

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

বিস্মিল্লাহির রাহমানির রাহীম



উদ্দান

একাডেমিক এন্ড এডমিশন কেয়ার

Class: 9 Physics (Chapter: 03)

Force

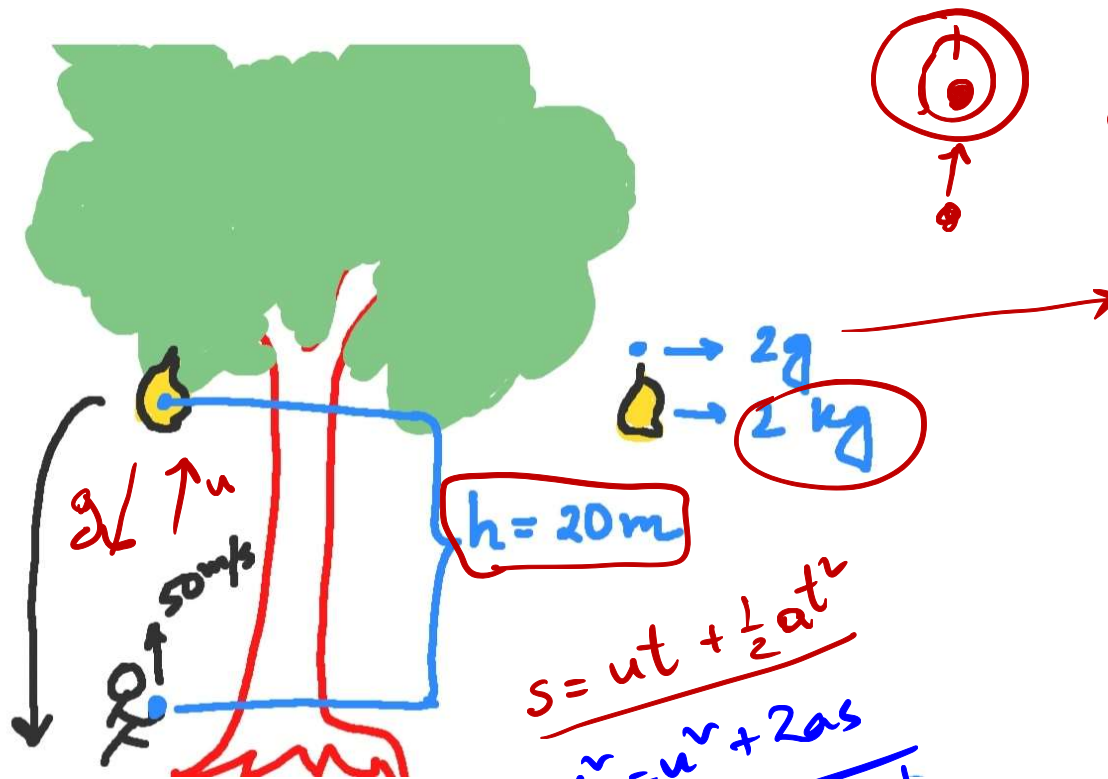
Lecture: P-07

Special Math of Combined Object

What will be the velocity of the Combined Object?

$$v_1 = v_2 = v$$

From, Lecture-2



conservation law of momentum
object $\rightarrow$ ol mango $\rightarrow$ ol

$$m_1 = 2\text{gm} = 0.002\text{kg}$$

$$m_2 = 2\text{kg}$$

$$u_2 = 0\text{ms}^{-1}$$

$$\rightarrow u_1 = 45.9\text{ms}^{-1} \uparrow$$

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2) v$$

$$0.002 \times 45.9 + 0 = 2.002 v$$

$$s = ut + \frac{1}{2} at^2$$

$$v^2 = u^2 + 2as$$

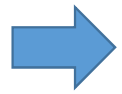
$$v = \sqrt{u^2 - 2gh}$$

$$= \sqrt{50^2 - 2 \times 9.8 \times 20} = 45.9\text{ m/s}$$

$$v = 0.04585\text{ms}^{-1}$$

upwards

Solve it



$$v_1^2 = u^2 - 2gh$$

$$\Rightarrow v_1^2 = (50)^2 - 2 \times 9.8 \times 20$$

$$\rightarrow v_1 = 45.91 \text{ m} \quad [m_1 = \text{mango}]$$

$$m_2 = \text{brick particle}]$$

Now,

$$m_1 u_1 + m_2 u_2 = (m_1 + m_2)v$$

$$\Rightarrow 2 \times 0 + 2 \times 10^{-3} \times v_1 = (2 + 2 \times 10^{-3})v$$

$$\Rightarrow 2 \times 10^{-3} \times 45.91 = (2 + 2 \times 10^{-3})v$$

$$v = 0.046 \text{ m/s (Ans.)}$$

(Effect of Force on Motion: Newton's 2nd Law)

