04/08/2021
Wednesday

MODULE - 4

RECTILINEAR TRANSLATION

- Velocity $v = \frac{dx}{dt}$

- accelaration $a = \frac{d^2x}{dt^2} = \frac{dv}{dt}$

EQUATION OF KINEMATICS

$$\boxed{\begin{aligned} &\bullet\ v = u + at \\ &\bullet\ v^2 = u^2 + 2as \\ &\bullet\ s = ut + \tfrac{1}{2}at^2 \end{aligned}}$$

a = accelaration (m/s^2)
t = time
v = final velocity (m/s)
u = initial velocity (m/s)
s = distance

(a) For a freely falling body

$v = u + gt$
$v^2 = u^2 + 2gh$
$h = ut + \frac{1}{2}gt^2$

(b) When a particle moves upward

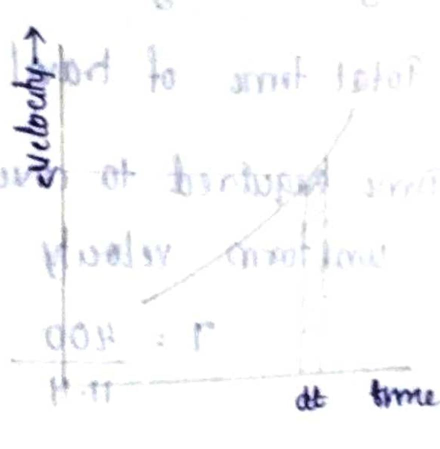
$v = u - gt$
$v^2 = u^2 - 2gh$
$h = ut - \frac{1}{2}gt^2$

VELOCITY-TIME CURVE

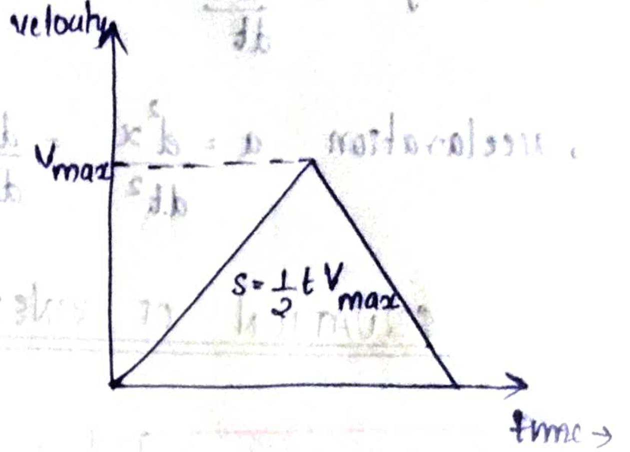
x axis → time   y-axis → velocity

area under v-t curve → displacement.

slope of v-t curve → accelaration.



① A train travels b/w 2 stopping stations, 7 m apart in 14 min. Assuming that its motion is one of uniform accelaration for part of the journey and uniform retardation for the rest, prove that the greatest speed on the journey is 60 km/hr.



$S = 7km \qquad u = 0$

$t = 14 \text{ min} = \left(\frac{14}{60}\right) hr$

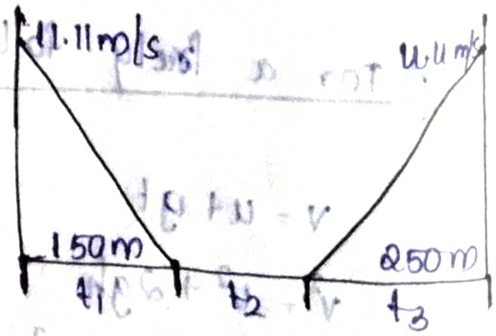
$S = \frac{1}{2} t V_{max}$

$V_{max} = \frac{S \times 2}{t} = \frac{7 \times 2 \times 60}{14} = \underline{60 \text{ km/hr}}$

05/08

② A car travelling at 40 kmph sights a distant signal at 150m and comes uniformly to rest at the signal. It remains at rest for 20s. As allowed by the signal, it uniformly accelarate and attain 40 kmph in 250m. Calculate the time lost due to signal.

From velocity-time graph



$150 = \frac{1}{2} \times t_1 \times 11.11$

$t_1 = \frac{300}{11.11} = 27s$

$t_2 = 20s$

$t_3 \quad 250 = \frac{1}{2} \times t_3 \times 11.11 \Rightarrow t_3 = \frac{500}{11.11} = 45s$

Total time of travel $= t_1 + t_2 + t_3 = 27 + 20 + 45 = \underline{92s}$

Time required to cover a distance of (150 + 250m) = 400m with a uniform velocity of 11.11 m/s

$T = \frac{400}{11.11} = \underline{36s}$

Time lost due to signal

$(t_1+t_2+t_2) - T = 92 - 36 = \underline{56 s}$

③ The motion of a particle along a straight line is defined as $S = 25t + 5t^2 - 2t^3$, where S is in metres and t in second.

Find (i) velocity and accelaration at the start.

(ii) the time the particle reaches maximum velocity

(iii) the maximum velocity of the particle

$S = 25t + 5t^2 - 2t^3$

Velocity $V = 25 + 10t - 6t^2$

Accelaration $a = 10 - 12t$

(i) At $t = 0$,

$V = 25 + 0 - 0 = \underline{25 \text{ m/s}}$

$a = 10 - 0 = \underline{10 \text{ m/s}^2}$

(ii) At maximum velocity, $\frac{dV}{dt} = 0$ i.e, $a = 0$

$0 = 10 - 12t$

$12t = 10 \Rightarrow t = \frac{10}{12} = \underline{0.83 s}$

(iii) The maximum velocity of the particle at $t = 0.83 s$

$\therefore V_{max} = 25 + 10 \times 0.83 - 6 \times 0.83 \times 0.83$

$= 25 + 8.3 - 4.13 = 25 + 4.17$

$= \underline{29.17 \text{ m/s}}$

H.W

(4) The displacement of a particle is given by $s = t^3 - 3t^2 + 2t + 5$. Find the time at which the accelaration is zero and the time at which velocity is 2m/s.

