CBCS SCHEME

USN [ ] **18CIV14/24**

First/Second Semester B.E. Degree Examination, Jan./Feb. 2021
Elements of Civil Engineering and Mechanics

Time: 3 hrs. Max. Marks: 100

Note: *1. Answer any FIVE full questions, choosing ONE full question from each module.*
2. Missing data, if any, may be suitably assumed.

Important Note : 1. On completing your answers, compulsorily draw diagonal cross lines on the remaining blank pages.
2. Any revealing of identification, appeal to evaluator and /or equations written eg, 42+8 = 50, will be treated as malpractice.

Module-1

1 a. Explain briefly the scope of following areas of civil engineering :
i) Irrigation engineering
ii) Environmental engineering. **(10 Marks)**

b. What are the roles of civil engineers in the infrastructural development of a country? **(10 Marks)**

OR

2 a. State and explain basic idealization in mechanics. **(06 Marks)**

b. State and prove law of parallelogram of forces. **(06 Marks)**

c. Two forces acting on a body are 500N and 1000N as shown in Fig.Q2(c). Determine the third force F such that the resultant of all the three forces is 1000N, directed at 40° to the X axis.

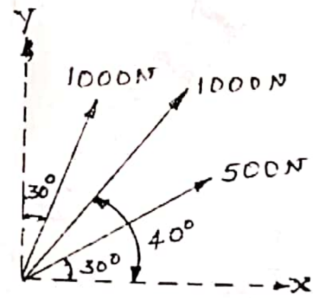

Fig.Q2(c) **(08 Marks)**

Module-2

3 a. State and prove Lami's theorem. **(08 Marks)**

b. Two identical cylinders, each weighing 500N are arranged in a through as shown in Fig.Q3(b). Determine the reactions developed at contact points A, B, C and D. Assume all points of contact are smooth.

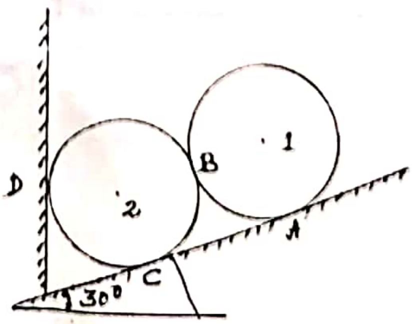

Fig.Q3(b) **(10 Marks)**

c. List the equations of equilibrium. **(02 Marks)**

OR

4 a. State the laws of dry friction. **(04 Marks)**

b. Explain the types of friction. **(06 Marks)**

c. Find the force p just required to slide the block B in the arrangement shown in Fig.Q4(c). Find also the tension in the string. Given weight of block A = 500N and weight of block B = 1000N. $\mu = 0.2$ for all contact surfaces.

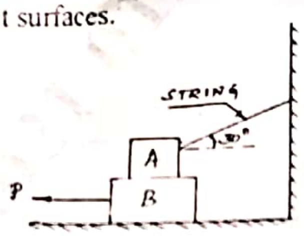

Fig.Q4(c) **(10 Marks)**

Module-3

5 a. Explain with sketches different types of loads. **(04 Marks)**

b. Explain with sketches different types of supports. **(06 Marks)**

c. Determine the reactions developed at supports A and B of overhanging beam shown in Fig.Q5(c).

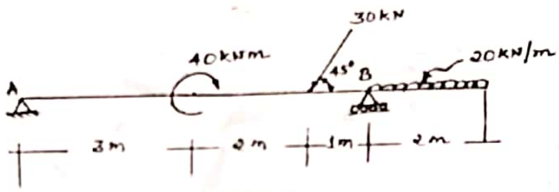

Fig.Q5(c) **(10 Marks)**

OR

6 a. List the different types of trusses. **(06 Marks)**

b. Analyse the truss shown in Fig.Q6(b) by method of joints.

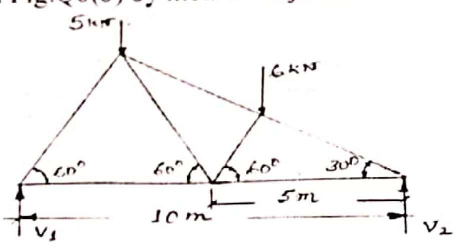

Fig.Q6(b) **(14 Marks)**

Module-4

7 a. Determine the centroid of a semicircular lamina from the first principle. **(08 Marks)**

b. Locate the centroid of the lamina shown in Fig.Q7(b), with respect to axes 1 – 1 and 2 – 2.

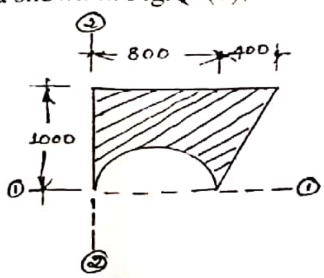

Fig.Q7(b) **(12 Marks)**

OR

8 a. State and prove parallel axes theorem. **(08 Marks)**

b. Determine the moment of inertia of the symmetric I-section shown in Fig.Q8(b) about its centroidal axes x-x ad y-y.

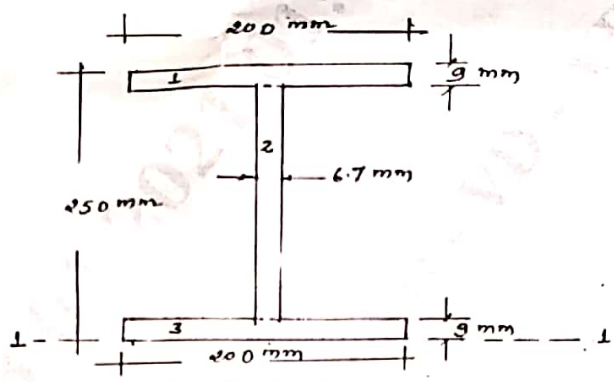

Fig.Q8(b) **(12 Marks)**

Module-5

9 a. Define the following :
i) Projectile
ii) Trajectory
iii) Time of flight
iv) Range. **(08 Marks)**

b. A projectile is fired at certain angle has a horizontal range of 3.5km. If the maximum height reached is 500m, what is the angle of elevation of the cannon? What was the muzzle velocity of the projectile? **(06 Marks)**

c. A Burglar's car starts with an acceleration of 2m/sec^2. A police van came after 10 sec and continued to chase the burglar's car with an uniform velocity of 40m/sec. find the time taken by the police van to overtake the Burglar's car. **(06 Marks)**

OR

10 a. State Newton's second law of motion and D'Alembert's principle. **(04 Marks)**

b. A lift carries a man of weight 4000kN and is moving with a uniform acceleration of 3.5m/sec^2. Determine the tension in the cable when :
i) Lift is moving upwards
ii) Lift is moving downwards. **(08 Marks)**

c. A car travelling at a speed of 75kmph applies brake and comes to a halt after skidding 60m. Determine :
i) Deceleration
ii) Time to stop the car
iii) Coefficient of friction between road and tyres. **(08 Marks)**

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KLS's VDIT, HALIYAL.