➔ **Newton's 2nd Law:

The rate of change of momentum of a body is proportional to the applied force acting on it and the change of momentum also takes place in the direction in which the force acts.

$$\boxed{\vec{F} = m\vec{a}}$$

$$\rightarrow \frac{mv - mu}{t}$$

$$a = \frac{v - u}{t}$$

$$F \propto \frac{mv - mu}{t}$$

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

$\downarrow$
 a



$$m = 1 \text{ kg}$$

$$a = 1 \text{ ms}^{-2}$$

$$F = 1 \text{ N}$$

$$\Rightarrow F \propto ma$$

$$\therefore \boxed{F = k \cdot ma}$$

definition:

If you apply a force on an object of 1 kg and it gains the acclⁿ. 1 ms⁻² then the amount of applied force is 1 N.

$$1 = k \cdot 1 \cdot 1 \rightarrow \boxed{k = 1}$$

$F = ma$

→ $F = ma$ Derivation:

Newton's Second law:

Object's mass = m , Initial velocity = u

Final velocity = v , Time = t

∴ Change of momentum = Final – Initial = $mv - mu$

∴ Rate of change of momentum,

$$= \frac{mv - mu}{t} = m \left(\frac{v - u}{t} \right) = ma$$

From Newton's 2nd Law,

$$F \propto \frac{mv - mu}{t} \Rightarrow F \propto ma$$

So, $F = kma$ [k = proportionality constant]

Let, $k = 1$ [Simply considered as 1]

∴ $F = ma$. (Ans.)

Poll Question-01:

- A truck is moving at 10 m/s velocity. The sand from the truck is dropping at a rate of 2 kg/s What is the amount of force working on it?

- a) 20 kg m/s $\rightarrow$ momentum
- b) 20 kg m/s² $\rightarrow$ N
- c) 20 N s $\rightarrow$ ~~x~~
- d) i+ii

$$F = ma = m \frac{v-u}{t} = \frac{m \Delta v}{t}$$

$$= \frac{\Delta m \times v}{t}$$

$$= 2 \text{ kg s}^{-1} \times 10 \text{ ms}^{-1}$$

$$= 20 \text{ kg ms}^{-2}$$

ପ୍ରାରମ୍ଭ ଗତିଶୀଳତା, $\Delta v = v - u$

$v = 10 \text{ ms}^{-1}$

$\Delta \rightarrow$ ଅବିଚଳ

2 s $\rightarrow$ 20 kg ମାଟ୍ରିକ୍ସ 4 kg
 1 s " " " $\frac{4}{2} \text{ kg/s}$

$\left\{ \frac{\Delta m}{t} = 2 \text{ kg/s} \right.$

Force

→ Force:

Unit : $N/kgms^{-2}$ *Newton*

Dimension: $[F] = [MLT^{-2}]$ ✓

$$\begin{array}{l} F = ma \\ \downarrow \quad \downarrow \\ kg \quad ms^{-2} \\ \downarrow \quad \downarrow \\ kgms^{-2} \\ \downarrow \quad \downarrow \quad \downarrow \\ [MLT^{-2}] \end{array}$$

Mathematical Problem

Q. A force of 100N is applied on a stationary body of mass 5kg for 10s.

(a) $a = ?$

(b) After 10s $v = ?$

(c) After 20s $v = ?$

(d) What is the distance travelled in 20s?

(e) Draw v-t & s-t Graphs!