$$s = t^3 - 3t^2 + 2t + 5$$

(i) $\frac{dv}{dt} = a = 0$;

$$a = \frac{d^2 s}{dt^2} = \frac{d}{dt}(3t^2 - 6t + 2) = 6t - 6$$

$$a = 0$$

$$0 = 6t - 6 \Rightarrow 6t = 6 \Rightarrow \underline{t = 1s}$$

(ii) Time at which $v = 2m/s$

$$v = 3t^2 - 6t + 2$$

$$2 = 3t^2 - 6t + 2 \Rightarrow 3t^2 - 6t = 0$$

$$3t^2 = 6t \Rightarrow \underline{t = 2s}$$

H.W

(5) A point is moving in a straight line with accelaration given by $a = 15t - 20$. It passes through a reference point at $t = 0$ and another point 30m away after an interval of 5 seconds. Calculate the displacement, velocity and accelaration of the point after a futher interval of 5 seconds.

$a = 15t - 20$; at $t = 0$, $s = 0$, at $t = 5$, $s = 30m$

$$a = \frac{dv}{dt} = 15t - 20$$

$$v = \int \frac{dv}{dt} = \frac{15t^2}{2} - 20t$$

$$v = \frac{ds}{dt} = 7.5t^2 - 20t + C_1$$

$$S = \int (7.5t^2 - 20t + C_1) \cdot dt$$

$$= \frac{7.5t^3}{3} - \frac{20t^2}{2} + C_1 t + C_2$$

$$= 2.5t^3 - 10t^2 + C_1 t + C_2$$

At $t=0$, $S=0$,

$$0 = 0 - 0 + 0 + C_2$$

$$\therefore \quad C_2 = 0$$

At $t=5$, $S = 30m$ (1)

$$30 = 2.5 \times 5^3 - 10 \times 5^2 + C_1 \times 5 + 0$$

$$30 = 2.5 \times 125 - 10 \times 25 + C_1 \times 5$$

$$30 = 312.5 - 250 + 5C_1$$

$$30 = 62.5 + 5C_1$$

$$5C_1 = 32.5$$

$$C_1 = -6.5$$

Displacement, velocity and accelaration at the end of 10s

$$S = 2.5t^3 - 10t^2 - 6.5t$$

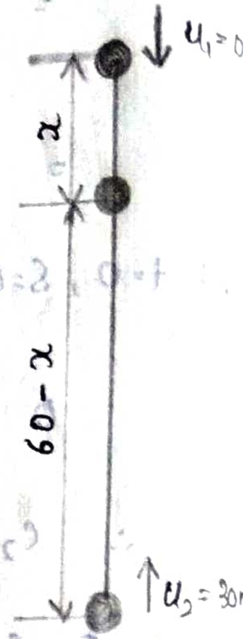
$$= 2.5 \times 10^3 - 10 \times 10^2 - 6.5 \times 10$$

$$= 2500 - 1000 - 65 \qquad = \underline{1435\,m}$$

Velocity $V = 7.5t^2 - 20t - 6.5 = 7.5 \times 10^2 - 20 \times 10 - 6.5 = \underline{543.5\,m/s}$

Accelaration $a = 15t - 20 = 15 \times 10 - 20 = \underline{130\,m/s^2}$

⑥ A stone is dropped from the top of a tower, 60 m high. At the same time another stone is thrown upwards from the foot of the tower with a velocity of 30 m/s. When and where does the two stones cross each other?



Height of tower $h = 60\,m$

$u_1 = 0$, $u_2 = 30\,m/s$

$t_1 = t_2 = t$

Let x be the distance from the top of the tower where the two stone cross each other.

$$x = u_1 t + \frac{1}{2}gt^2 = 0 + \frac{1}{2}gt^2 \quad \text{--- (1)}$$

$$60 - x = u_2 t - \frac{1}{2}gt^2 \quad \text{--- (2)}$$

Adding equations (1) and (2)

$$60 = u_2 \times t$$

$$t = \frac{60}{30} = 2\,s$$

$$x = u_1 t + \frac{1}{2}gt^2$$

$$= 0 + \frac{1}{2} \times 9.81 \times 2^2 = 9.81 \times 2 = 19.62\,m$$

The two stones will cross each other at a distance of 19.62 m from the top of the tower after 2 seconds.

KINETICS

Three approaches to solution of problems in kinetics

1. Direct application of Newton's Second Law.
2. Use of Work-energy Principle.
3. Solution by Impulse and Momentum.

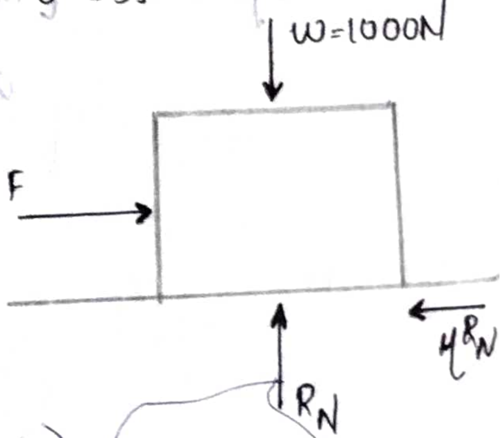
DIRECT APPLICATION OF NEWTON'S SECOND LAW

- Force is directly proportional to the product of mass and accelaration.
- Newton's law reduces to $F = m \times a$.
- When a system of force acts on a body.

Resultant/Net force = (mass) x (Accelaration in the direction of resultant of force)

(1) A block weighing 1000N rest on a horizontal plane. Find the magnitude of the force required to give the block an accelaration of $2.5\ m/s^2$ to the right. The coefficient of kinetic friction b/w the block and the plane is 0.25.

