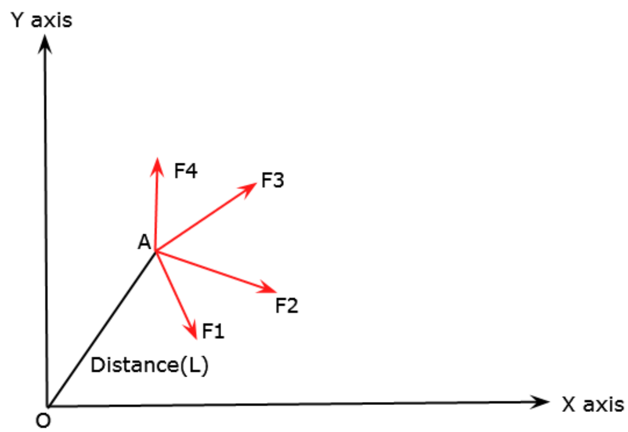
SUMMER – 2022 EXAMINATION

Subject Name: AME | **Model Answer** | **Subject Code:** 22203

Important Instructions to examiners:

1) The answers should be examined by key words and not as word-to-word as given in the model answer scheme.
2) The model answer and the answer written by candidate may vary but the examiner may try to assess the understanding level of the candidate.
3) The language errors such as grammatical, spelling errors should not be given more Importance (Not applicable for subject English and Communication Skills.
4) While assessing figures, examiner may give credit for principal components indicated in the figure. The figures drawn by candidate and model answer may vary. The examiner may give credit for any equivalent figure drawn.
5) Credits may be given step wise for numerical problems. In some cases, the assumed constant values may vary and there may be some difference in the candidate's answers and model answer.
6) In case of some questions credit may be given by judgement on part of examiner of relevant answer based on candidate's understanding.
7) For programming language papers, credit may be given to any other program based on equivalent concept.
8) As per the policy decision of Maharashtra State Government, teaching in English/Marathi and Bilingual (English + Marathi) medium is introduced at first year of AICTE diploma Programme from academic year 2021-2022. Hence if the students in first year (first and second semesters) write answers in Marathi or bilingual language (English +Marathi), the Examiner shall consider the same and assess the answer based on matching of concepts with model answer.

Q. No.	Sub Q. N.	Answer	Marking Scheme
Q.1		**Attempt any FIVE of the following** **Marks:10**	
	a)	**Effects of forces:** A force may produce the following effects in a body, on which it acts: 1. May change the State of rest or state of motion of a body 2. May accelerate or retard the motion of a body. 3. May enlarge or compress body or may change the shape of a body (This effect may be temporary or permanent) 4. May introduce internal stresses in the body.	Any TWO 1M 1M
	b)	**Non-reversible / irreversible or self-locking machine** When the machine is not capable of doing any work in the reversed direction, after the effort is removed, then the machine is called a non-reversible/irreversible or self-locking machine. The condition for a machine to be self-locking is that its efficiency should not be more than 50%. $\eta < 50\%$	1M 1M
	c)	**Varignon's Theorem** The algebraic sum of moments about a point of a system of concurrent forces is same as the moment of resultant of all these forces about the same point.	1M

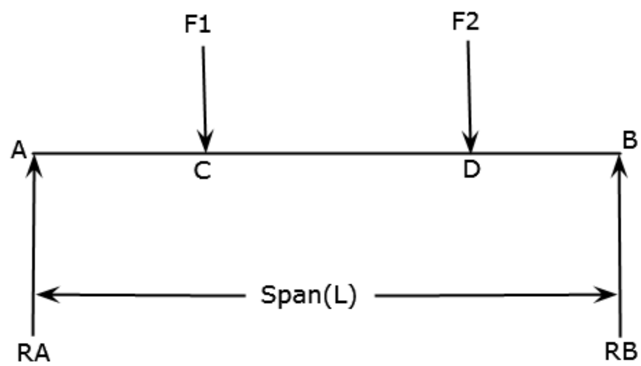


1M

Fig:Varignon's Theorem

d) **Types of Beams** — Any TWO

1. Simple supported Beam: If the both the ends of the beam are simply supported then it is called as Simple Supported Beam.



