Challenge:

Now, have the students guess how far away their Moon should be from the Earth. Have one student take your Earth, and another take their Moon. Have the 'Earth' hold the free end of the twine, and the 'Moon' person walk away from the Earth as far as he or she thinks the Moon is away from the Earth, unrolling the twine. Did the Moon go far enough away? (They generally won't).

Because the circumference of the Earth is about 40,000 km, and the distance from the Earth to the Moon is about 384,000 km, then the distance from the Earth to the Moon is about 9.5 times the circumference of the Earth. Have ten of the students form a line from the Earth to the Moon, each stretching out their string, with the last person using theirs folded. For most globes, the Moon won't be in the classroom, but will be in the hallway (for a large globe, a LONG way down the hallway!).

Now that the Moon is the proper size and in the correct location, estimate its angular size as seen from Earth (one finger at arm's length is about 2 degrees — is it a degree wide?).

The figure on the next page shows the Sun, Earth and Moon to the same scale - for the distance of a page, the Sun is just 2.5 mm and the Earth and Moon are each smaller than the smallest dot! What is the angular size of the Sun from the Earth? (It may be difficult with a typical protractor).

The lower figure shows the Sun, Earth and Moon with the sizes of the bodies each increased by a factor of 40. What is the angular size of the Sun as seen from the Earth? Now divide by 40 to get the real angle. What angle do you get?

Back to the string. The Sun's diameter is about 400 times the diameter of the Moon, so, since the Moon can exactly cover it up in an eclipse, the Sun must be 400 times farther away than the Moon! How far away would your 'Sun' be for your Earth? How big would it be? (almost 100 times the diameter of the Earth). (Calculate the exact ratios by using the distances given on the figure). The ratio (Diameter of Sun)/ 1 AU is roughly equal to (Diameter of Moon)/(distance to Moon). This ratio is approximately the angle, if the angle is measured in *radians*. One radian is about 57.3 degrees (the definition of radian is that a circle = 2π radians = 360 degrees). So, for a ratio of about 1/120, the Moon's angle is about 1/2 degree. Did your students get that correctly, each way they tried it?

Sun, Earth and Moon true scales for size and distance (note that Earth and Moon are invisible!)

- Diameter of Sun = 1.392×10^6 km
- Sun-Earth Distance = 1.496×10^8 km (1.7%)
- Earth-Moon Distance = 3.84×10^5 km (5%)
- Diameter of Earth = 1.256×10^4 km
- Diameter of Moon = 3476 km
- Angle (radians) = D/L (good if $D \ll L$)
- Angle (degrees) = $(D/L)(180/\pi) = 57.3 D/L$



Sun, Earth and Moon Size scales a factor of 40 enhanced over distance scale