$W = 1000N$, $a = 2.5\ m/s^2$, $\mu = 0.25$



Since there is no motion in the vertical direction,

Net force in the vertical direction = 0

$$R_N - W = 0$$

$$R_N = W = 1000\ N$$

Net force in the horizontal direction = $m \times a$

$$F - \mu R_N = m \times a$$

$$F - 0.25 \times 1000 = \frac{1000}{9.81} \times 2.5$$

$$F - 250 = 254.84$$

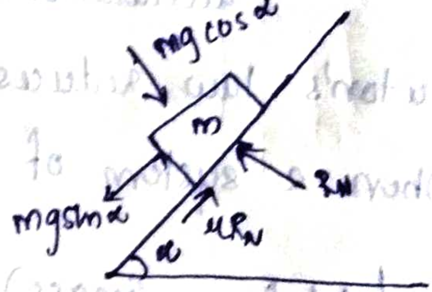
$$F = 254.84 + 250$$

$$\underline{F = 504.84}$$

11/08/21

8 A body of mass 50 kg slides down a rough inclined plane whose inclination to the horizontal is 30°. If $\mu = 0.4$, find a?

$m = 50\,kg \quad \alpha = 30^\circ \quad \mu = 0.4$



No motion in $\perp^r$ direction of inclined plane

$$R_N - mg\cos\alpha = 0$$

$$R_N = mg\cos\alpha$$

Net force along inclined plane

$$mg\sin\alpha - \mu R_N = ma \quad \Rightarrow mg\sin\alpha - \mu mg\cos\alpha = ma$$

$$a = g\sin\alpha - \mu g\cos\alpha$$

$$= 9.81 \sin 30 - 0.4 \times 9.81 \times \cos 30$$

$$\underline{= 1.51\ m/s^2}$$

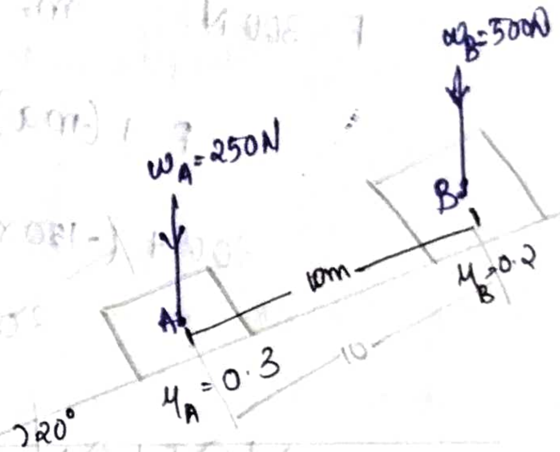
(9) Two blocks A and B are held stationary 10m apart on a 20° incline as shown. The coefficient of friction μ_A = 0.3 while it is 0.2 b/w plane B μ_B = 0.2. If blocks are released simultaneously, calculate the time taken & distance travelled by each block before they are at verge of collision.

Consider motion of block A

$$\boxed{\text{Net force} = m \times a}$$

$$m_A g \sin\theta - \mu R_{NA} = m_A a_A$$

$$m_A g \sin\theta - \mu m_A g \cos\theta = m_A a_A$$



$$250 \sin 20 - 0.3 R_{NA} = \frac{250}{9.81} a_A$$

$$250 \sin 20 - 0.3 \times 250 \times \cos 20 = \frac{250}{9.81} a_A$$

$$\underline{a_A = 0.59 \text{ m/s}^2}$$

Consider the motion of block B,

Net force = mass x accelaration

$$m_B g \sin\theta - \mu R_{NB} = M_B \times a_B \Rightarrow m_B g \sin\theta - \mu m_B g \cos\theta = m_B \times a_B$$

$$500 \sin 20 - 0.2 \times R_{NB} = \frac{500}{9.81} \times a_B \Rightarrow \underline{a_B = 1.51 \text{ m/s}^2}$$

Let x be the distance travelled by A in t seconds then the distance travelled by B in the same t second will be $(10+x)$

$$S_A = x = u_A t + \frac{1}{2} a_A t^2 \rightarrow x = 0 + \frac{1}{2} \times 0.59 \times t^2$$

$$S_B = 10 + x = 0 + \frac{1}{2} \times a_B t^2 = 0 + \frac{1}{2} \times 1.51 \times t^2$$

$$\therefore \underline{t = 4.66 s}$$

$$x = \frac{1}{2} \times 0.59 \times (4.66)^2 = \underline{6.41 m}$$

D'ALEMBERT'S PRINCIPLE :- application of Newton's law

The resultant of a system of force acting on a body in motion is in dynamic equilibrium with the inertia force.

(10) A force of 300 N acts on a body of mass 150 kg. Calculate the accelaration of the body using D'Alembert's Principle.

$F = 300\text{ N}$ $m = 150\text{ kg}$

$$\boxed{\begin{array}{l} F + (-ma) = 0 \\ (-ma) = \text{inertia force} \end{array}}$$

$$F + (-ma) = 0$$

$$300 + (-150 \times a) = 0$$

$$300 = 150a \Rightarrow \underline{a = 2\,m/s^2}$$

MOTION OF LIFT

- application of newton's second law.

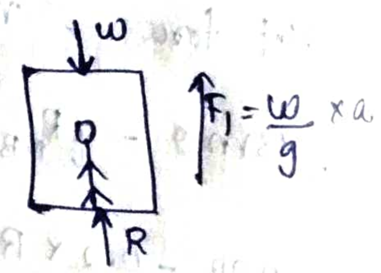
(a) Lift moving downwards

- a → downwards ; inertia of force → upwards.

$$R + F_1 - W = 0$$

$$R = W - F_1$$

$$= W - \frac{W}{g}a$$

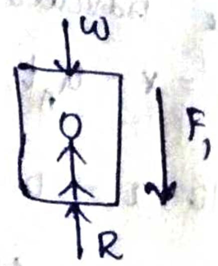


$$\boxed{R = W\left[1 - \frac{a}{g}\right]}$$

(b) Lift moving upwards

$$R - W - F_1 = 0$$

$$R = W + F_1$$



$$\boxed{R = W\left[1 + \frac{a}{g}\right]}$$

NOTES :-

- A lift moves with uniform velocity, the accelaration of lift is 0.
- when lift moves down with accelaration, man exerts less force on the floor of lift, and when lift moves up with accelaration, man exerts more force on the floor of lift.
- Direction of inertia force is opposite to direction of accelaration
  → when lift accelarates
- Direction of inertia force is same to direction of accelaration
  → when lift decelarates.

