

Chapter 9

Gravitation



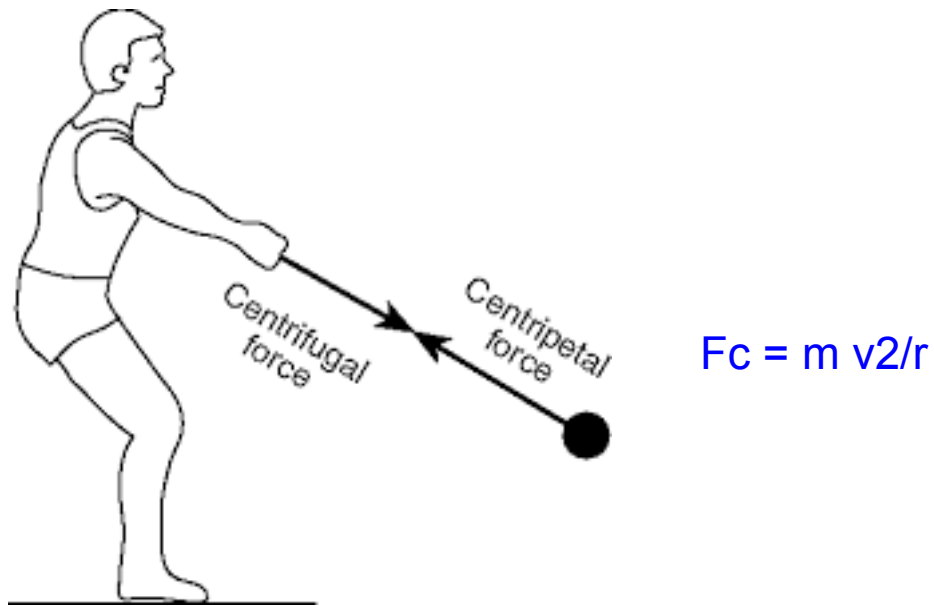
Gravity.
It's not just a good idea.
It's the Law.

What makes things fall down?

What keeps the moon in orbit around the earth?

What keeps the earth in orbit around the sun?





We know:

Centripetal force is needed to keep a thing moving in a circle.

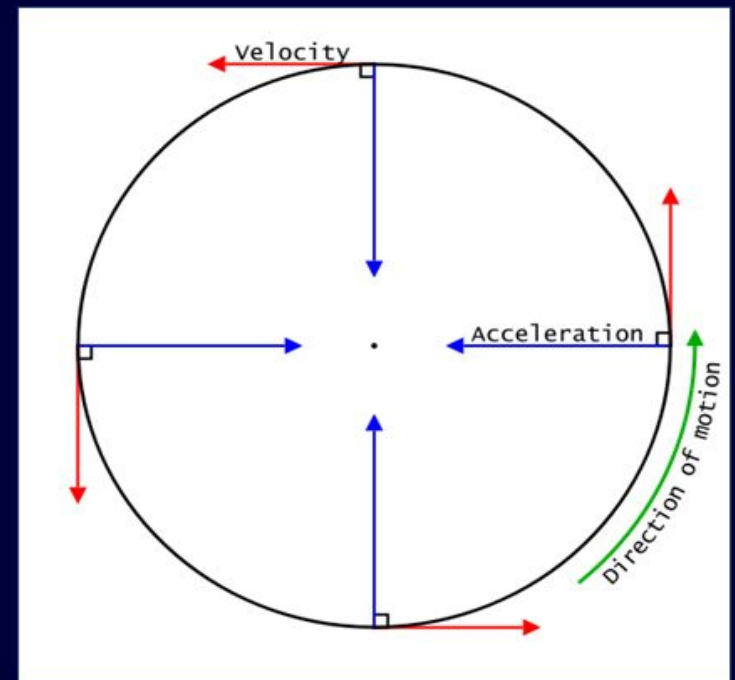
Centripetal force is proportional to the mass and is directed toward the center of the circle. Planets move in roughly circular orbits. What force is keeping them in orbit?

