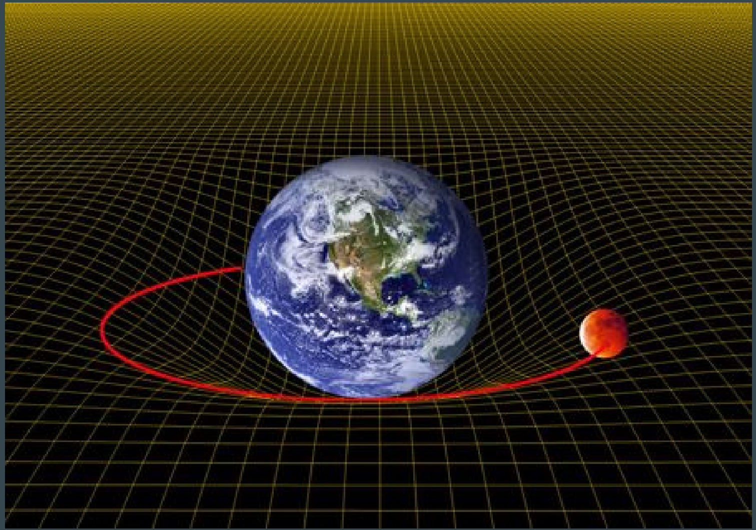
GRAVITY

By Jenna Kaufman, Jillian Pih, Celeste Padilla, and Armand Bogossian

What is Gravity?

- Geometry of time and space due to the presence of mass
  - It's a distortion of spacetime!
- Gravity is the means by which masses communicate to each other
  - Mass always attracts each other!



- $F_c = =mv^2/r$

What Factors Does Gravity Depend On?

1. How big is the first object m_1
2. How big is the second object m_2
3. How far apart are they r

$$F_g = m_1 m_2 / r^2$$

Inverse Square Law

- The concentration of gravity washes out if you move farther away from the object
- Gravity radiates like light
  - If you move twice the distance away, the brightness is ¼ as bright

- **$F_g = GMm/r^2$**

Gravitational Potential Energy

$$PE = mgh = -Gm_1m_2/r$$

- Why negative?
  - Indicates that movement is from high PE to a lower PE

Escape Speed

- **Escape speed:** speed needed to escape a particular planet
- Independent of mass of the object
- Does not matter what direction you are traveling!

- $V_{esc} = \sqrt{2GM/r}$

Common Misconception #1

F_g=mg can be used to find the force of gravity on any planet.

But... the only place this formula can be used is when the effects of Earth's gravity are applicable.

Common Misconception #2

Objects of different masses will be affected by gravity differently in free fall.

But... objects in free fall will fall at the same rate, regardless of their mass, in the absence of air resistance.

Common Misconception #3

When you're weightless that gravity does not affect you.

But... gravity is always acting on you! There is no escaping it!

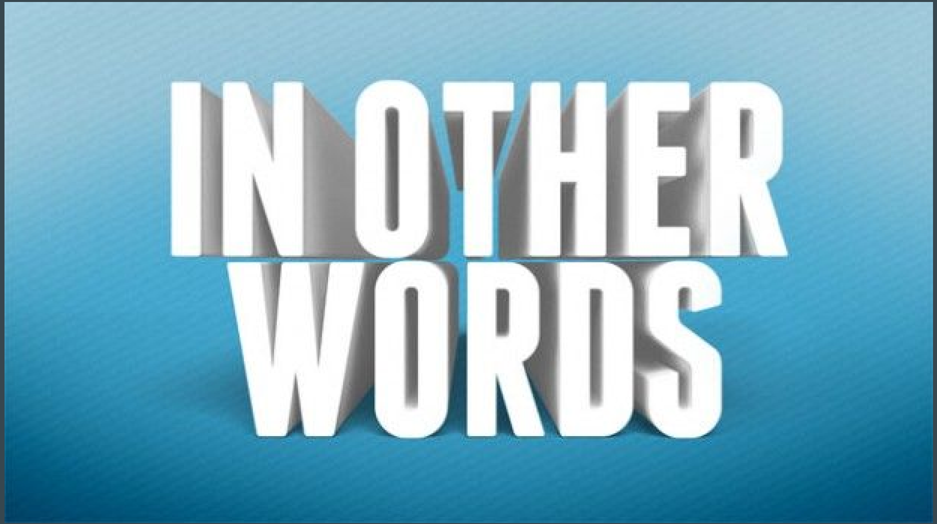
An example of this is that astronauts in space who are experiencing “weightlessness” are just in perpetual free fall.

Kepler's 3 Laws of Planetary Motion

1) The orbit of a planet is an ellipse with the sun at one of the two focus points.
2) A line segment joining a planet and the sun sweeps out equal areas during equal intervals of time.
3) The square of the orbital period of a planet is proportional to the cube of its average distance from the sun.

In other words...

1) Planets orbit in an ellipse.
2) The change in area swept out by a planet per time is always constant.
3) $T^2=4\pi^2r^3/GM$



Einstein's Special Theory of Relativity

The speed of light is the same in all inertial reference frames.

The laws of physics are the same in all inertial reference frames.

Implications:

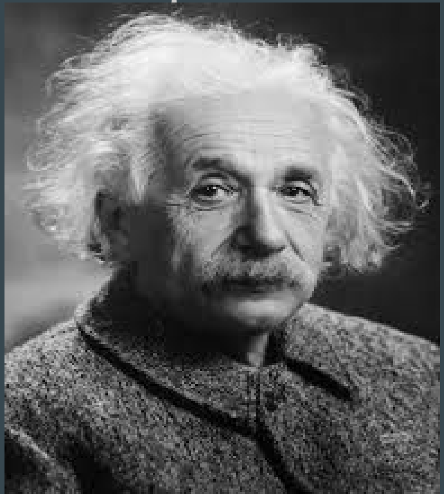
- Nothing can go faster than the speed of light= 3.0×10^8 m/s
- Length and time are malleable-they change depending on your reference frame

Einstein's General Theory of Relativity

Gravity is the universal attraction between all masses and energy.