(a) $F = ma$

$$100 = 5a$$

$$\Rightarrow a = 20 \text{ ms}^{-2}$$

(b) $v_{10} = ?$

$$u = 0 \text{ ms}^{-1}$$

$$t = 10 \text{ s}$$

$$a = 20 \text{ ms}^{-2}$$

$$v = u + at$$

$$= 0 + 20 \times 10$$

$$= 200 \text{ ms}^{-1}$$

(d) $ab + bc = 3000 \text{ m}$

$$F = 100 \text{ N}$$

$$m = 5 \text{ kg}$$

$$t = 10 \text{ s}$$

(c)

after 10s Force applied on the body was zero. So there won't be any change in velocity

$$v_{20} = 200 \text{ ms}^{-1}$$

10s 10s

a ————— b ————— c

$$s = ut + \frac{1}{2}at^2$$

$$= \frac{1}{2}at^2$$

$$= \frac{1}{2} \times 20 \times 10^2$$

$$= 1000 \text{ m}$$

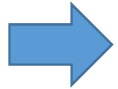
$$s = ut + \frac{1}{2}at^2$$

$$= 200 \times 10 + \frac{1}{2} \times 20 \times 10^2$$

$$= 2000 + 1000$$

$$= 3000 \text{ m}$$

Solution



(a) $a = \frac{F}{m} = \frac{100}{5} = 20 \text{ ms}^{-2}$

(b) v after 10s $\Rightarrow$

$$v = u + at = (0 + 20 \times 10)$$

$$= 200 \text{ m/s}$$

(c) 200m/s [As no force is applied after 10s]

(d) Distance travelled in 1st 10s $\Rightarrow$

$$s_1 = ut + \frac{1}{2} at^2$$

$$= \frac{1}{2} \times 20 \times (10)^2 = 1000m$$

Last 10 s $\Rightarrow$

$$S_2 = vt = (200 \times 10) = 2000m$$

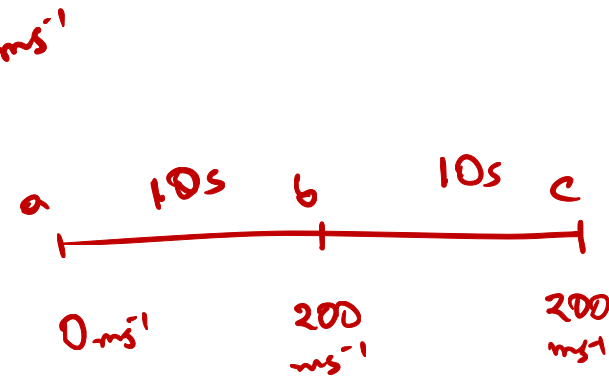
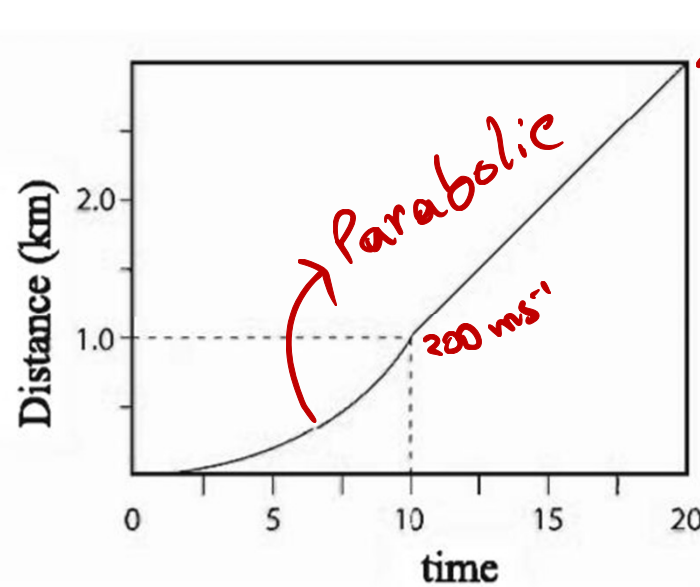
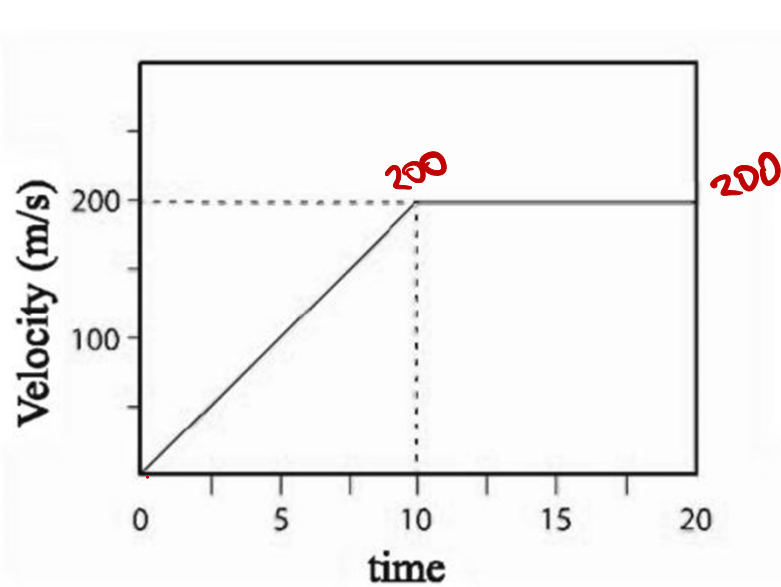
$$\therefore \text{Total, } s = s_1 + s_2$$

