Measurement & Calculation

I. SI Units, Prefixes, Orders of Magnitude

II. Rates

III. Skinny Triangles

IV. Circles, Arcs

V. Spherical Coordinates

	The student will be able to:	HW:
1	Utilize and convert SI units and other appropriate units in order to solve problems.	1
2	Utilize the concept of orders of magnitude to compare amounts or sizes.	2 – 3
3	Solve problems involving rate, amount, and time.	4 – 7
4	Solve problems involving "skinny triangles."	8 – 13
5	Solve problems relating the radius of a circle to diameter, circumference, arc length, and area.	14 – 15
6	Define and utilize the concepts of latitude, longitude, equator, North Pole and South Pole in order to solve related problems.	16 – 21
7	Define and utilize the concepts of altitude, azimuth, zenith, and nadir in order to solve related problems.	22 – 24

The **light-year** is a unit of

A. Speed
B. Distance
C. Time
D. Space-Time

Rates

ratio of change

Rate, Amount, Time

- Rates are very important in science and astronomy is no exception.
- A rate is a numerical value that shows how rapidly something occurs.

$$rate = \frac{amount}{time}$$

Speed

Speed is a rate based on the distance traveled per unit time.

$$v = \frac{d}{t}$$

where: v = speed

d = distance

t = time

The Apollo spacecraft traveled 239000 miles to the Moon in about 76 hours. Find the average speed.

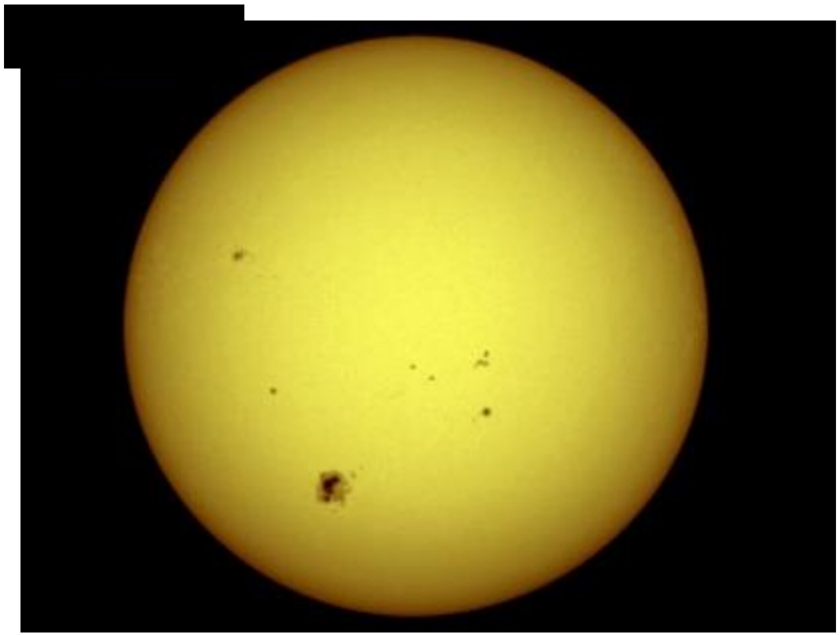
In order to escape Earth's gravity, a spacecraft must attain a speed of about 25000 mph. At this speed how far can a spacecraft travel in 76 hours?

In order to reach Mars, a spacecraft must travel at least 47 million miles. Determine the time to do this at a speed of 25000 mph.

Which is bigger – the Sun or the Moon?