(11) A lift has an upward a. is $1.2 m/s^2$, what a force will a man weighing 750 N exert on floor of lift? what force would be exert if the lift had an accelaration of $1.2 m/s^2$ downwards what upward a would cause his weight to exert a force of 900N on the floor?

[KTU Jan 2016, June 2016, May 2019]

case (i)

when the lift moves upward $a = 1.2 m/s^2$ $W = 750 N$

$$R = W\left[1 + \frac{a}{g}\right] = 750\left[1 + \frac{1.2}{9.81}\right] = \underline{841.74 N}$$

case (ii)

when lift moving downwards

$$R = W\left[1 - \frac{a}{g}\right] = 750\left[1 - \frac{1.2}{9.81}\right] = \underline{658.26 N}$$

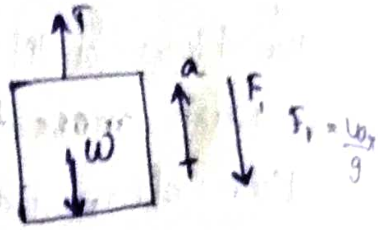
case (iii)

$W = 750N$ $R = 900N$

when lift moves up $R = W\left[1 + \frac{a}{g}\right]$ $\Rightarrow$ $900 = 750\left[1 + \frac{a}{9.8}\right]$

$$\frac{900}{750} = 1 + \frac{a}{9.8} \Rightarrow \underline{a = 1.96 m/s^2}$$

(12) An elevator of total weight 5000N starts to move upwards with a constant acc of $1 m/s^2$. Find the force in the cable during the accelaration motion. Also find the force at the accelaration elevator under the feet of a man weighing 600N when the elevator moves up with a uniform retardation of $1 m/s^2$.



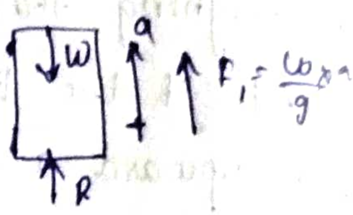
case (i) Elevator moves upwards with accelaration

$$T - W - F_1 = 0$$

$$T = W + \frac{W}{g}a$$

$$T = W\left[1 + \frac{a}{g}\right] = 5000\left[1 + \frac{1}{9.81}\right] = \underline{5509.68N}$$

case (ii) Elevator moves up with uniform decelaration; mut a of force is upwards $W = 600N$



$$R + F_1 - W = 0$$

$$R = W - F_1 = W - \frac{W}{g}a$$

$$= W\left[1 - \frac{a}{g}\right] = 600\left[1 - \frac{1}{9.81}\right] = \underline{538.84N}$$

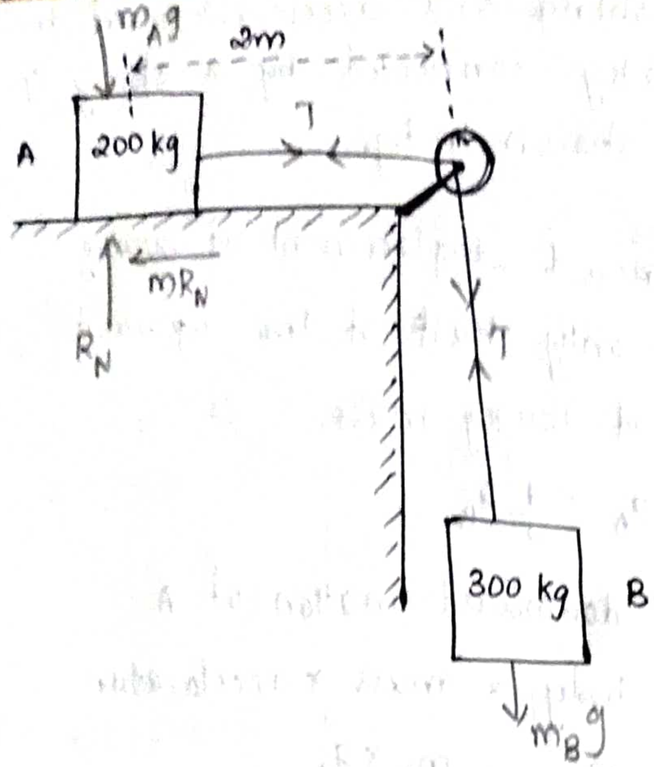
13/08/2021

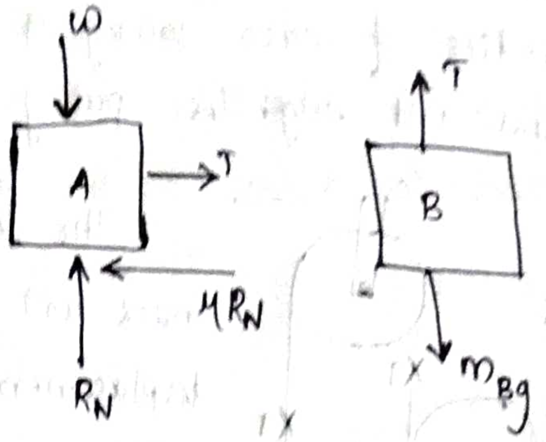
MOTION OF CONNECTED BODIES

Consider motion of each body seperately an apply Newton's Law of motion and find accelaration of the body and tension in the string.

- Force in the direction of motion = +ve
- Force in the opp. direction of motion = -ve.