$$= (1000 + 2000)m$$

$$= 3000m.$$

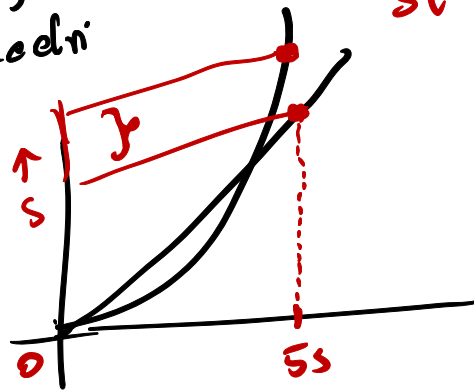
(e) Next Slide $\rightarrow$ Graph

Graph



$vt \rightarrow$ inclined line $\rightarrow$ uniform accn

$$a = \frac{\Delta v}{t} = \frac{200}{10} = 20 \text{ ms}^{-2}$$



$st \rightarrow$ inclined line $\rightarrow$ uniform velocity

5 ms^{-1}

$a = 1 \text{ ms}^{-2}$

1s $\rightarrow$ 5m
 2s $\rightarrow$ 5 + 5
 3s $\rightarrow$ 5 + 5 + 5

1s $\rightarrow$ 5m
 2s $\rightarrow$ 5 + 6
 3s $\rightarrow$ 5 + 6 + 7

Poll Question-02:

$$F = ma$$

Diagram showing the relationship between force, mass, and acceleration. The equation $F = ma$ is written. An arrow points from a to a circle containing "const.". Another arrow points from F to a circle containing "constant".

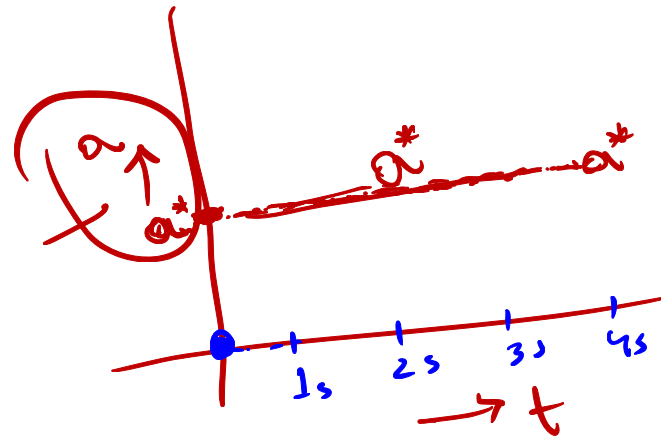
• A finite amount of force is being applied to a moving object. The shape of the "a" vs "t" Graph for this is:

• a) Inclined straight line

• b) Horizontal straight line ✓

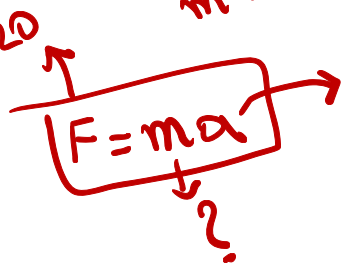
• c) Inclined curve

• d) Uniform curve



Solve it

Q. A force of 20N is applied on a stationary object for 10s and the object covered a distance of 100m. Mass =?

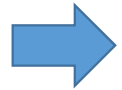
$$\begin{aligned} F &= 20 \text{ N} \\ u &= 0 \text{ ms}^{-1} \\ t &= 10 \text{ s} \\ s &= 100 \\ m &= ? \end{aligned}$$


$$\begin{aligned} s &= ut + \frac{1}{2}at^2 \\ 100 &= 0 \times t + \frac{1}{2}a \times 10^2 \\ 100 &= a \cdot 50 \\ \therefore a &= 2 \text{ ms}^{-2} \end{aligned}$$

$$\begin{aligned} F &= ma \\ \Rightarrow 20 &= m \cdot 2 \\ \Rightarrow m &= 10 \text{ kg} \end{aligned}$$

(Ans.)