1M

1M

Fig: Simple supported Beam

2. Cantilever Beam: If the beam is fixed at one end and free at other end, then it is called as cantilever Beam.

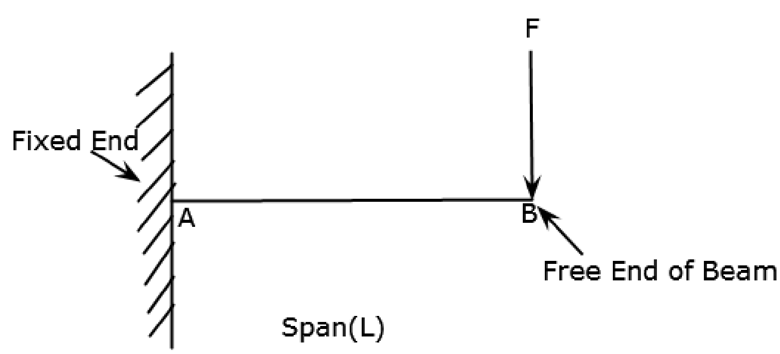


Fig : Cantilever Beam

3. Continuous Beam: If the beam is supported at more than two points then it is called as continuous Beam.

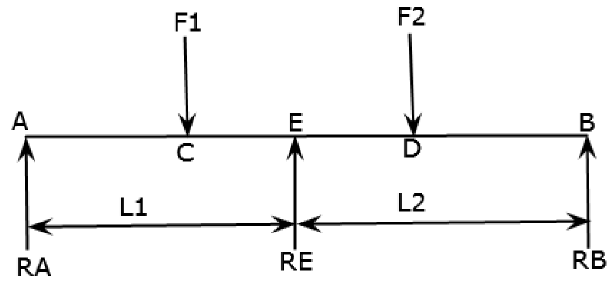


Fig: Continuous Beam

4. Overhanging Beam: If the end portion of the beam is extended beyond the support then it is called as overhanging Beam.

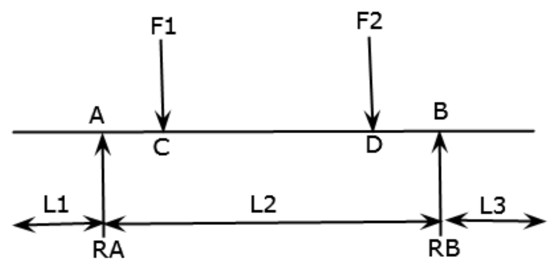


Fig: Overhanging Beam

5. Fixed Beam: If the both ends beam are fixed in the wall then it is called as fixed or constrained or built in Beam.

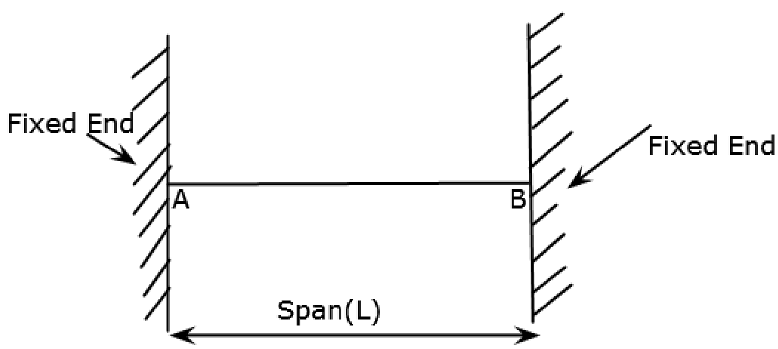


Fig: Fixed Beam.

e) **Advantages of friction:**

1. We can walk over the surface freely
2. We can easily hold the pen and write over the page.
3. Automobile braking system works under the principle of friction. 1M

4. Movement of vehicle with help of tyres over the road surface.
5. We can hold the object in our hand. 1M

f) **Center of Gravity (CG) :**

Center of gravity of a body is the point through which the whole weight of the body acts.