(13) Two blocks are joined by an inextensible string as shown in the fig. If the system is released from rest, determine the velocity of block after it has moved 2m. Assume the coefficient of friction b/w block and plane is 0.25. The pulley is weightless and frictionless.





$m_A = 200\,kg$ • $m_B = 300\,kg$

$\mu = 0.25$

Let T be the tension in the string, since $x_A = x_B$

Consider the motion of block A,

$$\text{Net force} = \text{mass} \times \text{accelaration}$$

$$T - \mu R_N = m_A \times a$$

$$T - 0.25 \times 200 \times 9.81 = 200 \times a \quad \text{—— (1)}$$

Consider the vertical motion of block B,

$$\text{Net force} = \text{mass} \times \text{accelaration}$$

$$m_B g - T = m_B \times a$$

$$300 \times 9.81 - T = 300 \times a \quad \text{—— (ii)}$$

Adding (i) + (ii)

$$300 \times 9.81 - T + T - 0.25 \times 200 \times 9.81 = 200a + 300a$$

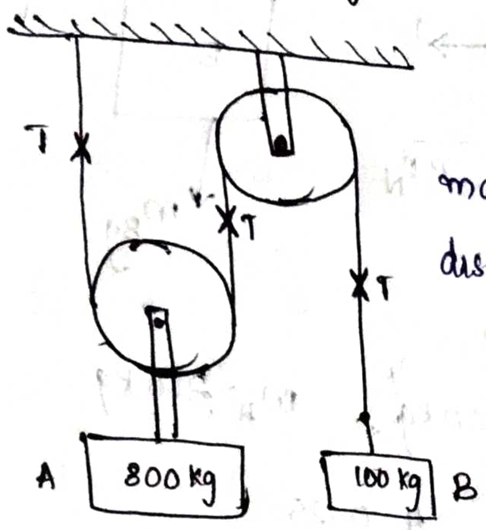
$$a = 4.905\ m/s^2$$

$$v^2 = u^2 + 2aS$$

$$v^2 = 0 + 2 \times 4.905 \times 2$$

$$\underline{v = 4.43\ m/s}$$

(14) Determine the tension in the string and accelaration of the two bodies of mass 300 kg & 100 kg connected by a string & frictionless and weightless pulley as shown in fig.



The downward displacement of 300 kg mass will be only half of the upward displacement of 100 kg mass.

$$a_A = \frac{1}{2} a_B.$$

Consider downward motion of A

Net body = mass × accelaration

$$m_A g - 2T = m_A \times a_A$$

$$300 \times 9.81 - 2T = 300 \times a_A$$

$$1471.5 - T = 150 a_A \quad \text{——— (i)}$$

Consider upward motion of B

Net force = mass × accelaration

$$T - m_B g = m_B a_B$$

$$T - 100 \times 9.81 = 100 \times 2 \times a_A$$

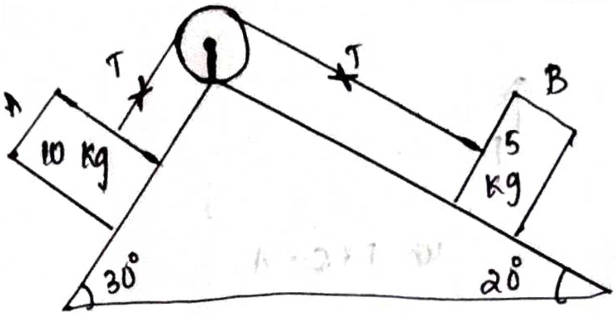
$$T - 981 = 200 a_A \quad \text{——— (ii)}$$

(i) + (ii)

$$1471.5 - T + T - 981 = 350 a_A$$

$$490.5 = 350 a_A \Rightarrow \underline{a_A = 1.40 \text{ m/s}^2}$$

(15) Two smooth inclined planes whose inclinations with horizontal are 30° and 20° are placed back to back. Two bodies of mass 10 kg and 5 kg are placed on them & are connected by a string as shown in fig. Calculate the T in the string and accelaration of the bodies.



The downward displacement of body A will be equal to upward placement of B

$a_A = a_B = a$

Consider motion of A

Net force $= m_A \times a_A$

$m_A g \sin\theta - T = m_A \times a_A$

$10 \times 9.81 \times \sin 30° - T = 10 \times a \Rightarrow 9.81 \times 5 - T = 10a$ ——— (i)

Consider motion of B

$T - m_B g \sin\theta = m_B \times a_B$

$T - 5 \times 9.81 \times 0.34 = 5a_B$ ——— (ii)

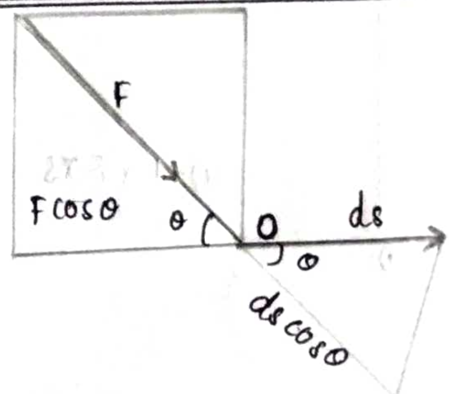
(i) + (ii)

$9.81 \times 5 - T + T - 5 \times 9.81 \times 0.34 = 15a$

$32.37 = 15a \Rightarrow \underline{a = 2.16\ m/s^2}$

18/08/2021

WORK-ENERGY EQ. IN RECTILINEAR TRANSLATION

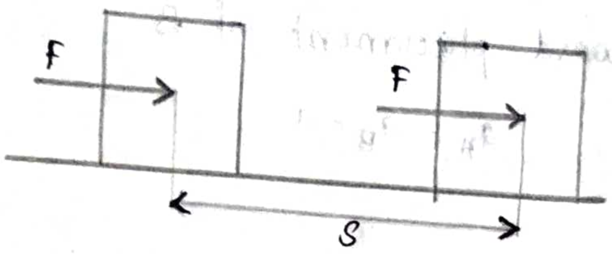


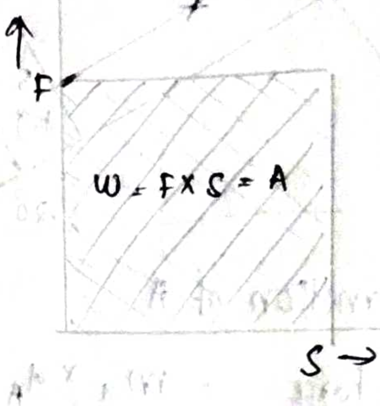
WORK

- Force → body moved along the line of action.
- Work done, $dW = F\,ds\cos\theta$