Solution:



Given,

$$F = 20N$$

$$t = 10s$$

$$s = 100m$$

Now,

$$s = ut + \frac{1}{2}at^2$$

$$\Rightarrow 100 = 0.5 \times a \times (10)^2$$

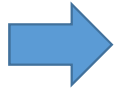
$$\Rightarrow a = 2 \text{ m/s}^2$$

Again,

$$F = ma$$

$$\Rightarrow m = \frac{F}{a} = \frac{20}{2} = 10kg. \text{ (Ans.)}$$

Gravitational Force & Gravity



Gravitational force $\Rightarrow$



$$F = \frac{Gm_1m_2}{d^2}$$

Here, G = Gravitational Constant

Gravity $\Rightarrow$



So, $F = \frac{GMm}{R^2}$

Here, $M = 5.98 \times 10^{24} \text{ kg}$

$R = 6.37 \times 10^6 \text{ m}$

$G = 6.673 \times 10^{-11} \text{ Nm}^2\text{kg}^{-2}$

$$F = \frac{Gm_1m_2}{d^2}$$

d
distance of the point mass

④ Suppose two objects having mass of 1 kg and they have a distance of 1 m. Then the gravitational Force acting on them is $6.673 \times 10^{-11} \text{ N}$

$$F \propto m_1m_2$$

$$F \propto \frac{1}{d^2}$$

$$F \propto \frac{m_1m_2}{d^2}$$

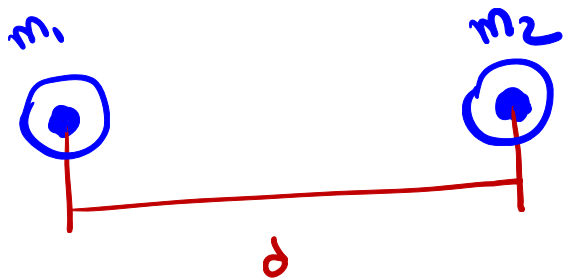
$$F = G \frac{m_1m_2}{d^2}$$

$$F = \frac{Gm_1m_2}{d^2} = G \frac{1 \cdot 1}{1^2}$$

$$\Rightarrow F = G \Rightarrow 6.673 \times 10^{-11} = G$$

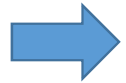
Poll Question-03:

- Two same spherical objects keeping their mass unchanged but, their radii have been increased two times. The new attraction force between them is :
 - a. 4 times increased
 - b. 2 times increased
 - c. 1.41 times increased
 - d. Unchanged ✓



radius change 21213
center change 21213

G (gravitational constant)



Gravitational Constant $\Rightarrow$

$$\Rightarrow F = \frac{Gm_1m_2}{d^2}$$

$$\Rightarrow G = \frac{Fd^2}{m_1m_2}$$

$\therefore$ Unit of G: Nm^2kg^{-2}

$\therefore$ Dimension:

$$\rightarrow Nm^2kg^{-2}$$

$$\rightarrow kgms^{-2}m^2kg^{-2}$$

$$\rightarrow kg^{-1}m^3s^{-2}$$

$$\therefore [G] = [M^{-1}L^3T^{-2}].$$

$$\begin{aligned} N m^2 kg^{-2} \\ kg ms^{-2} m^2 kg^{-2} \\ kg^{-1} m^3 s^{-2} \\ \downarrow \\ M^{-1} L^3 T^{-2} \end{aligned}$$

$$g = GM/R^2$$

➔ Proof that, $g = GM/R^2$:

$$\begin{aligned}
 &g = \frac{GM}{R^2} \\
 &W = mg \\
 &F = \frac{GMm}{R^2} \\
 &\downarrow \\
 &\cancel{mg} = \frac{\cancel{GMm}}{R^2} \\
 &g = \frac{GM}{R^2}
 \end{aligned}$$