Dept. of Civil Engineering.

Elements of Civil Engineering and Mechanics. (18CIV14/24)

Scheme and Solution

Module 1

1\. a. Explain briefly the scope of following areas of civil Engineering.

i) Irrigation Engineering

ii). Environmental Engineering

Ans : i) Irrigation Engineering

Irrigation may be defined as the process of supplying water to the soil for raising the crops by artificial means. Irrigation is not just limited to application of water to soil but also watershed and agricultural form. It deals with the design and construction of all works, such as dams, weirs, head regulators etc.

The scope of Irrigation Engineering can be divided into two heads.

a) Engineering Aspect

This deals with.

1). Storage of water by constructing dam as. reservoir.

2) Diversion of stored water to canals for distribution

3) Lifting of water by digging wells and feld to small channels.

4) Conveyance of water to agricultural fields by some suitable distribution system like flooding, forrow, sprinkler and drip. irrigation.

5) Development of hydroelectric power.

6). Drainage and relieving the water logging. to maintain high productivity of canal.

b) Agricultural Aspect.

This deals with

1) Distribution of water uniformly and periodically to maintain proper depths of water for crops.

2) Capacities of different soils for irrigation water

3). Reclaimation of waste and alkaline lands.

— 05m.

1. a. ii) Environmental Engineering

Proper distribution of water to rural areas, town & cities and disposal of waste water and solid waste are another field of civil engg. Industrialisation & increase in vehicular traffic are creating air pollution problems. Environmental engineering while tackling all these problems provides healthy environment to public.

1 b. What are the roles of Civil engineers in the infrastructural development of a country?

Ans : A civil engineer has to play a very imp. role by looking into the public needs through shelter, water supply for drinking and irrigation of crops, sewerage, transportation, enegy and disaster protection, which forms the basic infrastructural demands of the society but keeping our social and cultural heritage. The various jobs to be performed are.

1). Civil Engineer takes up the construction sector job.

2) He should be competent in the various fields of surveying, planning, anlysing, designing, estimating, scheduling, execution inspection and maintenance of work.

3) He plans the buildings, towns, cities, recreational centres.

4). He builds structures like building, dam, bridges, reservoirs, tunnels, railways harbours etc.

5) He builds water purifying units and distributes water for drinking purpose.

— 10m

Q a. State and explain basic idealizations in mechanics

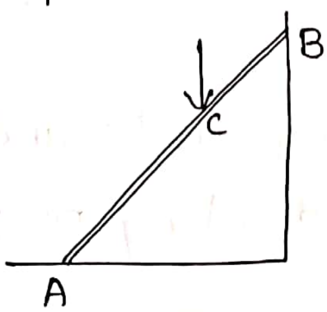
Ans: Basic idealizations in mechanics are

1) Particle – It is defined as an object which has only mass but no size. Such a body cannot exist theoretically. However while dealing with problems involving distances considerably larger when compared to the size of the body, the size of the body may be neglected without sacrificing accuracy.

2) Continuum – The body is assumed to consist of a continuous distribution of matter. ie, the body is treated as continuum. The concept of continuum of body enables us to simplify the problems in engineering mechanics

3) Rigid body – It is defined as a body in which the relative positions of any two particles do not change under the action of the forces.

4) Point force – The contact area is ignored compared to other dimensions involved.



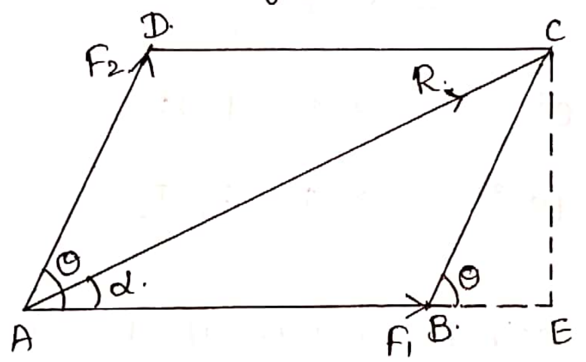
— $1\frac{1}{2} \times 4$

6m.

b. State and prove law of parallelogram of forces.

Ans: Statement :

If two forces acting simultaneously on a body at a point are represented in magnitude and direction by the two adjacent sides of a parallelogram, their resultant is represented in magnitude and direction by the adjacent diagonal of the parallelogram which passes through the point of intersection of the two sides representing the forces.



Let F_1 & F_2 be the two forces, θ be the angle between them.

According to law of parallelogram of forces,

$$R = AC$$

$$= \sqrt{AE^2 + CE^2}$$

$$= \sqrt{(AB+BE)^2 + CE^2}$$

$AB = F_1$

$BE = BC\cos\theta = F_2\cos\theta$

$CE = BC \sin\theta = F_2 \sin\theta$

$$R = \sqrt{(F_1 + F_2\cos\theta)^2 + (F_2 \sin\theta)^2}$$

$$= \sqrt{F_1^2 + 2F_1F_2\cos\theta + F_2^2\cos^2\theta + F_2^2\sin^2\theta}$$

$$R = \sqrt{F_1^2 + 2F_1F_2\cos\theta + F_2^2}$$

$$\tan\alpha = \frac{CE}{AE} = \frac{F_2\sin\theta}{F_1 + F_2\cos\theta}$$

$$\alpha = \tan^{-1}\left[\frac{F_2\sin\theta}{F_1 + F_2\cos\theta}\right]$$

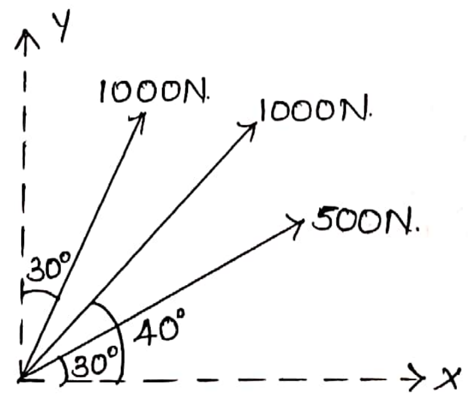
Particular cases

i) When $\theta = 90^\circ$ $\Longrightarrow$ $R = \sqrt{F_1^2 + F_2^2}$.

ii) When $\theta = 0^\circ$ $\Longrightarrow$ $R = F_1 + F_2$.

iii) When $\theta = 180^\circ$ $\Longrightarrow$ $R = F_1 - F_2$

c) Two forces acting on a body are 500N and 1000N as shown in fig. Determine the third force F such that the resultant of all the three forces is 1000N, directed at 40° to the x-axis



Ans: Let the third force make an angle θ with x-axis.