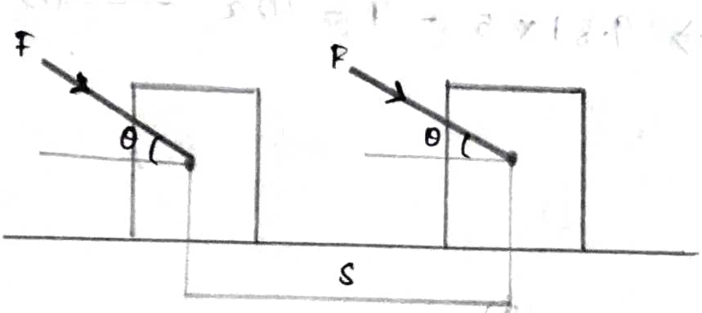
- Work is positive :- force or component of force in same direction of displacement
- Work is negative :- opp. direction
- Unit :- ~~Jo~~ Joule [Newton-metre (N.m)]

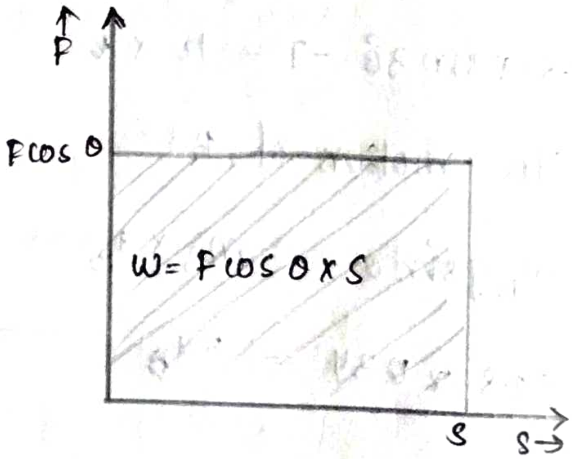
Case (i) When force F is constant and $\theta = 0$



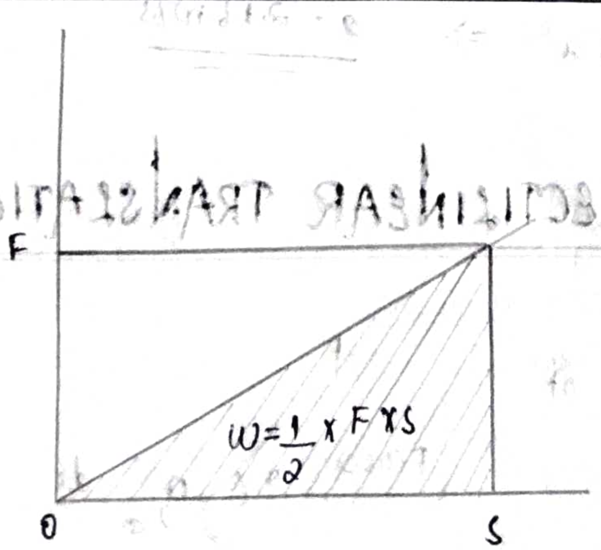


(ii) When F is constant and is inclined at θ with direction of motion.





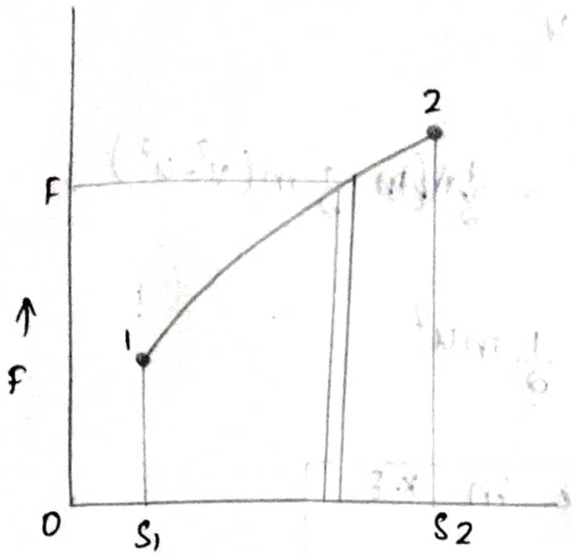
(iii) When the force F varies linearly & $\theta = 0$



work done W = (average force during the displacement) × displacement

$$W = \frac{(0+F)}{2} \times S = \frac{1}{2} \times F \times S$$

case (IV): Work done by a variable force, $F = f(s)$



work done W = area under the curve 1-2 of force displacement diagram

$$W = \int_1^2 F \times ds$$

ENERGY

- capacity to do work
- unit = N-m or J
- K.E = $\frac{1}{2} m v^2$
- P.E = mgh

WORK - ENERGY PRINCIPLE

The work done by a system of force acting on a body during a displacement is equal to the change in kinetic energy of the body during the same displacement.