Gravitation of the Earth $\Rightarrow$ $M = \text{mass of earth}$
 $m = \text{object mass}$

$$F = \frac{GMm}{R^2} \dots \dots \dots (i)$$

Also we know $\Rightarrow$

Gravitation of the earth = Weight of the object

So,

$$F = W = mg \dots \dots \dots (ii)$$

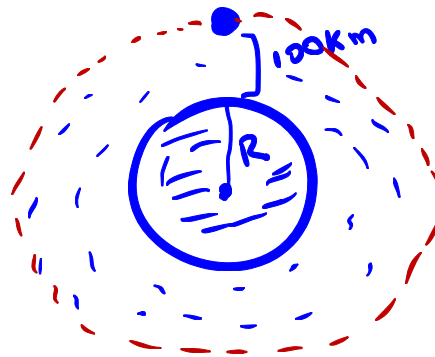
From (i) & (ii) $\Rightarrow$

$$GMm/R^2 = mg$$

$$\Rightarrow g = \frac{GM}{R^2}. \text{ (Showed)}$$

Mathematical Problems

Q. The height of the spaceship from the Earth's Surface is 100km, Value of g there=? ($h=100\text{ km}$)



$M_{\text{Earth}} = 6 \times 10^{24} \text{ kg}$
 ~~$M_{\text{air}} = 2000 - 3000 \text{ kg}$~~

$g = 9.80665 \text{ ms}^{-2}$
 $\uparrow g' = 9.47645 \text{ ms}^{-2}$

$R = 6400 \text{ km}$
 $g = \frac{GM}{R^2}$
 Total mass with the radius
 distance from the center
 $(R+h)$

$g' = \frac{GM}{(R+h)^2}$
 $= \frac{6.673 \times 10^{-11} \times 6 \times 10^{24}}{(6.5 \times 10^6)^2}$
 $= 9.47645 \text{ ms}^{-2}$

Solution

➡ We know $\Rightarrow$

$$g = GM/R^2$$

$\therefore$ At h height,

$$g' = \frac{GM}{(R+h)^2} \rightarrow \text{ପ୍ରଶ୍ନ ୨}$$

$$= \frac{GM}{\left\{R\left(1+\frac{h}{R}\right)\right\}^2}$$

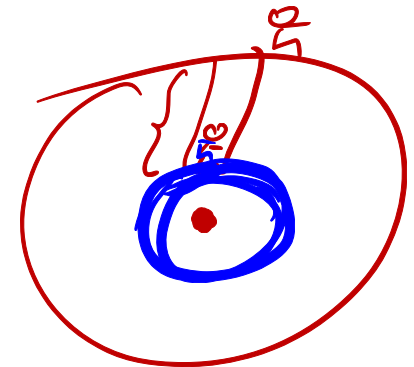
$$= \frac{GM}{R^2} \times \frac{1}{\left(1+\frac{h}{R}\right)^2}$$

$$= g \times \frac{1}{1.03}$$

$$= 9.8 \times \frac{1}{1.03} = 9.48 \text{ms}^{-2}. (\text{Ans.})$$

Poll Question-04:

- If a man goes inside a mine, then the distance between him and the center of earth decreases. So the force between them will :
 - A) Increase
 - B) Decrease ✓✓
 - C) Unchanged
 - ~~D) The mass of the man will decrease~~ but the attraction will increase