$\therefore \; R\cos\alpha = \Sigma F_x$

$1000\cos 40 = 500\cos 30 + 1000\cos 70 + F\cos\theta$

$F\cos\theta = -8.98\text{ N}$ — (1)

$R\sin\alpha = \Sigma F_y$

$1000\sin 40 = 500\sin 30 + 1000\sin 70 + F\sin\theta$

$F\sin\theta = -546.9\text{ N}$ — (2)

(2) ÷ (1)

$\tan\theta = 60.90$

$\theta = 89.05^\circ$

$F = -546.97\text{ N}$

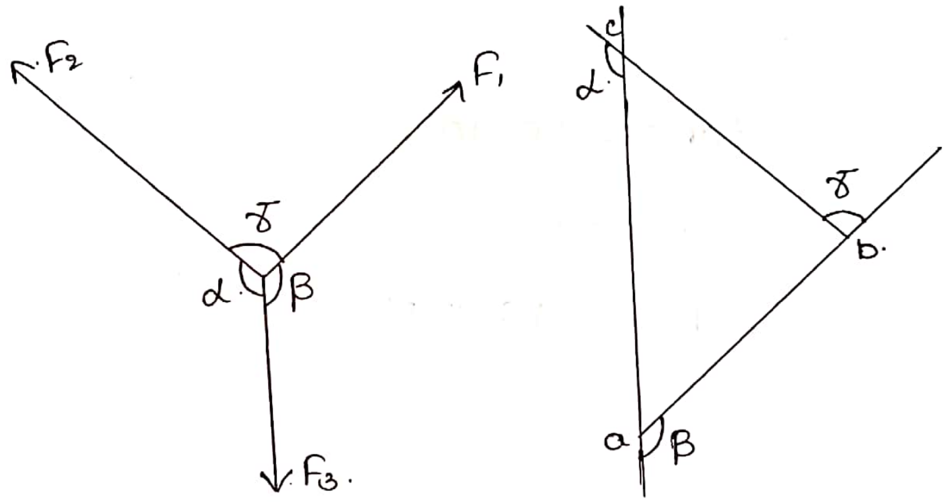
Module 02

3.a. State and prove Lami's theorem.

Ans: Statement :

If a body is in equilibrium under the action of only three forces, each force is proportional to the sine of angle between the other two forces.

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$



Derivation:

Draw the three forces F_1, F_2 & F_3 one after the other in direction and magnitude starting from point 'a'. Since the body is in equilibrium, the resultant should be zero, which means the point of contact force diagram should coincide with a.

In the Δ abc.

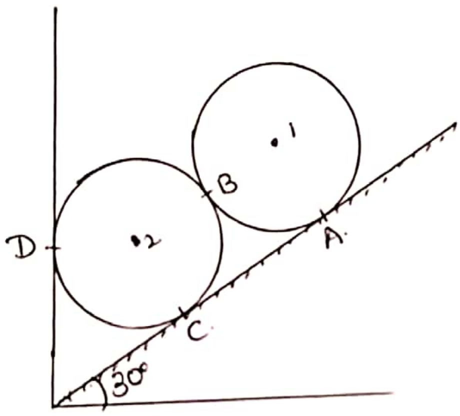
ab = F_1 , bc = F_2 , ca = F_3

Applying the sine rule.

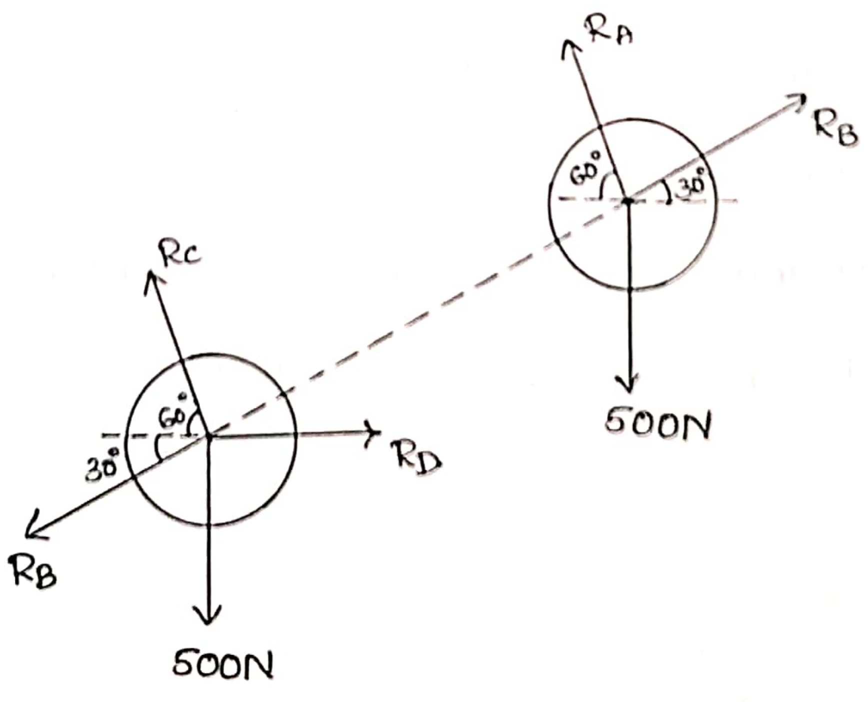
$$\frac{ab}{\sin(180-\alpha)} = \frac{bc}{\sin(180-\beta)} = \frac{ca}{\sin(180-\gamma)}$$

$$\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}$$

3b. Two identical cylinders, each weighing 500N are arranged in a through as shown in fig. Determine the reactions developed at contact points A, B, C & D. Assume all point of contact are smooth.