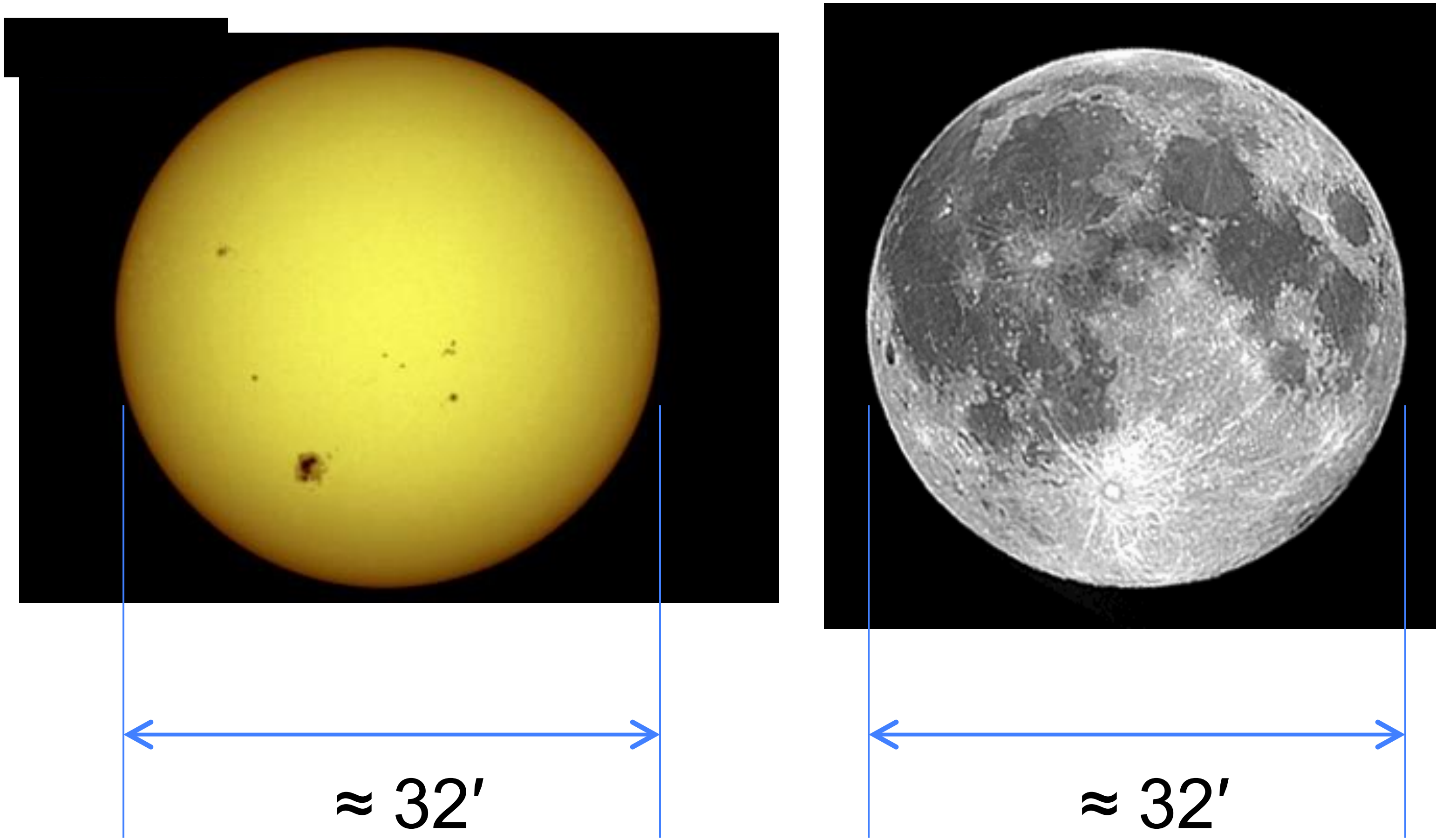
Which *appears* bigger – Sun or Moon?

The Sun is **much** bigger than the Moon!