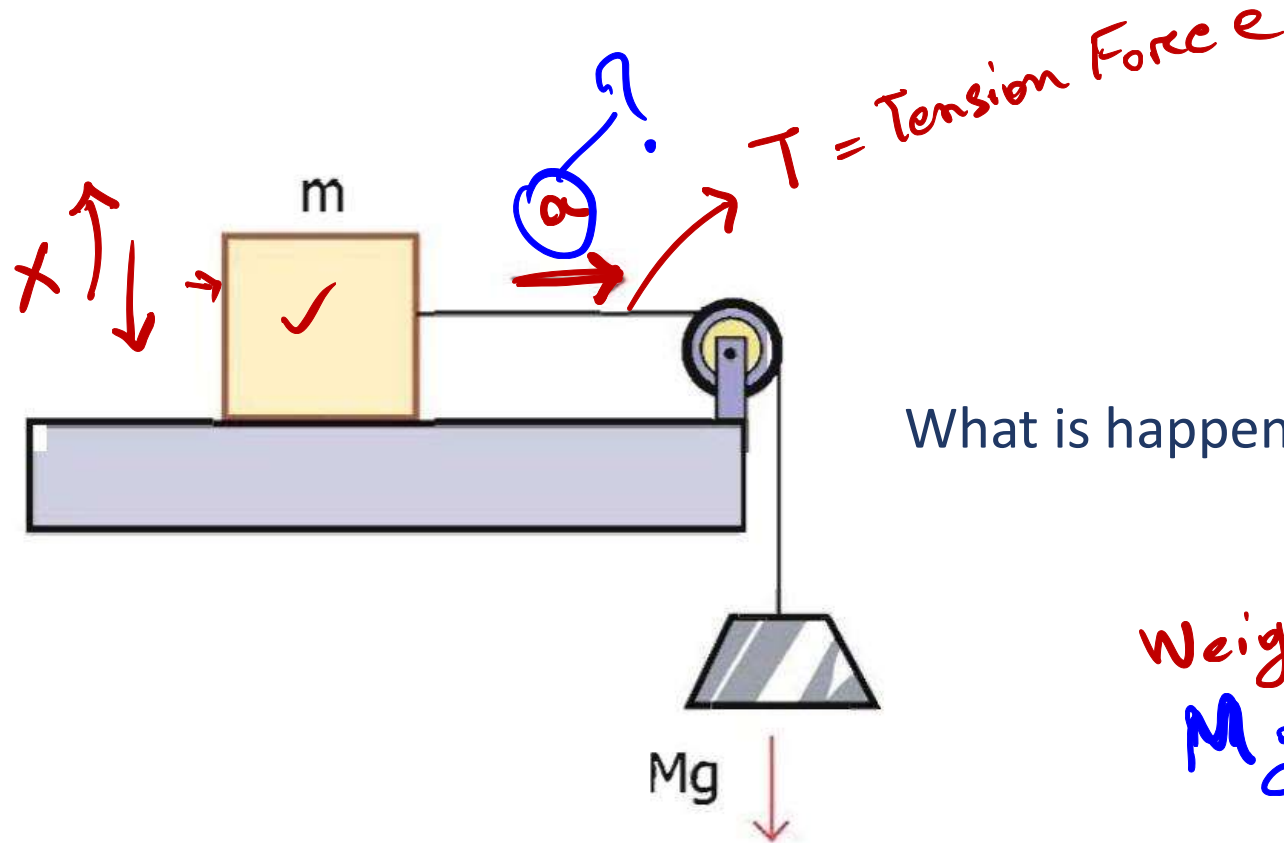


$$F = \frac{GMm}{d^2}$$

$$d \downarrow \Rightarrow F \uparrow$$

$$GM \rightarrow F \downarrow \downarrow$$

Extra



What is happening here?

Weight = Tension Force

$$Mg = ma$$
$$a = \frac{Mg}{m}$$

$$\mathbf{F = Mg}$$

.....