Sol: FBD



Sphere 1

ΣF Using lami's theorem

$$\frac{R_A}{\sin(90+30)} = \frac{R_B}{\sin(90+60)} = \frac{500}{\sin 90}.$$

$R_A = 433.01$ N.

$R_B = 250$ N.

Sphere 2.

Using equations of equilibrium

$\Sigma F_x = 0$

$R_D - R_C \cos 60 - R_B \cos 30 = 0$ —— (1)

$\Sigma F_y = 0$

$R_C \sin 60 - R_B \sin 30 - 500 = 0$

$\Rightarrow R_C = 721.68$ N.

$R_D = 577.34$ N.

c). Equations of equilibrium

Sol^n: → Coplanar concurrent force system

$\Sigma F_x = 0 \quad , \quad \Sigma F_y = 0.$

→ Coplanar nonconcurrent force system.

$\Sigma F_x = 0 \quad , \quad \Sigma F_y = 0 \quad , \quad \Sigma M = 0.$

4 a. State the laws of dry friction

Ans: Laws of dry friction.

1) The frictional force always acts in a direction opposite to that in which the body tends to move.

2). Till the limiting value is reached, the magnitude of the frictional force is dexactly equal to the tangential force which tends to move the body.

3) The magnitude of the limiting friction bears a constant ratio to the normal reaction between the two contacting surfaces.

4). The force of friction depends upon the rougness or smoothness of the surfaces.

5) The force of friction is independent of the area of contact between the two surfaces.

b) Explain the types of friction.

Ans: i) Static friction:

When the applied tangential force is less than the limiting friction, the body remains at rest and such friction is called static friction which will have any value between zero and limiting friction.

ii) Dynamic friction

If the value of applied tangential force exceeds the limiting friction, the body starts moving over another body and the frictional resistance experienced while moving is known as Dynamic friction.

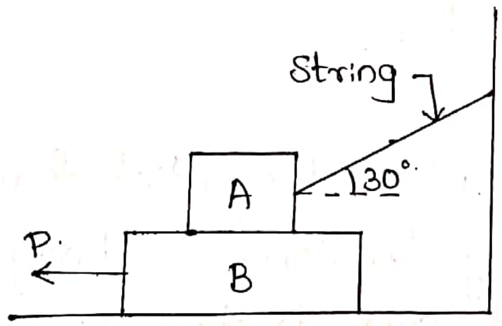
→ Sliding friction:

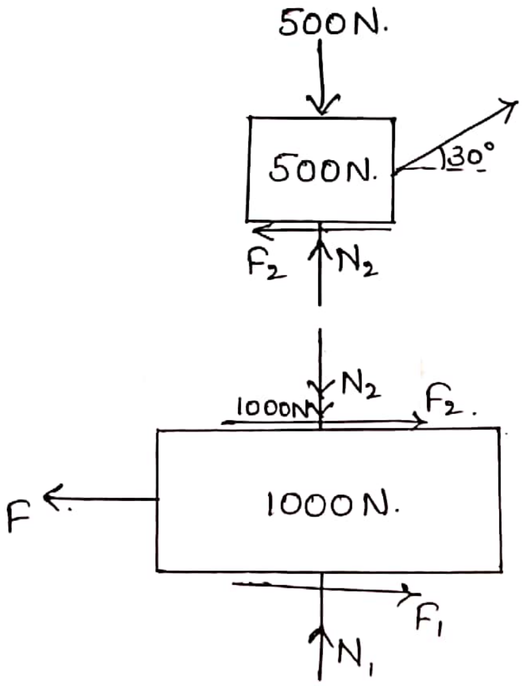
It is the friction experienced by a body when it slides over other body.

→ Rolling friction:

It is the friction experienced by a body when it rolls over another body

c) Find the force P just required to slide the block B in the arrangement shown in fig. Find also the tension in the string. Given weight of block A = 500N and weight of block B = 1000N. $\mu = 0.2$ for all contact surfaces.





$$\frac{F_2}{N_2} = 0.2$$

500N. Block.

$\Sigma F_x = 0.$

$T\cos 30 - F_2 = 0. \Rightarrow T\cos 30 - 0.2N_2 = 0.$ —(1)

$\Sigma F_y = 0.$

$T\sin 30 - 500 + N_2 = 0.$ —(2)

From (1)

$$T = \frac{0.2N_2}{\cos 30}.$$

Substituting in (2)

$$\frac{0.2N_2}{\cos 30} \times \sin 30 - 500 + N_2 = 0.$$

$\Rightarrow N_2 = 448.24\ N$

$F_2 = 89.65\ N$

$T = 103.52\ N$

1000 N block

$\Sigma F_x = 0.$

$F_1 + F_2 - F = 0$

$\Sigma F_y = 0$

$N_1 - N_2 - 1000 = 0$

$\frac{F_1}{N_1} = 0.2.$

$N_1 = 1448.24 \, N.$

$F_1 = 289.65 \, N$

$F = 379.29 \, N$

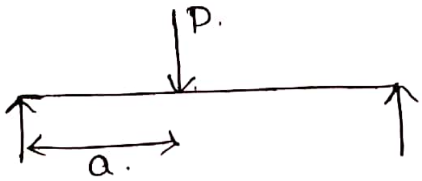
Module 03

5a. Explain with sketches different types of loads.

Ans: Types of loads:

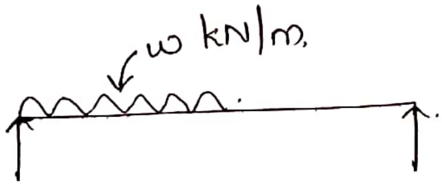
1> Concentrated load:

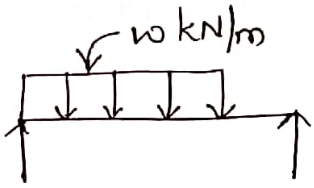
If a load is acting over a very small length compared to span of the beam, it is considered as point load.



2> Uniformly distributed load. (UDL)

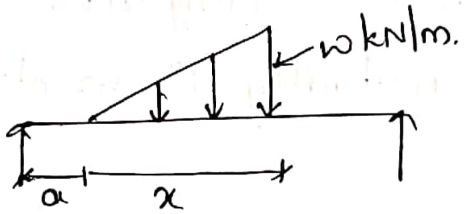
A load which has got same intensity over a considerable length is called as UDL.