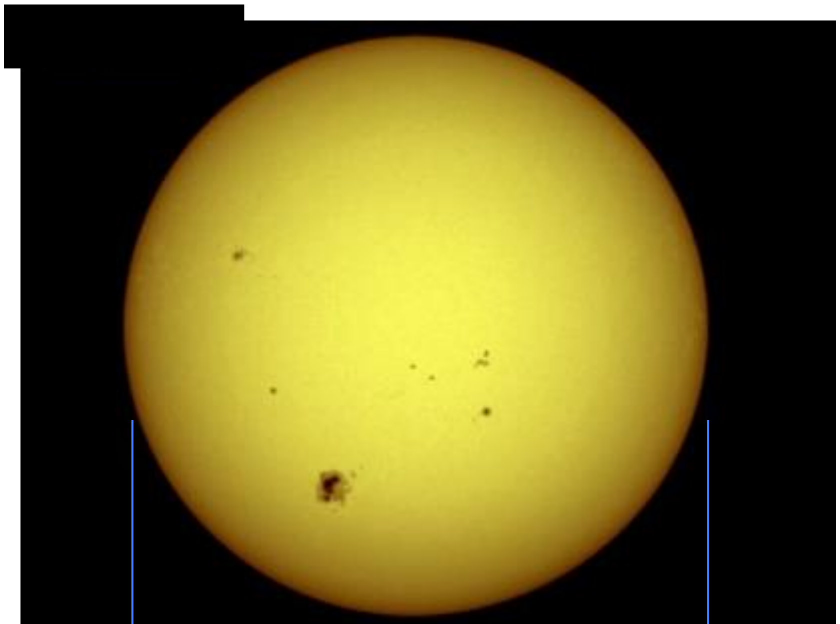


but…

The Sun and Moon *appear* to be the same size!



But not always ***exactly*** the same…



31.5′ to 32.5′

29.4′ to 33.6′

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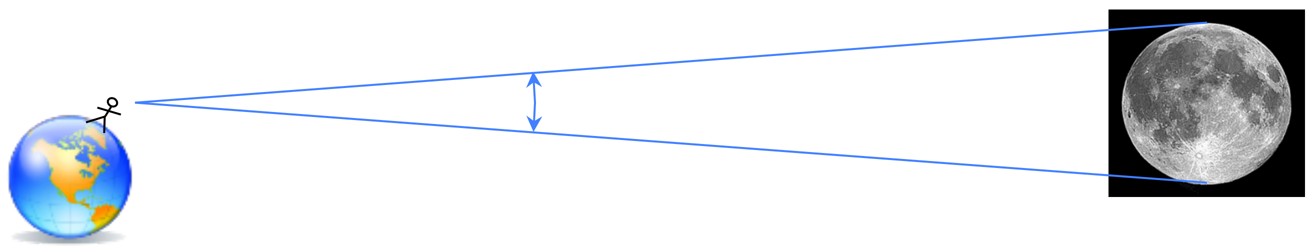
Angles

a KEY concept in Astronomy

Angular Size

- Astronomers often describe the size of objects by using angles.
- The **angular size** is the angle formed by rays drawn from the observer to the object:



Angle Units – in Words

1 degree = central angle that delimits $^{1}/_{360}$ the circumference of a circle

1 arc minute = $^{1}/_{60}$ of one degree

1 arc second = $^{1}/_{60}$ of one arc minute

1 radian = central angle that delimits an arc equal in length to the radius of the circle

Angle Units – Conversions

$$1' = {}^{1}/_{60}{}^{\circ} \quad \text{or} \quad 60' = 1^{\circ}$$

$$1'' = {}^{1}/_{60}{}' \quad \text{or} \quad 60'' = 1'$$

$$2\pi \text{ rad} = 360^{\circ} \quad \text{or} \quad 1 \text{ rad} \approx 57.3^{\circ}$$

Convert to Decimal Degrees

1. 32′
2. 6″
3. 2º 40′
4. 30′ 15″
5. 5º 10′ 18″

Convert to Decimal Degrees

1.	32′	0.53º
2.	6″	0.0017º
3.	2º 40′	2.67º
4.	30′ 15″	0.5042º
5.	5º 10′ 18″	5.1717º

