

## A "Handy" Measuring Tool

Learn how to use your hands to measure the size to distance ratio of a familiar astronomical object-- the Moon.

### Materials Needed

- your hand
- your arm
- meter sticks
- a partner



### What To Do: Using Your "Handy Tool" To Find The Distance To Your Partner

- To start, use the meter stick to measure the height of your partner's head. Measure from their chin to the top of their head. Save this measurement -- you'll need it later.
- Make a fist. You will use the *width of your fist* as a unit of measure. Carefully measure the length of your arm (from wrist to the top of your shoulder) in "fists." Write down this number -- for example, the arm measured in Figure 1 is "6 fists" long (see **Figure 1**).

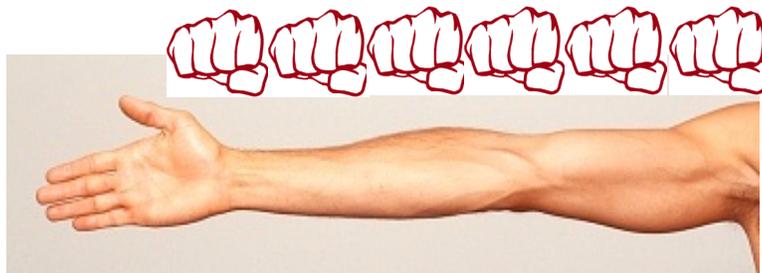


Figure 1

- Extend your arm straight out in front of you and make a fist. Close one eye and look at your fist, extended at arms length. Move your partner away from you until your closed fist just barely covers their head. Believe it or not, you now have enough information to estimate how far away your partner is standing from you.
- Let's say that your arm is 6 fists long. That means that anything you can barely cover with your closed fist is 6 times further away than it is high. So, in this example, your partner's head would also be 6 times further away than it is high.

- Using the height of your partner's head (measured earlier) and the length of your arm in fists, estimate how far your partner is away from you. Check your answer with the meter stick.
- Below is a table of other "handy measuring tools" and the distance to size ratios for each. For example, anything you can just cover with the tip of your outstretched thumb will be 30 x farther away from you than it is big.

Part Of Hand To Compare ...	Sketch	Distance to size ratio	Angular Degrees (approximate)
Outstretched Thumb & Pinkie		3:1	20°
Clenched Fist		6:1	10°
Thumb		30:1	2°
Pinkie		60:1	1°

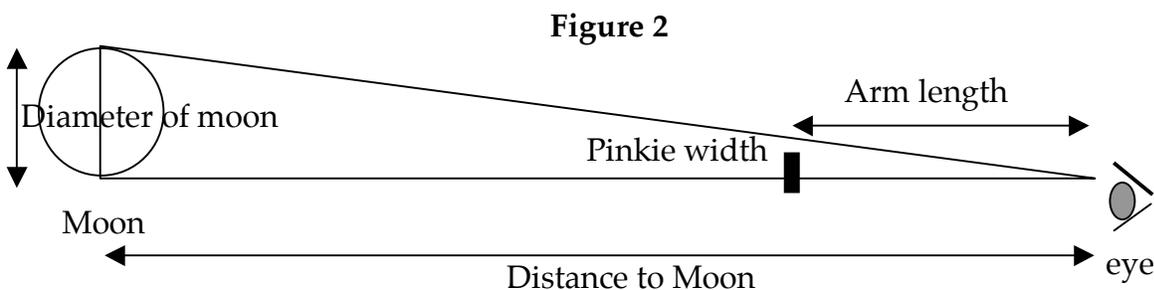
### Using Your "Handy Tool" To Find The Distance To The Moon

- Look at a calendar and find a night when the Moon will be full. (During this phase, the Moon will rise at sunset and set at sunrise.) Before going outside to look at the full moon, make the following guess -- what part of your hand (extended at arm's length) will you need to hold out in front of you to just barely cover the full moon? Your fist? Your thumb? Your pinkie? Less than a pinkie? More than your clenched fist?

- Find the full moon and check your prediction. *Were you surprised that the full moon appeared smaller than any of your fingers?*
- As best you can, estimate the apparent size of the full moon in "pinkie nail widths." For most people, the full moon is about 1/2 pinkie nail widths in apparent size.
- The Moon is about 2000 miles in diameter. Let's say that the moon looked like it was about 1/2 pinkie nail width in apparent size. Anything you can just barely cover with the tip of your entire pinkie is 60 times farther away than its diameter. Since the moon appeared to be only 1/2 pinkie in size, this means that the moon is 120 times further away than it is big. In other words, the moon is  $120 \times 2000 \text{ miles} = 240,000 \text{ miles}$  away from the Earth.

### What's Going On?

These activities make use of similar triangles and linear proportion. When you extend your arm and clench your fist, you are forming a triangle. The base of this triangle is your arm and the height is your clenched fist. When you use your fist to cover a distant object, you are essentially forming another triangle -- its base is the distance between your eye and the object and the height is the height of the object itself. These two triangles are *similar triangles*. This is because the angles making up one triangle are the same as the angles making up the other triangle (**Figure 2**).



When two triangles are similar, the lengths of their sides are proportional. Mathematically, this is written as:

$$\frac{\text{Height (triangle A)}}{\text{Base (triangle A)}} = \frac{\text{Height (triangle B)}}{\text{Base (triangle B)}}$$

Let's apply this relationship to the Moon problem. In this example, triangle A is the triangle formed by half your pinkie nail (height A) your arm (base A). Triangle B is the triangle formed by the actual diameter of the Moon (height B) and its distance away from your eye (base B). Rewriting the relationship above, we have

$$\frac{\text{half pinkie width}}{\text{arm length}} = \frac{\text{diameter of the moon}}{\text{distance to the moon}}$$

In this example, we knew three of the parameters -- the half pinkie nail width, arm length, and diameter of the moon. The fourth parameter (distance to the moon) was the variable we solved for.