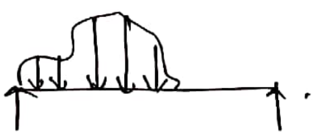


3> Uniformly varying load (UVL)

If the intensity of the load increases linearly along length, it is called as UVL.



4> General loading



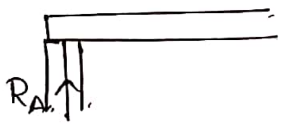
5>. External moment

b. Explain with sketches different types of supports.

Ans: Types of support

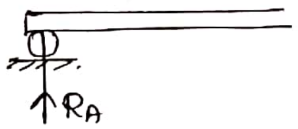
1> Simple support

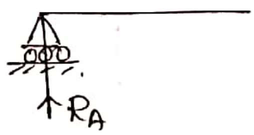
The end of the beam rests simply on a rigid support. The reaction is always normal to the support. There is no moment resistance at support.



2> Roller support

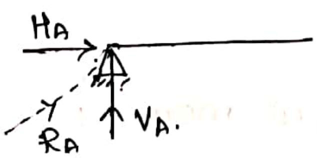
The beam end is supported on rollers. The reaction is normal to the support. The ends are free to rotate.





3> Hinged / Pinned support

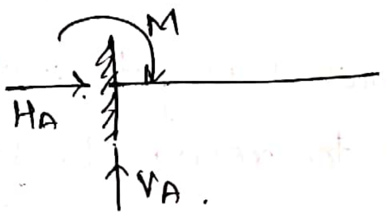
The position of the end of the beam is fixed but free to rotate. At such supports the reaction can be in any direction which is usually represented by its components in two mutually ⊥r directions.



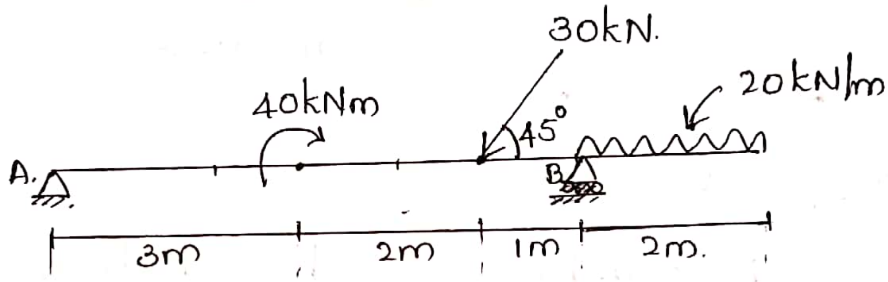
4> Fixed support

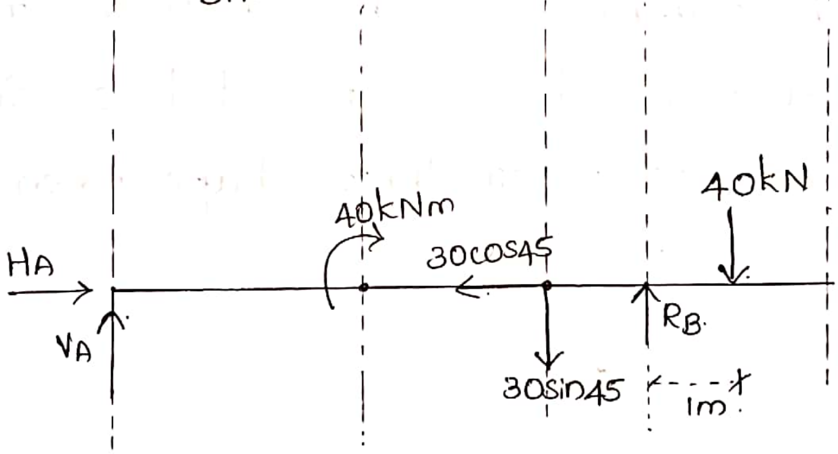
4) Fixed support:

The beam is neither permitted to move in any direction nor allowed to rotate.



c) Determine the reactions developed at supports A & B of overhanging beam shown in fig.





$\Sigma F_x = 0.$

$H_A - 30\cos 45 = 0 \Rightarrow H_A = 21.21\ kN.$

$\Sigma F_y = 0.$

$V_A - 30\sin 45 + R_B - 40. = 0.$ —— ①

$\Sigma M_A = 0.$

$40 + (30\sin 45 \times 5) - (R_B \times 6) + (40 \times 7) = 0$

$R_B = 71.071\ kN.$

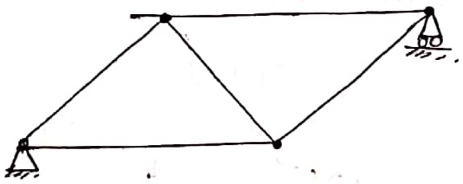
① ⇒. $V_A = 9.79 \downarrow kN$

6. a. List different types of trusses.

Ans: Types of trusses.

1) Perfect truss.

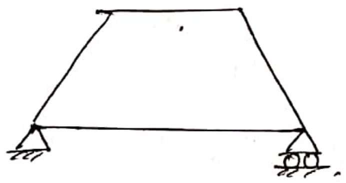
A pin jointed truss which has got just sufficient number of members to resist the loads without undergoing appreciable deformation in shape is called a perfect truss.



$m = 2j - 3.$

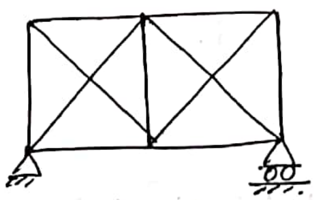
2) Deficient truss

The number of members in truss are less than that required for a perfect truss. Such trusses cannot retain their shape when loaded.

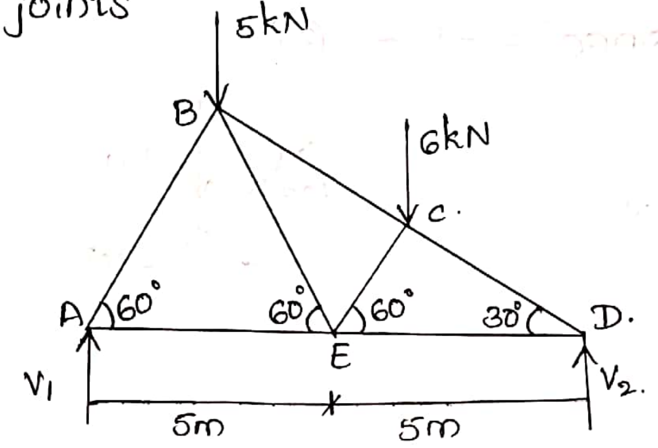


3) Redundant truss.

