Topic 3A: Newton's Laws, Force Vectors and Equilibrium Equations

ΔV / a | t   Fnet / m | a   Δp / m | ΔV   Δp = J   J / Fnet | t

Skill 20: Inertia, Momentum, Impulse, Newton's Laws

Force is a push or pull due to interactions (contact or fields) between two objects. Force is a vector quantity, measured in Newtons

$1 \text{ Newton} = 1 \, kg \, m/s^2$ (units)

Mass is measured in kg
Weight is force due to gravity measured in Newtons

Newton's Laws of Motion summarize how objects interact

1st Law – Objects remain in motion, or at rest, unless acted upon by an unbalanced force. [remain in constant, straight line motion; or rest]

AKA "Law of INERTIA"

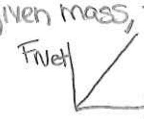
→ ie; Objects do NOT speed up slow down or change direction unless they ← experience a net Force (F_{Net})

For linear motion

Inertia - the tendency of an object to keep doing the same thing - INERTIA IS MASS in quantitative problems

2nd Law - For any given mass, the acceleration is directly related to the net force.

$F_{Net} = ma$



Direct relationship

$\frac{\Delta y}{\Delta x} = \frac{F_{Net}}{a} = \text{mass} \rightarrow$ slope (constant)

If $F_{Net} = 0$ then $a = 0$ [equilibrium]

If F_{Net} is positive, acc is positive } right, up

If F_{net} is negative, acc is negative } left, down

Main idea { WHATEVER HAPPENS to NET FORCE HAPPENS TO ACCELERATION (And Vice Versa)

If F_{NET} is zero, acc is zero; If F_{NET} is constant, acc is constant

3rd Law - For every force, there exists an equal and opposite force (Regardless of difference in objects)

Note: The resulting accelerations are a function of mass and therefore only equal for interactions between two objects of equal mass

The Earth & Moon exert equal force on each other but the Moon's small mass causes circular orbit around Earth

Momentum (symbolized by "p") is a measure of mass & velocity. $p = mv$ (vector)

Change in momentum (Δp) is a change in velocity during a time interval (ie an acceleration) which requires a F_{net} applied for a time: AKA an IMPULSE symbolized by "J" (vector)

Change in momentum is Impulse (J)

$\Delta p = J$

$m \Delta v = F_{net} t$ ☆

$\Rightarrow F_{Net} = \frac{m \Delta v}{t} \Rightarrow F_{Net} = ma$

When time of interaction ☆ changes, the impulse and momentum does not change → the size of the net Force changes

units
$kg \cdot m/s = N \cdot s$
$= kg \frac{m}{s^2} \cdot s$
$= kg \, m/s$

$\Rightarrow$ $F_{Net} = \frac{\Delta p}{t}$ or $F_{Net} = \frac{J}{t}$

Net force is the rate of change in momentum or impulse

F_{Net} and t are inversely related for a constant Δp

REVIEW SKILLS 9 & 12 for Kinematic graphs for Constant acc & equilibrium dvst, vvst, avst

Net force is ma or rate of change in momentum

$F_{net} = ma = \frac{m \Delta v}{t} = \frac{\Delta p}{t}$