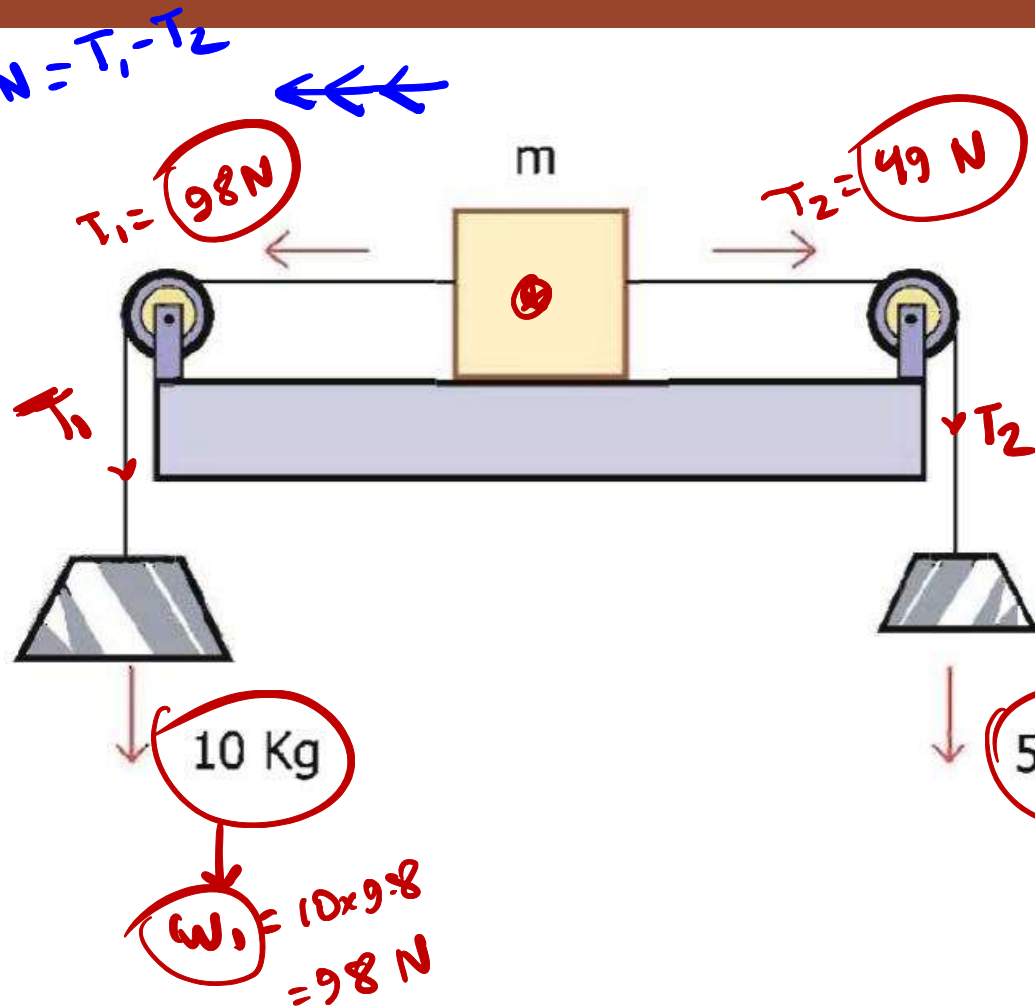
$$F = Mg$$

So, 1st Object $\Rightarrow$

$$a = \frac{F}{m}$$

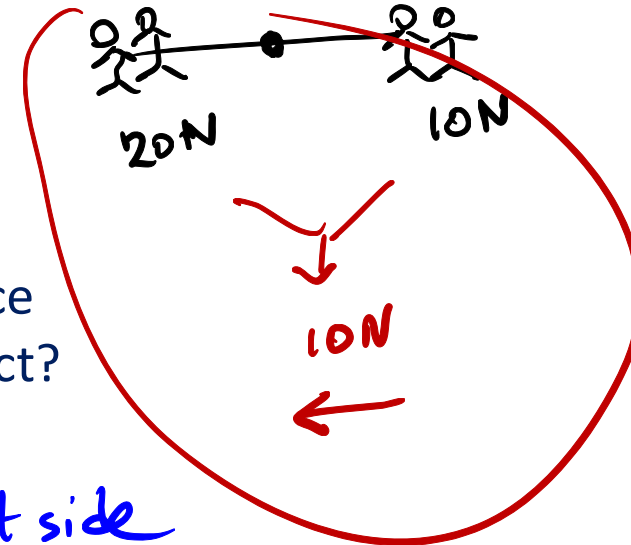
$$\therefore a = \frac{Mg}{m}$$

Mathematical Problems

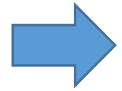


Q. What is the force acting on the object?

49 N
on the left side



Solution



$$[\because F = ma]$$

For 10 kg object $\Rightarrow$

$$F_1 = (10 \times 9.8) = 98N$$

For 5 kg object $\Rightarrow$

$$F_2 = (5 \times 9.8) = 49N$$

So, As figure $\Rightarrow$

$$\begin{array}{cc} \overleftarrow{\hspace{1cm}} & \overrightarrow{\hspace{1cm}} \\ 98N & 49N \end{array}$$

$\therefore$ Resultant $\Rightarrow$

$$\overleftarrow{\hspace{1cm}} \text{ (Ans.)} \\ 49N.$$

Poll Question-05:

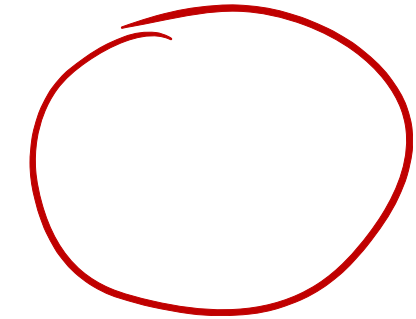
weight = gravitational
Force

$$g = \frac{GM}{R^2}$$

• If two objects have same weights. Then we can say:

- ~~A) Their masses are obviously same~~
- B) The attraction of earth to them are obviously same
- ~~C) The amount of 'g' acting on them is obviously same~~
- ~~D) All~~

$100N \rightarrow 9.7ms^{-2}(g)$
 $100N \rightarrow 9.6ms^{-2}(g)$



$w = mg$
(m) same hence na

লেগে থাকো সৎভাবে,
স্বপ্ন জয় তোমারই হবে

D™ ¢vm-D#b¥I শিক্ষা
পরিবার

Thank You