The number of members in it are more than that required in a perfect truss.



6b. Analyse the truss shown in fig by method of joints



$\Sigma F_x = 0$

$\Sigma F_y = 0$

$V_1 + V_2 = 11\,kN$

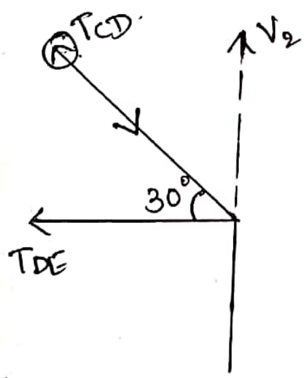
$\Sigma M_A = 0$

$(5 + 5\cos 60) + (6 \times 6.25) - (V_2 \times 10) = 0$

$V_2 = 5\,kN$

$V_1 = 6\,kN$

Joint D

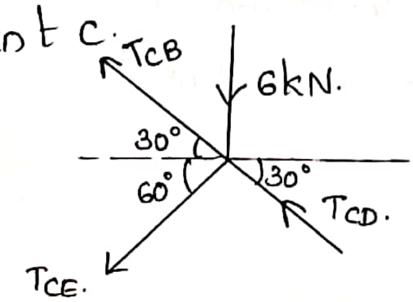


$$\frac{V_2}{\sin 30} = \frac{T_{CD}}{\sin 270} = \frac{T_{DE}}{\sin 60}$$

$T_{CD} = -10\,kN$

$T_{DE} = 8.66\,kN$

Joint C.



$\Sigma F_x = 0$.

$-T_{CB}\cos 30 - T_{CE}\cos 60 - T_{CD}\cos 30 = 0$

$T_{CB}\cos 30 + T_{CE}\cos 60 = -8.66$ —— (1)

Scanned with CamScanner

$\Sigma F_y = 0.$

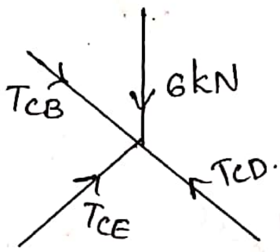
$T_{CB} \sin 30 - T_{CE} \sin 60 + T_{CD} \sin 30 - 6 = 0$

$T_{CB} \sin 30 - T_{CE} \sin 60 = -1$ —— ②

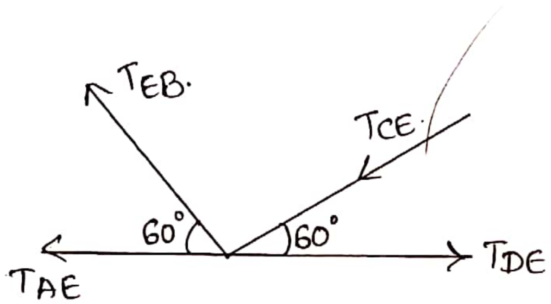
Solving ① & ②

$T_{CB} = -7.99$ kN.

$T_{CE} = -3.46$ kN



Joint E



$\Sigma F_x = 0.$

$-T_{AE} + T_{DE} - T_{EB} \cos 60 - T_{CE} \cos 60 = 0$

$T_{AE} + T_{EB} \cos 60 = 6.93.$

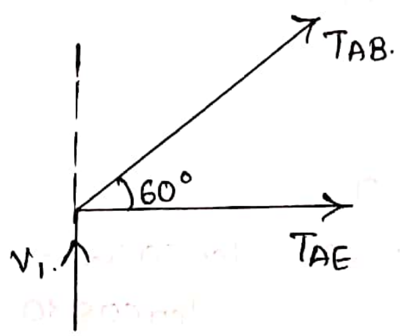
$\Sigma F_y = 0.$

$+T_{EB} \sin 60 - T_{CE} \sin 60 = 0$

$T_{EB} = 3.46$ kN

$T_{AE} = 6.43$ kN.

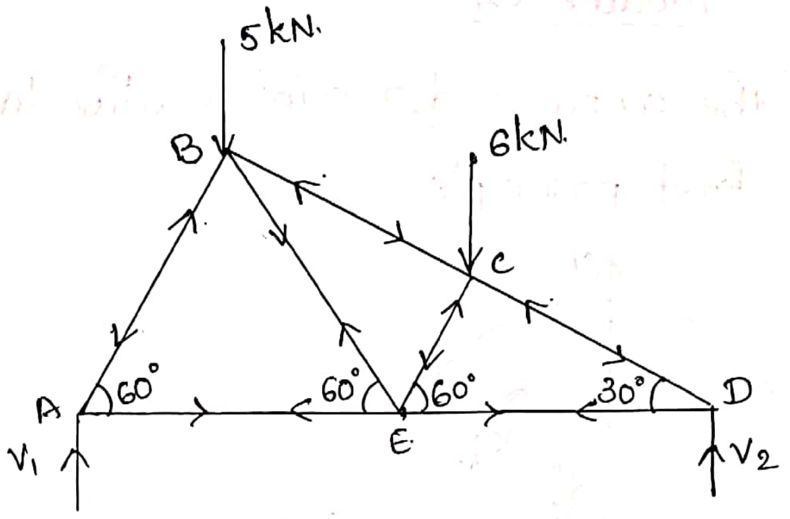
Joint A



$\Sigma F_x = 0.$

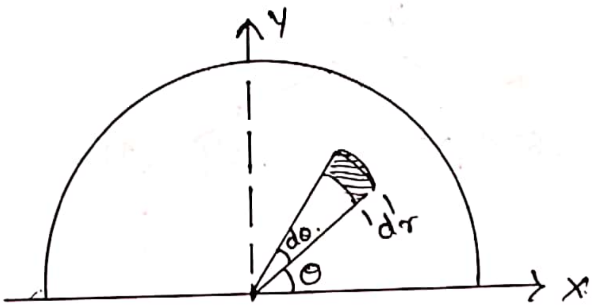
$T_{AE} + T_{AB} \cos 60 = 0.$

$T_{AB} = -12.86$ kN


5kN.
6kN.
B
C
A
E
D
60°
60°
60°
30°
V_1
V_2

Module 04

7. a. Determine the centroid of a semicircular lamina from the first principle.



The elemental area may be treated as a rectangle of sides $r d\theta$ and dr.