Convert to Decimal Degrees

6. 15′
7. 15″
8. 10º 25′
9. 25º 50′ 08″

Convert to Decimal Degrees

6.	15′	0.25º
7.	15″	0.0042º
8.	10º 25′	10.42º
9.	25º 50′ 08″	25.8356º

Convert to Degrees, Minutes, Seconds

1. 0.75º
2. 0.0015º
3. 0.5050º
4. 4.8975º

Convert to Degrees, Minutes, Seconds

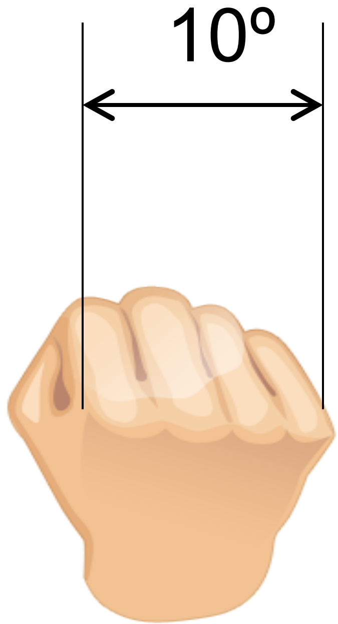
1.	0.75º	45′
2.	0.0015º	5.4″
3.	0.5050º	30′ 18″
4.	4.8975º	4º 53′ 51″