Resultant Force = $m \times a$

$$a = \frac{dv}{dt} = \frac{dv}{ds} \times \frac{ds}{dt} = \frac{dv}{ds} \times v$$

$$a = v\frac{dv}{ds}$$

$$F = m \times a$$
$$= m \times v \frac{dv}{ds}$$

$$\boxed{F \times ds = m\, v\, dv}$$

Integrating on both sides

$$\int_0^s F.ds = \int_u^v m\,v\,dv$$

$$F \times S = m\left[\frac{v^2}{2}\right]_u^v = \frac{1}{2}m(v^2-u^2)$$

$$= \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\boxed{\text{workdone} = \text{change in K.E}}$$

IMPULSE - MOMENTUM PRINCIPLE

- derived from Newton's Second Law
- momentum = product of mass & velocity. $(m \times v)$
- Impulsive force = large force acts over a short period of time
- The impulsive of a force F acting over a time interval t_1 to t_2 is defined by the integral. $\int_{t_1}^{t_2} F\,dt$

- If F is the resultant force acting on a body of mass m, then Newton's second law

$$F = ma$$

$$a = \frac{dv}{dt}$$

$$F = m\frac{dv}{dt} = \frac{d}{dt}(mv)$$

$$F\,dt = d(mv) \Rightarrow \int F\,dt = \int d\,mv = m\int dv$$

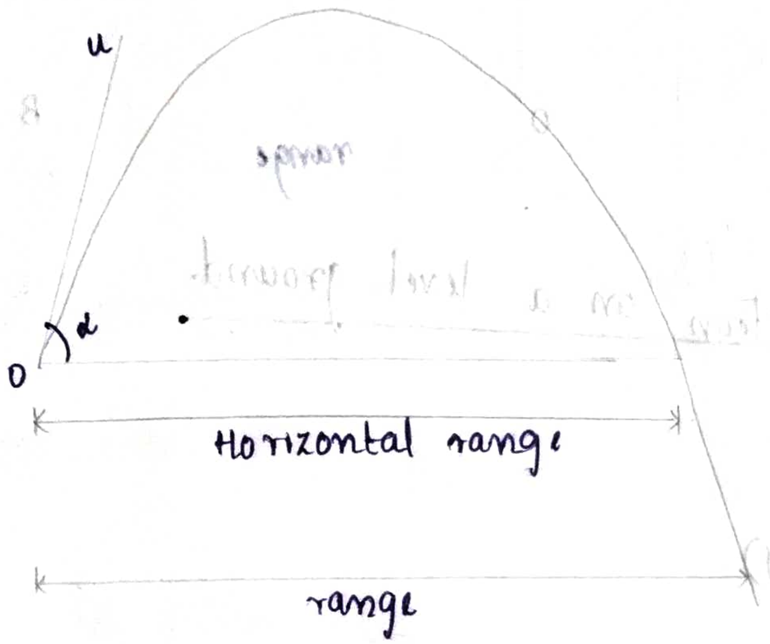
$$\int_{t_1}^{t_2} F.dt = m[v]_{v_1}^{v_2} = m(v_2 - v_1)$$

$$F(t_2 - t_1) = m(v_2 - v_1) \rightarrow \boxed{Ft = m(v_2 - v_1)}$$

$$\boxed{\text{Impulse} = \text{final momentum} - \text{initial momentum}}$$

01/09

MOTION OF PROJECTILE

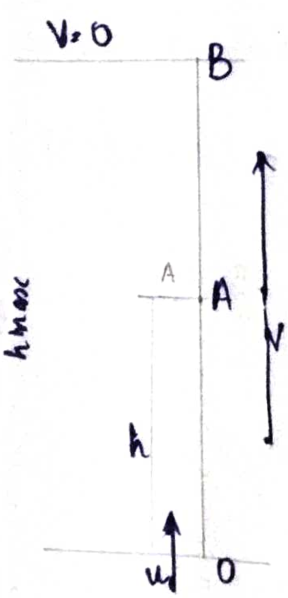


Case 1 :- Motion of a particle projected vertically into space

$\alpha = 90^\circ$

when $h = h_{max}$, $V = 0$

$$\boxed{h_{max} = \frac{u^2}{2g}}$$



Time to attain max height $t_1 = \frac{u}{g}$

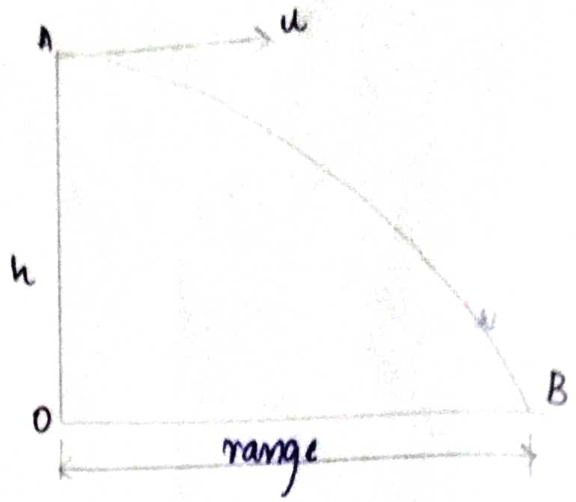
time of flight $\boxed{2t_1 = \frac{2u}{g} = T}$

$\boxed{\text{Range} = 0}$

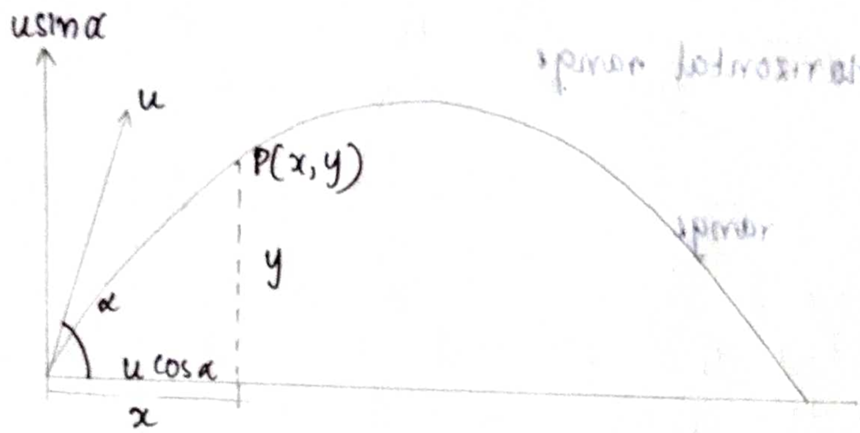
Case 2 :- motion of a plane thrown horizontally into space

Time of flight $\boxed{T = t = \sqrt{\frac{2h}{g}}}$

$\boxed{\text{range} = u \times t = u\sqrt{\frac{2h}{g}}}$



case 3 :- Inclined projection on a level ground.



