Physics Lecture 2 – Force

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Mass/Weight

- Mass measures an object's inertia (tendency to remain in current state of motion)
  - Doesn't change no matter where you are/what forces are applied
- Weight is the gravitational force, equal to $W = mg$
- Center of mass is the "balance point" where many objects can be considered a single point mass

$$(x_{center}, y_{center}) = \left(\frac{m_1x_1 + m_2x_2 + \cdots}{m_1 + m_2 + \cdots}, \frac{m_1y_1 + m_2y_2 + \cdots}{m_1 + m_2 + \cdots}\right)$$

- Center of gravity is the same as the center of mass

Types of Force

- You only need to look at forces acting on your system
- Gravitational force: $W = mg$
- Electromagnetic force: only if there are charges/magnets (Lecture 7)
- Contact force: anything touching your system
  - Split into components parallel and perpendicular to your surface
  - Most contact forces are ONLY one of the above i.e. friction, normal force, etc.

Newton's Laws

Law of inertia - object at rest will stay at rest, object in motion will stay in motion unless outside net force acts on it

$F = ma$

For every action there's an equal and opposite reaction

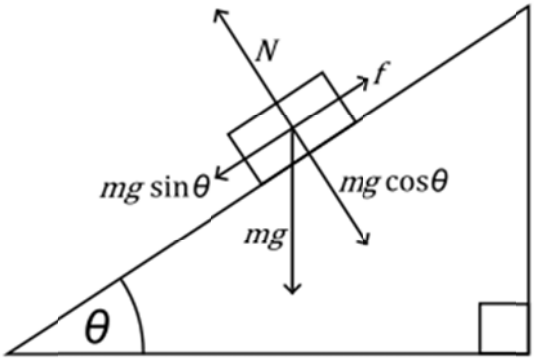
Law of Gravitation

$$F = G\frac{m_1m_2}{r^2}$$

- Always points from one mass to another
- For two masses, there are two equal forces pointing in opposite directions

Inclined Planes

- Normal force: force of inclined plane pushing back against gravitational force
  - ALWAYS PERPENDICULAR TO THE SURFACE
  - $F_N = mg\cos\theta$
- Net force on object (in absence of friction): $F_{net} = mg\sin\theta$



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Centripetal Force

$$F_c = m\frac{v^2}{r}, \qquad a_c = \frac{v^2}{r}$$

- Deals with objects moving/spinning in circles
- Always points towards the center of the circle
- Always caused by another force
- THINGS IN ORBIT: set centripetal force = gravitational force

$$F_g = F_c$$
$$\frac{GMm}{r^2} = m\frac{v^2}{r}$$
$$v^2 = \frac{GM}{r}$$
$$v = \sqrt{\frac{GM}{r}}$$

- What does this mean?
  Orbit velocity depends ONLY on the mass of the Earth and the orbital radius, NOT the mass of the object →
  For any two objects, if they're orbiting at the same distance from the Earth, they're traveling at the same velocity

Frictional Force

$$f_s \leq \mu_s F_N, \qquad f_k = \mu_k F_N$$

- ALWAYS PARALLEL TO THE SURFACE
- Static friction f_s: when objects are not moving
- Kinetic friction f_k: when objects are sliding relative to each other
- Usually, $\mu_s > \mu_k$

Tension

- Equal and opposite forces on opposite sides of a rope
- Total tension is equal to the force at either end - NOT THEIR SUM!

Hooke's Law

$$F = -k\Delta x = -k(x_{stretched} - x_{natural})$$

- Force due to a compressed or stretched object (i.e. a spring)
- Force is always in the opposite direction of the displacement