$\therefore$ Area of element $= r.d\theta.dr$

Moment about its diametrical axis

$r.d\theta \times dr \times r\sin\theta = r^2 \sin\theta . dr . d\theta$

Total moment of area about diametrical axis,

$$= \int_0^{\pi}\int_0^{R} r^2 \sin\theta \, .dr.d\theta = \int_0^{\pi}\left[\frac{r^3}{3}\right]_0^R \sin\theta \, .d\theta$$

$$= \frac{R^3}{3}\left[-\cos\theta\right]_0^{\pi}$$

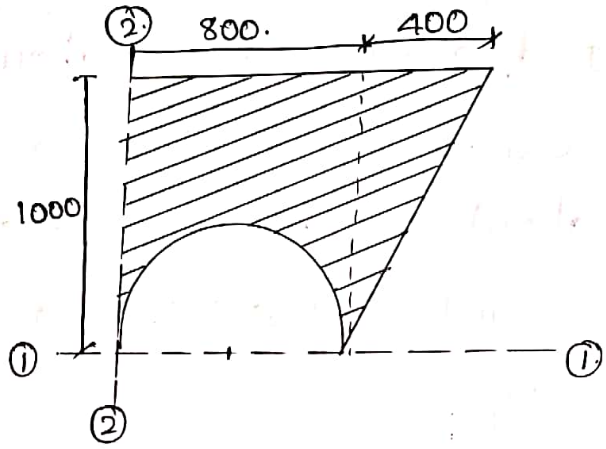
$$= \frac{R^3}{3}[1+1] = \frac{2R^3}{3}$$

Area of semicircle.

$A = \frac{1}{2}\pi R^2.$

$$\bar{y} = \frac{2R^3/3}{\frac{1}{2}\pi R^2} = \frac{4R}{3\pi}$$

7. b. Locate the centroid of the lamina shown in fig. wrt 1-1 & 2-2.



Components	Area mm^2.	Dist of centroid from ①① mm	Dist of centroid from ②② mm.	Ay. mm^3	Ax. mm^3.
g_1(rect)	80×1000 = 8×10^5	1000/5.	800/2.	4×10^8	3.2×10^8
g_2(Δ)	½×400×1000	⅔×1000	$800 + \frac{400}{3}$	1.33×10^8	1.867×10^8
Deductions.					
g_3 (semicircle)	$\frac{\pi}{8} \times 400^2$	0.424×400	800/2	0.43×10^8	1.005×10^8
	7.48×10^5			4.907×10^8	4.062×10^8

$$\bar{x} = \frac{\Sigma ax}{\Sigma a} = 542.15 \text{ mm}$$

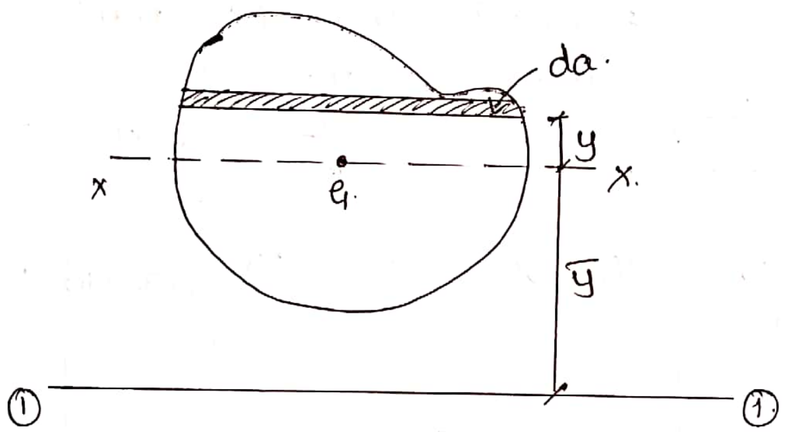
$$\bar{y} = \frac{\Sigma ay}{\Sigma a} = 654.53 \text{ mm.}$$

8. State and prove parallel axis theorem

Ans: Statement:

If the M.I of a plane area about an axis through its C.G is denoted by I_{xx}, then MI of the area about any reference axis ①-① parallel to x-axis and at a distance of $\bar{y}$ from C.G is given by

$$I_{1-1} = I_{xx} + A\bar{y}^2.$$



Let I_{xx} = MI about xx axis

I_{1-1} = MI of area about reference axis ①①

A = Area of body

$\bar{y}$ = Dist of C.G of body from ①①

MI of element about ①① $= da(\bar{y}+y)^2$.

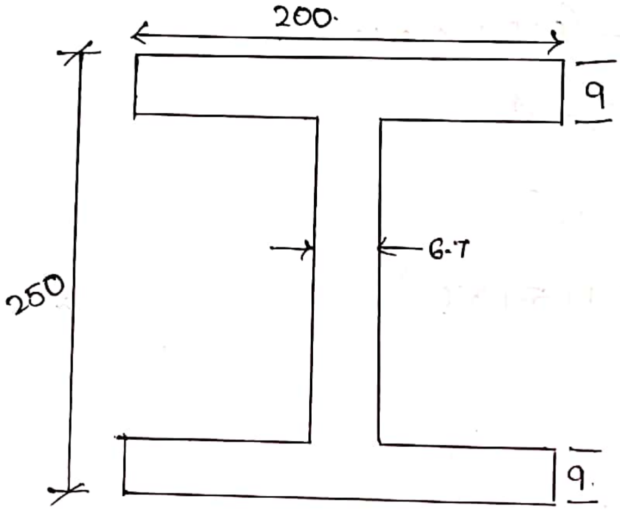
MI of whole body 1-1, $I_{1-1} = \Sigma da(\bar{y}+y)^2$.

$$= \Sigma da\bar{y}^2 + \Sigma day^2 + 2\Sigma day\bar{y}$$

$\Sigma day^2 = I_{xx}$, $\Sigma day = 0$.

$$\boxed{I_{1-1} = A\bar{y}^2 + I_{xx}}$$

8 b. Determine the moment of inertia of the symmetric I-section shown in fig. about its centroidal axis x-x & y-y



$\bar{x} = 100$ mm

$\bar{y} = 125.00$ mm

Component	Area	x	y	Ax	Ay
200 × 9 (top flange)	200×9	100	250 − 4.5	18×10^4	4.4×10^5
232 × 6.7 (web)	232×6.7	100	$9+\frac{232}{2}$	15.5×10^4	1.9×10^5
200 × 9 (bottom flange)	200×9	100	4.5	18×10^4	8100
	5154.4			5.15×10^5	6.38×10^5