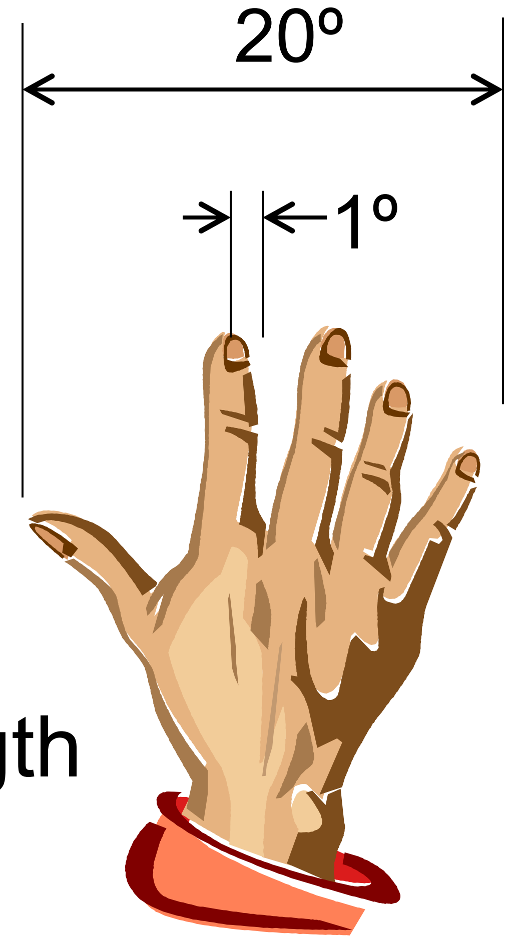
Convert to Degrees, Minutes, Seconds

5. 0.30°
6. 0.0075°
7. 0.251°
8. 5.2134°

Convert to Degrees, Minutes, Seconds

5. 0.30º	18′
6. 0.0075º	27″
7. 0.251º	15′ 04″
8. 5.2134º	5º 12′ 48″



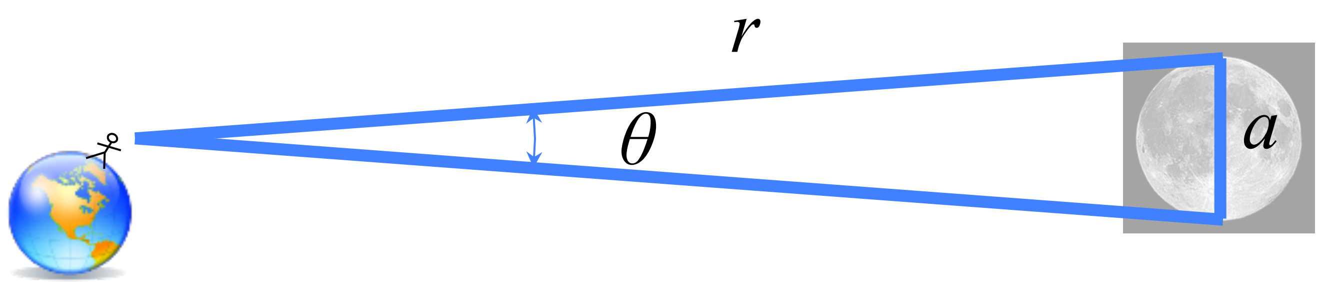


Hold your hand at arm's length and these are approximate angular sizes – handy for judging things in the sky!

What Determines Angular Size?

- The greater the actual size of the object and/or the closer it is, the greater the apparent angular size.
- Angular size is proportional to actual size and inversely proportional to distance.

Skinny Triangles



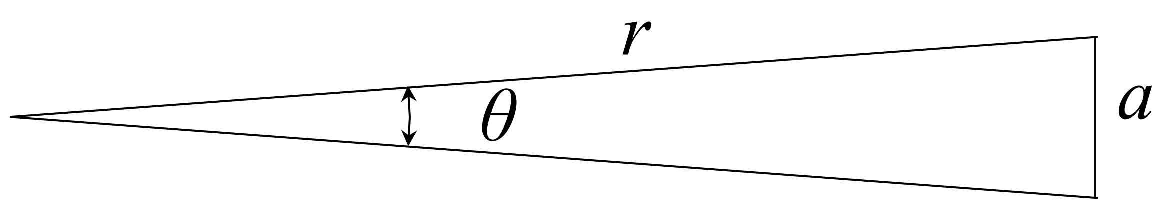
Skinny Triangles

$$\theta = \frac{a}{r}$$

θ = angle in <u>radians</u>

a = object size

r = distance to object



This works only if angle is <u>small</u> – *i.e.* triangle is *skinny*!

1. A 50 ft telephone pole viewed from a distance of 400 ft has what angular size?

2. What was the angular diameter of Earth (diameter = 1.3×10^7 m) as it appeared to the Apollo astronauts on the Moon at a distance of 3.8×10^8 m?

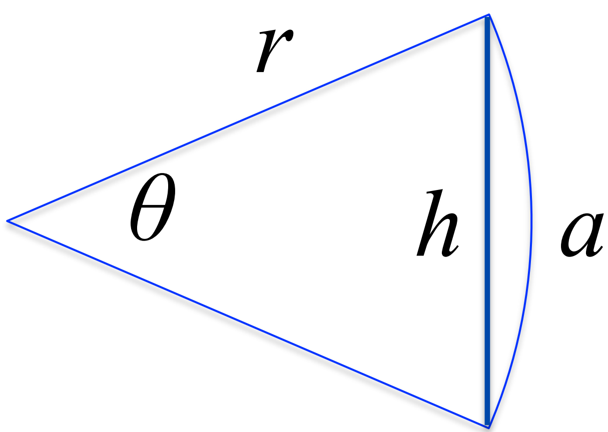
3. A certain tree has an angular height of 3.5º when viewed from a distance of 570 m. Find the tree’s height.

4. Suppose a ship at sea just “fills the view” through binoculars with a 5.0º field of view. If the ship is 0.65 miles away, what is its length.

5. A football field's goal posts have an angular separation of 2.6º as seen by a pilot in an airplane. How far away is the pilot from the field?

6. On a particular date Mars has an angular diameter of 7.0 arc seconds. If the diameter of Mars is 6800 km, how far away is it on that date?

Note: the "skinny triangle" formula is actually an approximation based on arc length. For "skinny" triangles the linear amount *h* is essentially the same as the arc length *a*.



$$\theta = \frac{a}{r}$$ exactly true for arc length *a*

$$\theta \approx \frac{h}{r}$$ approximately true for triangle side *h*