Since $e=mc^2$, all forms of energy feel the effects of gravity.

- Gravity is the curvature of spacetime - the four-dimensional fabric of the universe.

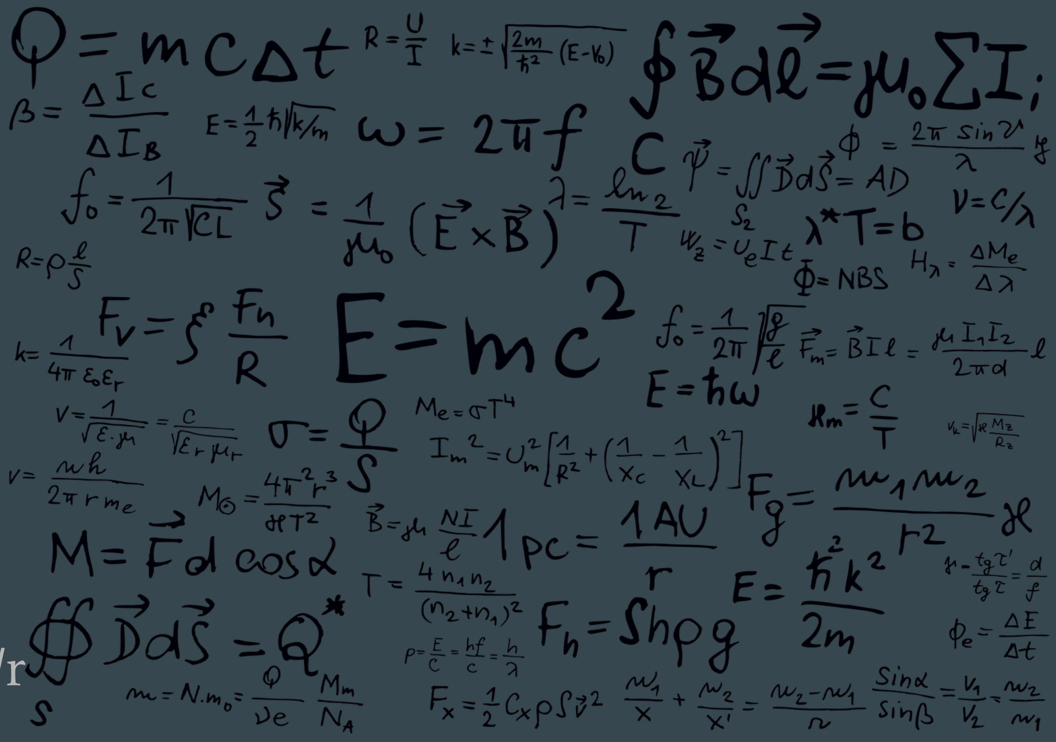


Satellite Motion

- **Shape of orbit:** Ellipse
- **Conservation of angular momentum:**
  - The closer the planet gets to the sun, the faster it orbits!
- Satellites have kinetic energy that allows it to move around Earth!
  - $L=mr^2\omega$
  - $KE_{rad}=1/2mv^2$
  - $KE_{rev}=L^2/2mr^2$
  - $E=1/2mv_r^2+L^2/2mr^2-GMm/r$

Formulas for Reference

- $F_g = mv^2/r$
- $F_g = mg$
- $F_g = Gmm/r^2$
- $PE = -Gmm/r$
- $V_{esc} = \sqrt{2gm/r}$
- $T^2 = 4\pi^2 r^3/GM$
- $L = mr^2\omega$
- $KE_{rev} = L^2/2mr^2$
- $E = 1/2mv_r^{\,2} + L^2/2mr^2 - GMm/r$



Class Practice Problem

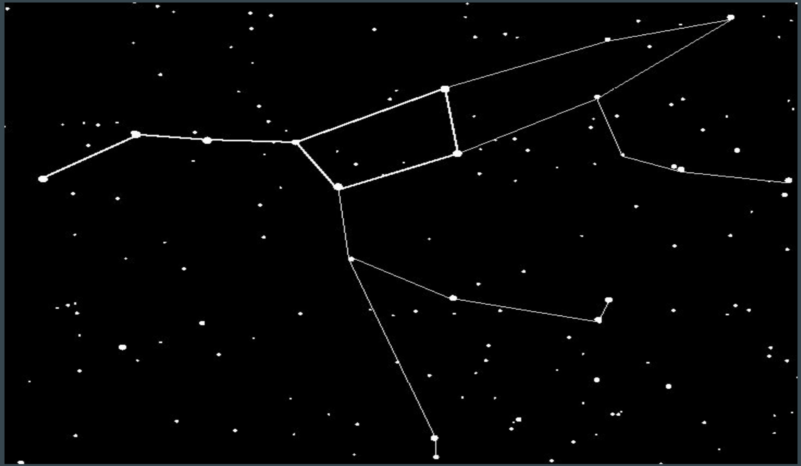
What is the force of gravity at 2.14x10^5 m above the surface of Earth on a 40 kg object?

Answer

368 N

Now YOU Try!

Ursa Major is a star near the north celestial pole. Its mass is 2.19x10^30 kg and it has a radius of 8.21 x10^8m. What is the escape velocity on the surface of Ursa Major?



Answer

V_{esc}=5.97x 10^5 m/s