Ax^2	Ay^2	I_{gx}	I_{gy}
18×10^7	1.08×10^8	~~1.09×10^5~~ 12150	6×10^6
1.5×10^7	2.4×10^7	6.97×10^6	5814.7
1.8×10^7	36,450	12150	6×10^6
5.1×10^7	1.32×10^8	6.99×10^6	12.0×10^6

$$I_{1-1} = \Sigma I_{gx} + \Sigma a y^2$$

$$= (6.99 \times 10^6) + 1.32 \times 10^8$$

$$= 1.38 \times 10^8 \text{ mm}^4$$

$$I_{xx} = I_{1-1} - A\bar{y}^2$$

$$= (1.38 \times 10^8) - (5154.4 \times 125^2)$$

$$= 57.46 \times 10^6 \text{ mm}^4$$

$$I_{2-2} = \Sigma I_{gy} + \Sigma a x^2$$

$$= (12.0 \times 10^6) + (5.1 \times 10^7)$$

$$= 63 \times 10^6 \text{ mm}^4$$

$$I_{yy} = I_{22} - A\bar{x}^2$$

$$= (63 \times 10^6) - (5154.4 \times 100^2)$$

$$= 11.45 \times 10^6 \text{ mm}^4$$

Module 05

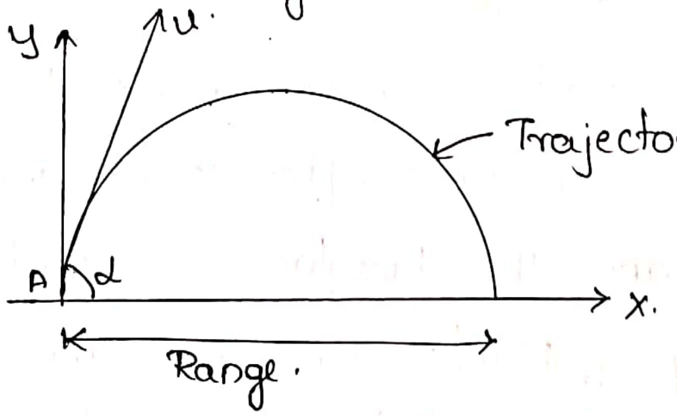
9a. Define the following
i) Projectile
ii) Trajectory
iii) Time of flight
iv) Range

Ans: i) Projectile : The freely projected particles which are having the combined effect of a vertical and a horizontal components of motion are called projectiles.

ii) Trajectory : The path traced by the projectile is called as its trajectory.

iii) Time of flight : The time interval during which the projectile is in motion is called the time of flight.

iv) Range : The horizontal distance through which the projectile travels in its flight is called the range.



9.b. A projectile is fired at certain angle has a horizontal range of 3.5km. If the max height reached is 500m, what is the angle of elevation of the cannon? What was the muzzle velocity of the projectile?

Ans: Range, $R = \frac{u^2 \sin 2\alpha}{g} = 3500$ —— ①

$H_{max} = \frac{u^2 \sin^2\alpha}{2g} = 500$ —— ②

$\therefore u^2 = \frac{500 \times 2g}{\sin^2\alpha}$ —— ③

Substituting ③ in ①

$$\frac{500 \times 2g}{\sin^2\alpha} \times \frac{\sin 2\alpha}{g} = 3500$$

$$\frac{1000 \sin 2\alpha}{\sin^2\alpha} = 3500$$

$$\frac{1000(2\cos\alpha)}{\sin\alpha} = 3500$$

$\therefore \alpha = 29.75°$

$\therefore u = 199.62$ m/s.

9.c. A Burglar's car starts with an acceleration of $2 m/s^2$. A police van came after 10 sec and continued to chase the burglar's car with an uniform velocity of 40m/s. Find the time taken by the police van to overtake the burglar's car.

Ans: Police van:

$u = 40 m/s$.

$s = ut = 40t$ — (1)

Burglar's car:

$u = 0$.

$a = 2 m/s^2$.

Dist travelled in $(t+10)$ sec.

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

$= 0 + \frac{1}{2} \times 2 \times (t+10)^2$

$= (t+10)^2$

$= t^2 + 20t + 100$ — (2)

Equating (1) & (2)

$40t = t^2 + 20t + 100$.

$t^2 - 20t + 100 = 0$.

$t = 10 sec$.

10. a. State Newton's second law & D'alembert's principle.

Newton's second law:

The rate of change of momentum is directly proportional to the impressed force and takes place in the same direction in which the force acts.

D'Alembert's principle:

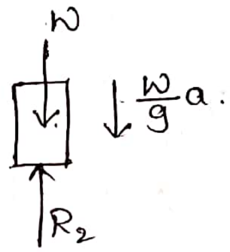
The system of forces acting on a body in motion is in dynamic equilibrium with the inertia force of the body.

10.b A lift carries a man of weight 4000kN & is moving with a uniform accl^n of $3.5 m/s^2$. Determine the tension in the cable when:

i> Lift is moving upwards

ii> Lift is moving downwards.

Ans: i> Lift is moving upwards



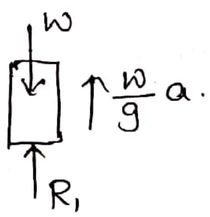
$$R_2 - W - \frac{W}{g}a = 0$$

$$R_2 = W\left(1 + \frac{a}{g}\right)$$

$$= 4000\left(1 + \frac{3.5}{9.81}\right)$$

$$= 5427 \text{ kN.}$$

ii> Lift is moving downwards



$$R_1 - W + \frac{W}{g}a = 0$$

$$R_1 = W\left(1 - \frac{a}{g}\right)$$

$$= 4000\left(1 - \frac{3.5}{9.81}\right)$$

$$= 2572.8 \text{ kN}$$

10.c. A car travelling at a speed of 75kmph applies brake & comes to a halt after skidding 60m. Determine.

i) Deceleration

ii) Time to stop the car

iii) Coefficient of friction between road & tyres.

Ans. $u = 75$ kmph $= 20.83$ m/s.

$v = 0$.

$s = 60$m.

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

$0 = 20.83^2 + 2(a)(60)$

$a = -3.61$ m/s^2

$v = u + at$

$t = 5.77$ s.

$F = \frac{W}{9.81} \times 3.61$

$\mu W = \frac{W \times 3.61}{9.81}$.

$\mu = 0.38$.