Force and Laws of Motion

✓ push & pull, pressing, lifting, stretching are effects

→ Force is an external agent or cause capable of changing the state of rest or motion of a particular body once applied on it

Eg - lifting a weight; stretching a Rubber band; Pressing a button

Force is a vector qty

Types of forces

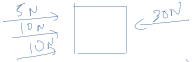
Resultant/net force :- Summation of all the forces being applied on the body.

Balanced forces :- If the resultant of all the forces acting on a body is zero, the forces are called balanced force.

Unbalanced forces :- If the resultant forces acting on the body is not zero, the forces are called unbalanced force.

Q. Type of force resultant acts direction

Rf : 30+20 - 40
= 50 - 40 = 10N



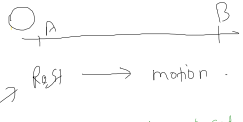
Rf : (5+10+10 - 30) = -5N

2) Find the value of x in the balanced force system.

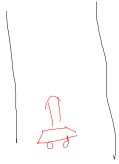
3) Find the value of x if system is an unbalanced force system, with resultant force equal to 23 units towards left

10 + 2x - 46 = -23
2x - 36 = -23
2x = 13
x = 13/2 = 6.5

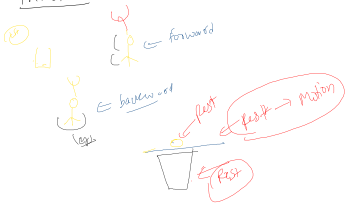
Newton's 1st law of motion



→ A body at rest will remain at rest and a body in motion will continue in motion in a straight line with a uniform speed, unless it is compelled by an external unbalanced forces to change its state of rest or of uniform motion.



Inertia



The tendency of a body due to which it resists a change in its state of rest or of uniform motion.

→ Why it is recommended to wear Seat belt in the car ? & if you wear & if you don't what will be the consequences ?

6.20

✓ Greater the inertia of a body, greater will be the force required to bring a change in its state of rest or of motion.

✓ Heavier the body, the more will be its inertia.

Law : The rate of change of momentum of a body is directly proportional to the applied force, and takes place in the direction in which the force acts.

Momentum

Force required to move big rock >>> wooden block.

$F \propto m$

$m\uparrow$ $F\uparrow$

Tennis ball → throwing of ball through hand → $V\uparrow$ (↙ mass of the ball remain same)
tennis Racket hit the ball → $V\uparrow\uparrow$

$F \propto V$

$$F \propto mV$$

✓ $F \propto P$ (momentum)

Momentum : Momentum is defined of a body as the product of its mass & velocity.

✓ It is a vector quantity.

✓ SI unit - $kg\,ms^{-1}$

Q) What is the p of a man of m 75000 gm when he walks with a uniform velocity of 18 Km/hr.

Velocity = ms^{-1}
momentum = $kg\,ms^{-1}$

(5:35)

$m = 75000\,gm$
$m = 75\,kg$
$V = 18\,Km\,h^{-1} = \frac{18 \times 5}{18} = 5\,ms^{-1}$

ms^{-1} ∴ $\frac{18\,Km}{1\,hr} = \frac{18 \times 1000\,m}{60\,min \times 60\,sec}$

$P = 75 \times 5 = 375\,kg\,ms^{-1}$

Q An object's momentum is 80 $Kg\,ms^{-1}$ & its mass is 16000g, Find the velocity of object.

$kg\,ms^{-1} \rightarrow P = mV$

$80 = \frac{16000}{1000}\,kg \times V$

$\frac{80}{16} = V$; $5\,ms^{-1}$

Q Calculate momentum

i) A truck of mass 2000kg moving at $5\,ms^{-1}$
ii) A bullet of mass 0.02kg " at $400\,ms^{-1}$.

$m \times v$

4000×2

8m

Q What is the change in momentum of a car weighing 1500kg when its speed increases from 36 Km/hr to 72 Km/hr uniformly.

