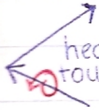
ive) in order
o add vectors



Relative Velocity

$\vec{V}_{AB} = \vec{V}_{AE} - \vec{V}_{BE}$; $\frac{\Delta \vec{r}_{AB}}{\Delta t} = \frac{\Delta \vec{r}_{AE}}{\Delta t} - \frac{\Delta \vec{r}_{BE}}{\Delta t}$

For any set of indices, $\vec{V}_{AB} = -\vec{V}_{BA}$

Isaac Newton (1642): early physicist

Classical Mechanics

Describes the relationship between the motion of objects in our everyday world and the forces acting on them

Conditions when CM doesn't apply: very tiny objects (< atomic sizes); objects moving near the speed of light

Newton's First Law

seems counter-intuitive

An object moves with a velocity that is constant in magnitude and direction, unless acted on by a non-zero net force

The net force is defined as the vector sum of all the external forces exerted on the object

Inertia

The tendency of an object to continue its original motion

Mass

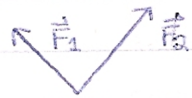
A measure of the resistance of an object to changes in its motion due to a force (you need more force for a heavier object than for a lighter one)

Scalar quantity

SI units are kg

Newton's Second Law

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass



$\Sigma \vec{F} = \vec{F}_1 + \vec{F}_2$

$\vec{a} = \Sigma \vec{F}/m$, or $\Sigma \vec{F} = m\vec{a}$, where F and a are both vectors

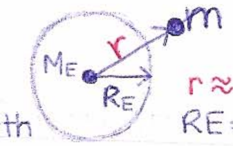
Units of Force

SI = Newton (N) = $1 \frac{kg\,m}{s^2}$ US Cust = pound (lb); 1N = .225 lb

$G = 6.67 \times 10^{-11}\,Nm^2/kg^2$

$g = G\dfrac{M_E}{R_E^2}$; $M_E = 5.98 \times 10^{24}\,kg$

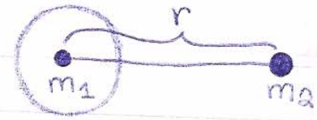
$g = 9.81\,m/s^2$



$F_g = G\dfrac{M_E \cdot m}{R_E^2} = m \cdot a = m \cdot g$

$r \approx R_E$ since m is close to E surface

$R_E = 6.38 \times 10^6\,m$



In this course we will use contact forces; F is the only exception

Gravitational Force

Mutual force of attraction between any two objects

Expressed by Newton's Law of Universal Gravitation: $F_g = G\dfrac{m_1 m_2}{r^2}$

Weight

The magnitude of the gravitational force acting on an object of mass m near the Earth's surface is called the weight w of the object

$w = mg$ is a special case of Newton's 2nd Law

g can also be found from the Law of Universal Gravitation (above)

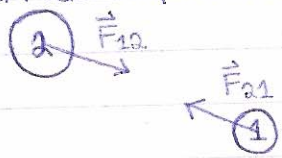
Newton's Third Law

If object 1 and object 2 interact, the force exerted on object 2 by object 1 is equal in magnitude but opposite in direction to the force exerted on object 1 by object 2

$\vec{F}_{12} = -\vec{F}_{21}$

Equivalent to saying a single isolated force cannot exist

The action and reaction forces act on different objects



Free Body Diagram

Must identify all the forces acting on the object of interest

Choose an appropriate coordinate system

Equilibrium

An object either at rest or moving with a constant velocity = in equilibrium

Net force acting on the object is zero $\Sigma \vec{F} = 0$

Easier to work in components

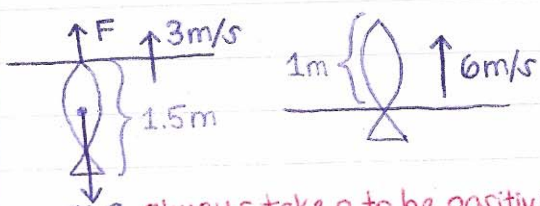
$\Sigma F_x = 0$ and $\Sigma F_y = 0$ (could be extended to 3D)

Multiple Objects – Example

When you have more than 1 object, the problem-solving strategy is applied to each object

- Draw free diagrams for each
- Apply Newton's Laws to each

Example 4-9



$m \cdot g$ always take g to be positive unless including direction

$\Delta y = 1m$, $v = 6m/s$, $v_0 = 3m/s$ } $v^2 = v_0^2 + 2a\Delta y$, $a = 13.5 m/s^2$ } $\Sigma \vec{F} = F - mg = m \cdot a$

$F = m(g + a)$

$= 61(9.81 + 13.5) = 1421.3N$