Circular motion requires constant acceleration
centripetal acceleration $a_c = v^2/r$
since force = mass * acceleration
centripetal force $f_c = mv^2/r$

CENTRIPETAL FORCE

- Centripetal force can be supplied by any type of force.
 - Gravity provides the centripetal force that keeps the moon in roughly a circular orbit
 - Friction provides the centripetal force that causes a car to move in a circular path on a flat road
 - Tension in a string tied to a ball will cause the ball to move in a circular path when you twirl it.

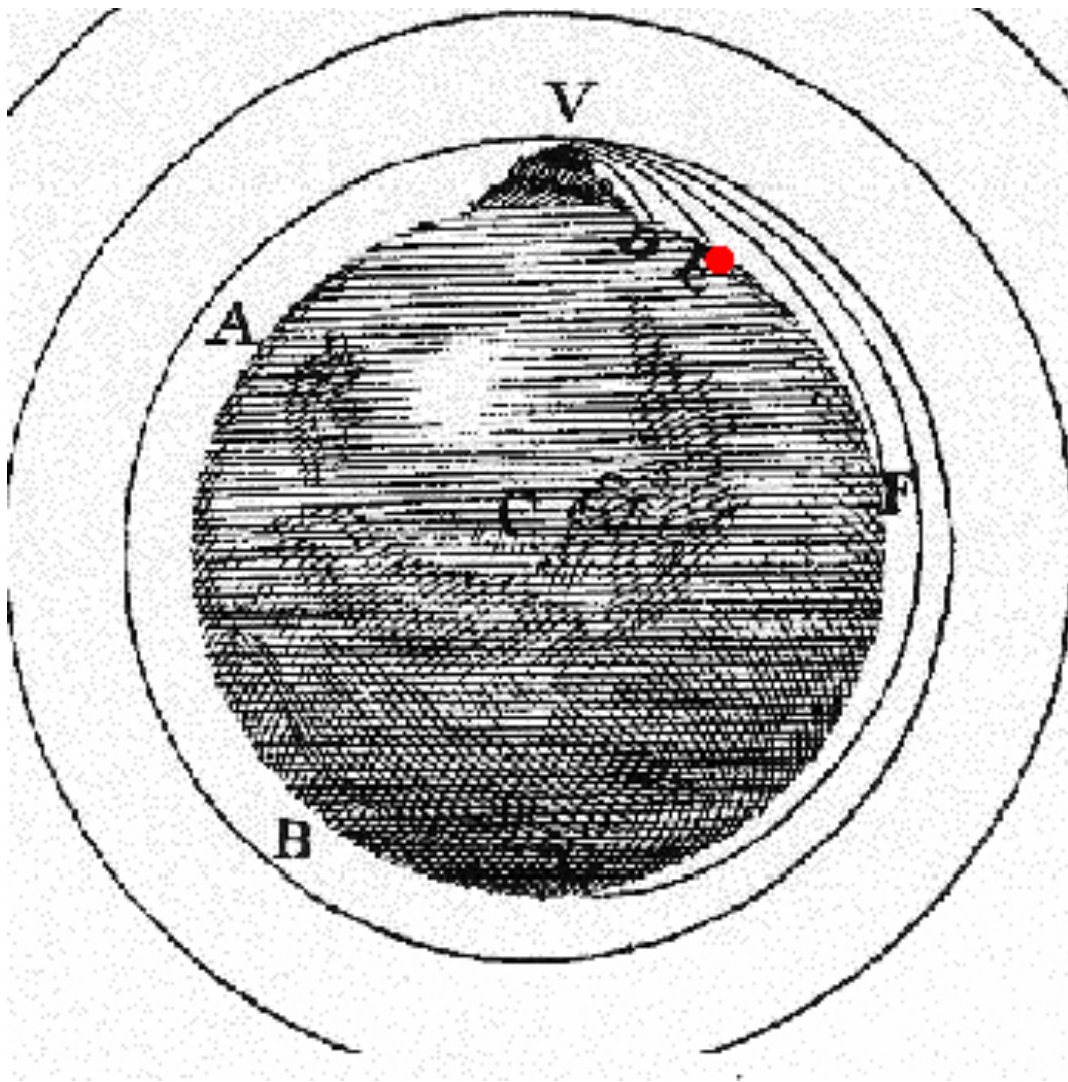
- $F_c = \frac{mv^2}{r}$



So we actually have two problems:

1. Why do things fall down
2. Why do the planets stay in orbit. (What supplies the centripetal force?)

With ONE ANSWER:
GRAVITY.



http://galileoandeinstein.physics.virginia.edu/more_stuff/flashlets/NewtMtn/home.html

Law of Universal Gravitation

Newton's "guess"

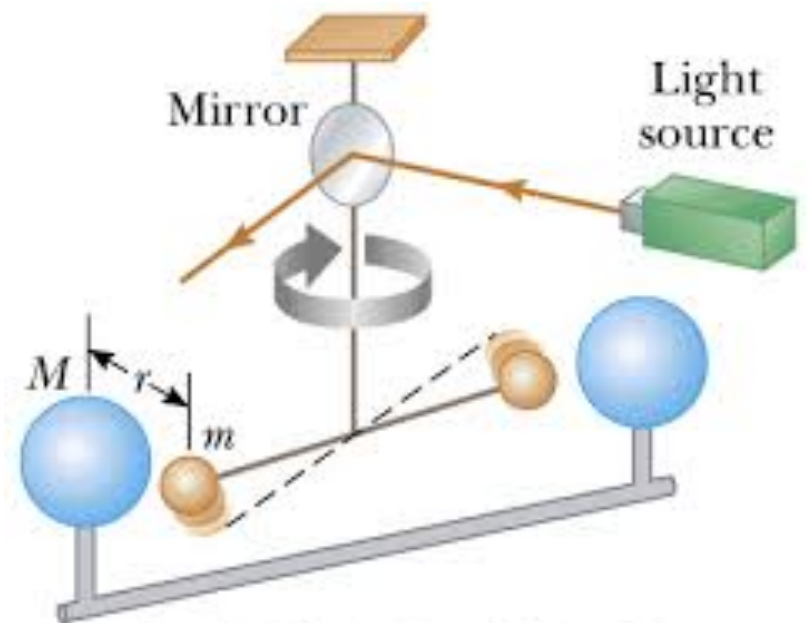
$$F = G \frac{m_1 m_2}{r^2}$$

But we need to find the
value of G which is called the
Universal Gravitational Constant!

The Cavendish Experiment

Newton proposed his equation in 1687.
More than 100 years elapsed before G
was measured by Henry Cavendish.

$$G = 6.67 \times 10^{-11} \text{ N m}^2 / \text{kg}^2$$



Serway, Physics for Scientists and Engineers, 5/e
Figure 14.3
Harcourt, Inc.

Inverse Square Law

If the distance doubles, the force.....

If the distance halves, the force

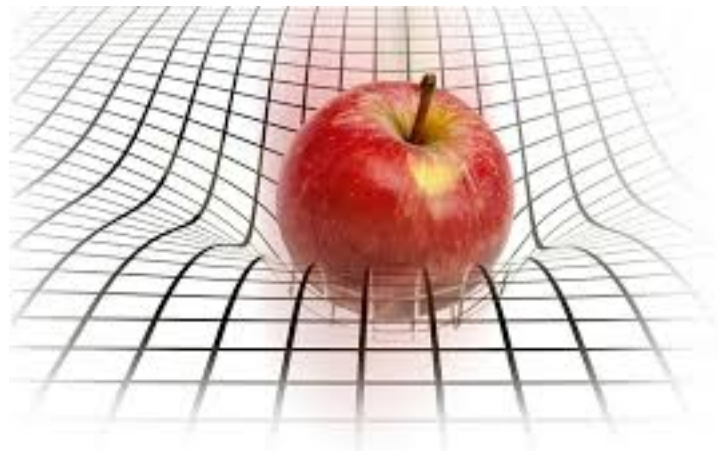
If the distance triples, the force

If the distance is $1/3$, the force

Problems:

Calculate the force of gravity on a 1 kg mass at the earth's surface. Assume the mass of the earth is 6×10^{24} kg and the radius of the earth is 6.4×10^6 m.

If you moved so that you were 6.4×10^6 m above the surface of the earth, what would be the force of gravity on that mass?



m = mass of ball
 r = radius of circle
 V = speed of ball

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