Prove that the trajectory of an inclined projection on a level ground is a parabola

$x = (u\cos\alpha) \times t$

$t = \frac{x}{u\cos\alpha}$ ——— (1)

$h = (u\sin\alpha) \times t - \frac{1}{2}gt^2$

$y = (u\sin\alpha)t - \frac{1}{2}gt^2$

$$y = u\sin\alpha \times \frac{x}{u\cos\alpha} - \frac{1}{2} g \left(\frac{x}{u\cos\alpha}\right)^2$$

$$y = x\frac{\sin\alpha}{\cos\alpha} - \frac{1}{2} g \frac{x^2}{u^2\cos^2\alpha}$$

$$\boxed{y = x\tan\alpha - \frac{1}{2}\frac{gx^2}{u^2\cos^2\alpha}}$$

Equation of a parabola

EQUATIONS OF A PROJECTILE MOTION

Maximum height $\boxed{h_{max} = \frac{u^2\sin^2\alpha}{2g}}$

Time to attain h_{max} $\boxed{T = \frac{2u\sin\alpha}{g}}$

Horizontal range $\boxed{R = \frac{u^2}{g}\sin 2\alpha}$

(16) $u = 100\,m/s$ $\alpha = 30^\circ$

Find the horizontal range, h_{max} attained by bullet & time of flight.

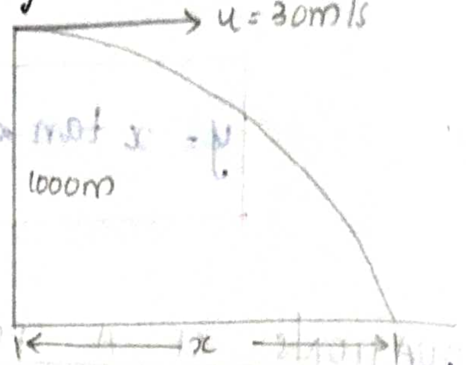
$$R = \frac{u^2}{g}\sin 2\alpha = \frac{100 \times 100}{9.8}\sin 60^\circ$$

$$= \frac{100 \times 100}{9.8} \times \frac{\sqrt{3}}{2} = 883.77\,m$$

$$H_{max} = \frac{u^2\sin^2\alpha}{2g} = \frac{\overset{25}{\cancel{100}} \times \overset{5}{\cancel{100}}}{2 \times \cancel{10}} \times \frac{1}{2} \times \frac{1}{2} = 127.55\,m$$

$$T = \frac{2u\sin\alpha}{g} = \frac{2\times100\times 1/2}{9.8} = \underline{10.20s}$$

(17) A pilot flying his bomber at a height of 1000m with uniform horizontal velocity of 30 m/s wants to strike a target on the ground. At what distance from the target, he should release the bomb?



$u = 0$, $h = ut + \frac{1}{2}gt^2$

$1000 = 0 + \frac{1}{2}gt^2$

$t = \sqrt{\frac{2000}{9}} = \underline{14.29s}$

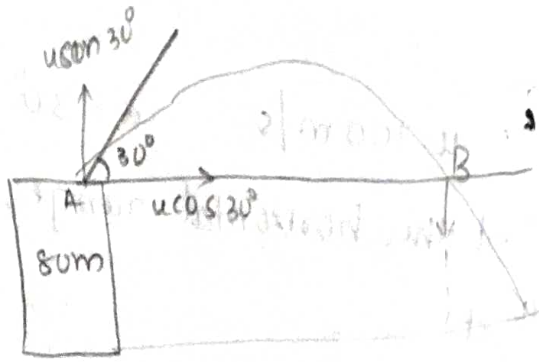
∵ the horizontal velocity remains constant, the horizontal distance moved in 14.29 seconds is $v \times t$

$x = 30 \times 14.29 = \underline{428.7m}$

PRACTISE PROBLEMS

(18) A stone is thrown upwards at an angle of 30° to the horizontal from a point P on a tower of height 80m and it strikes the ground. The initial velocity of stone = 100 m/s. Calculate (a) time of flight of stone (b) The greatest elevation above the ground reached by the stone.

$u = 100m/s$ $h = 80m$ $\alpha = 30°$



(a) t

$y = (u\sin\alpha)t - \frac{1}{2}gt^2$

$-80 = 100\sin 30 t - \frac{1}{2}\times 9.8 t^2$

$4.905t^2 - 50t - 80 = 0$ $\Rightarrow$ $\underline{t = 11.59s}$

(b)

$$H = \frac{v^2\sin^2\alpha}{2g} = \frac{100\times100\times\sin^2 30}{2\times9.8} = 127.42$$

Greatest elevation $= 127.42 + 80 = \underline{207.42m}$

(19) A cricket ball thrown by a fielder from a height of 2m at an angle 45° to the horizontal with an initial velocity 25 m/s hit the wickets at the height of 0.6m from ground. How far was the fielder from wickets?

$u_y = u\sin 45^\circ = 25 \times 0.707 = 17.68 \text{ m/s}$

$u_x = u\cos 45^\circ = 25 \times 0.707 = 17.68 \text{ m/s}$

$s_y = u_y t - \frac{1}{2} g t^2$

$(0.6 - 2) = 17.68 \times t - \frac{1}{2} \times 9.8 \times t^2$

$-1.4 = 17.68t - 4.9t^2 \Rightarrow 4.9t^2 - 17.68t - 1.4 = 0$

$\underline{t = 3.68 s}$

Range $= 25\cos 45 \times 3.68 = \underline{65.05 m}$