

Lesson 3-3.2 Tides

- Gravity causes tides
- The Law of Gravity
- The force of gravity is $F = \frac{Gm_1m_2}{r^2}$
 - Directly related to TWO masses
 - Inversely related to the square of the distance between them

The value of $G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2$. It is basically a proportionality constant to make the units work out right. You should note that the value is very small; that means it takes a huge amount of mass for gravity to have a value of any significance.

Lesson 3-3.3a Gravity

The fact that there are two masses in the law means that everything in the universe attracts every other thing.

Any two masses attract.

The sun attracts the earth

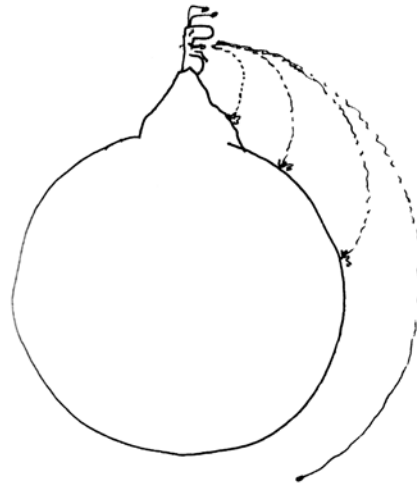
The earth attracts the moon

The moon attracts the earth

Carl Sagan once wrote that the force of gravity of an obstetrician is greater on the baby than the force of gravity of Jupiter on the baby. If the positions of the planets influence your life, gravity is not the cause of it.

Lesson 3-3.3b Gravity

- The moon attracts the earth
 - This includes the air, water, and rock of the earth
- The earth falls towards the moon, and the moon falls towards the earth
- Because they're moving sideways they miss
- This is called an orbit.



This is a variation on Isaac Newton's original explanation for how orbits work. The diagram illustrates the concept; if you throw an object off a tall mountain, it'll travel so far before hitting the ground. Throw it faster, and it'll go faster, but still will strike the ground. If you throw it fast enough, the earth will curve away beneath it as fast as it falls; thus the object orbits the earth, continuously falling but missing the ground.

Lesson 3-3.3c Gravity

The inverse square relationship means that as the distance between two objects increases, the force between them decreases.

Two objects are 1000 km apart and experience a force of gravity of 1 N between them.

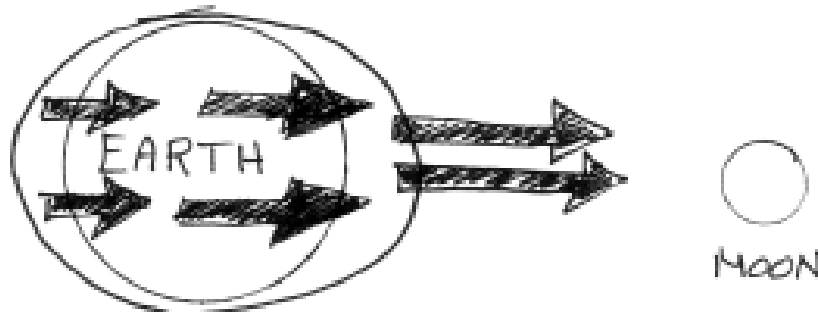
When the objects are separated by 2000 km, the force will be $\frac{1}{4}$ N.

Lesson 3-3.6a Tides

When the moon pulls on the earth, the near side of the earth is pulled harder *because it is closer* to the moon.

This *stretches* the earth, its atmosphere and its oceans.

The arrows get longer as you approach the moon because the force is stronger. Because the left hand arrows are shorter than the right ones, the earth (and its oceans) get stretched.



Lesson 3-3.6b Tides

As the earth rotates underneath the bulges, the water level of the ocean rises and falls locally. Typically there are two high tides and two low tides a day.



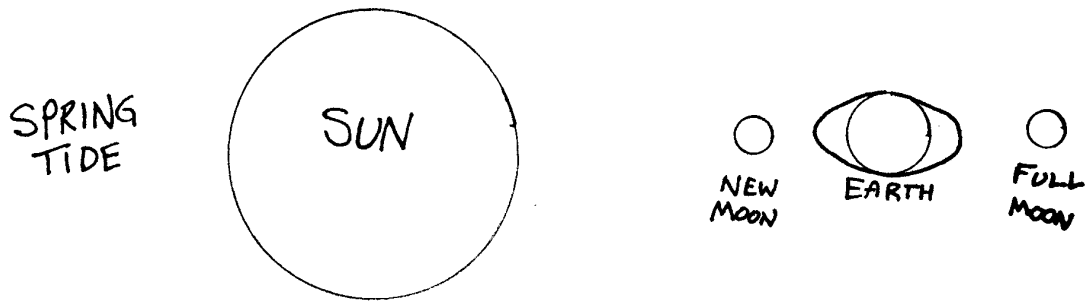
Lesson 3-3.6c Phases and Tides

The alignment of the earth, sun and moon affects the timing and strength of tides.

The sun causes tides as well, although they aren't as strong.

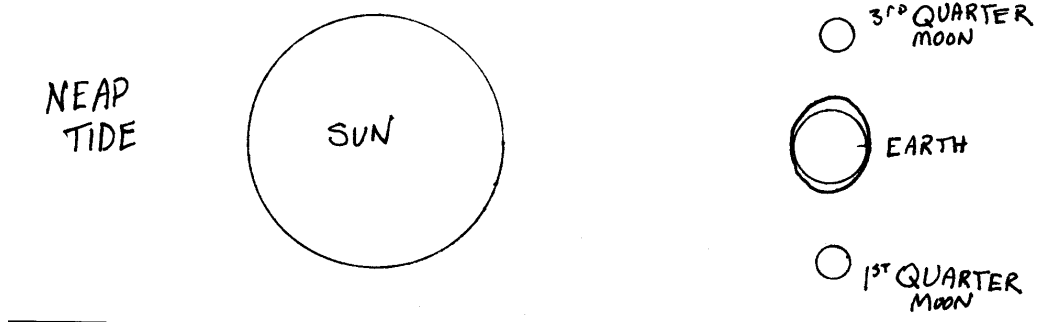
Lesson 3-3.6d Spring Tides

Occur when the earth, sun and moon are aligned.



Lesson 3-3.10 Neap Tides

Occur when the earth, sun, and moon are at right angles



Lesson 3-3.11 Other Tide Considerations

Local geography can affect the timing and speed of the tide.

The bulge of the earth's oceans takes time to move around the earth, so it lags behind the moon a bit.