$\Delta V = V_F - V_i$

$\frac{72 \times 5}{18} = 20$

$\Delta P = mV_F - mV_i$
$= m(V_F - V_i)$
$= 1500(20 - 10) = 15000\,kg\,ms^{-1}$

Newton's Second law of Motion

$$F \propto \frac{1}{t}$$

Case-I : $U = 0$, 2 Kg, $V = 5\,m/s$

$\Delta P = P_F - P_i$
$= mV - mU$
$= m(V - U)$
$= 2(5 - 0)$
$= 10\,kg\,ms^{-1}$

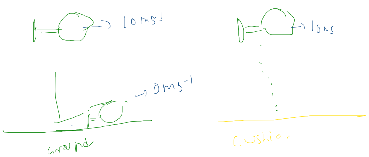
Case-II : $U = 0$, 2kg, $V = 10\,m/s$

More force applied → $20\,kg\,ms^{-1}$

$2(10 - 0)$
$= 20\,kg\,ms^{-1}$

$F \propto$ change in momentum

More the force more will be change in momentum.



✓ Change in momentum ∝ Force.

$F \propto \frac{1}{T}$

Time ↓ change in momentum ↑ Force ↑
Time ↑ Change in momentum ↓ Force ↓

$$F \propto \frac{1}{t}$$

t = time at which momentum velocity change.

$F \propto \frac{P}{t}$

$F \propto \frac{m(v-u)}{t}$ $\left(a = \frac{v-u}{t}\right)$

$F \propto ma$

$F = Kma$ (K = proportionality constant i.e. value of K in SI units 1.)

Force = mass × accⁿ

Newton's 2nd law of motion Numericals

1) What force would be needed to produce an acc^n of 6 m/s^2 in a ball of mass 4 kg?

→ $a = 6\ m/s^2$
$m = 4\ kg$
$F = ?\ N$

2) What is the acc^n produced by a force 34 N exerted on an object of mass 17000 g?

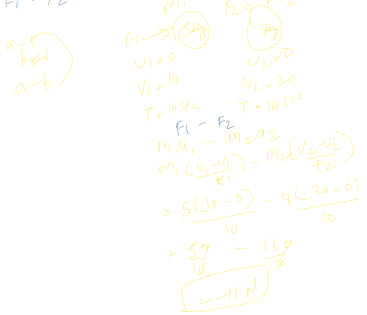
→ $F = ma$ (Newton's 2nd law)

$34 = 17 \times a$

$17000\ g = 17\ kg$ (1000 g = 1 kg)

$a = \frac{34}{17} = 2\ ms^{-1}$

Q Two objects of mass 5 kg and 8 kg are at rest. F_1 & F_2 are the forces applied on the both, if the speed of both the objects after 10 seconds become 10 ms^{-1} & 20 ms^{-1}, find the value of $F_1 - F_2$.

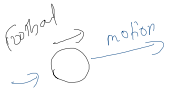


Q Calculate the force required to impart to car a velocity of 30 ms^{-1} in 10 sec starting from rest, the mass of the car 15×10^5 g.

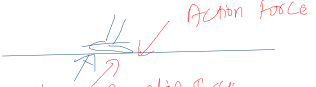
→ $u = 0$ $v = 30\ ms^{-1}$
$t = 10$ sec
$m = \frac{15 \times 10^5\ g}{1000}$
$m = 1500\ kg$

$F = ma$
$= m\left(\frac{v - u}{t}\right)$
$= 1500\left(\frac{30 - 0}{10}\right)$
$= 4500\ N$

Newton's 3rd law of motion.



Q When you are walking?



Swimming

→ Whenever one body exerts a force on another body, the second body exerts an equal & opposite force on the first body.

→ Force exerted by first body is action

→ Force " " second " is reaction.

→ Every action has an equal & opposite reaction.