The Center of gravity of a body refers to a three-dimensional solid body or lamina. Because of solid body, we have to consider thickness. Hence we need to consider volume and/or weight of over solid body. The term Center of gravity is applicable to the Volume of a three-dimensional Solid body or lamina. Therefore, we can say that the Center of gravity is the point on a solid lamina or body, where the whole weight is concentrated. 1M

The center of gravity is applicable for a solid body such as solid cube, solid cylinder, solid cone, sphere for which we have to consider volume.

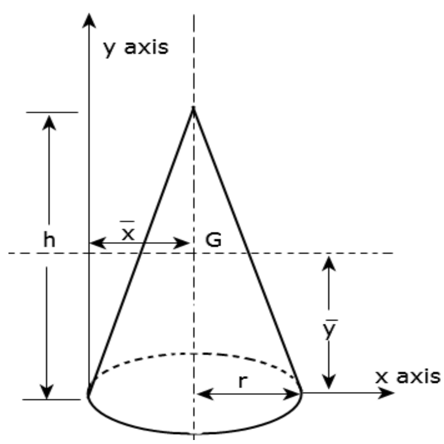
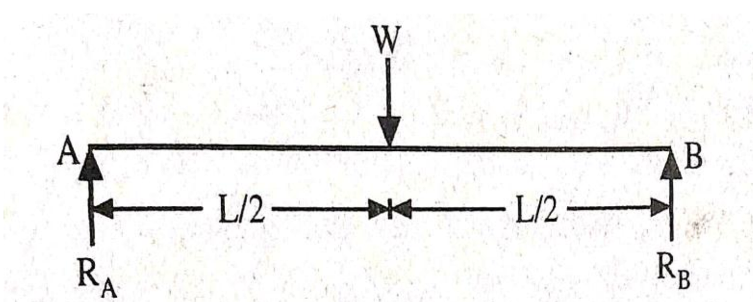


Fig:Solid Cone 1M

CG of the solid cone is $\bar{x} = r$ & $\bar{y} = \frac{h}{4}$

g) Simply supported beam with point load at the Centre.



1M

Fig: Simply supported Beam with point load the Centre.

Reaction at support R_A and R_B.

$R_A = W/2$ ………………Support Reaction at point A

$R_B = W/2$ ……………. Support Reaction at point B

Q.2 a) **Attempt any THREE of the following** **Marks:12**

1. Scalar and vector quantities

1.1 Scalar quantity

A scalar quantity is one that has magnitude only. Examples: Mass, Length, volume, time, temperature and density. 1M

Fig: Scalar quantity 2M

1.2 Vector quantity

A vector quantity is one that has magnitude as well as direction. Examples: Force, displacement, velocity, acceleration and momentum etc.

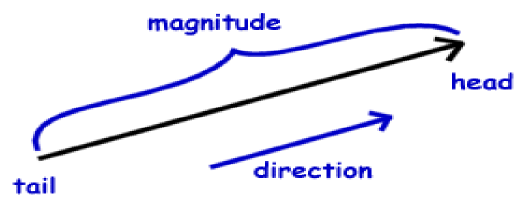


Fig: Vector quantity 2M

b) **Given Data-:**

Load lifted (W) =1400 N

Effort value of (P) =50 N

Distance moved by the effort (y) =6 m

Distance moved by the load(x) = 0.2 m

To Find-:1.Mechncial Advantage (M.A)

2. Velocity Ratio (V.R.)

3. Efficiency

4. Ideal Effort

Solution : We know that,

1.Mechanical Advantage (M.A)

$$M.A = \frac{W}{P}$$

M.A = 1400/50

M.A = 28 1M

2.Velocity ratio (V.R)

$$V.R = \frac{y}{x} = 6/0.2$$

$$V.R = 30$$

3.Efficiency 1M

$$\eta = \frac{M.A}{V.R} \times 100$$

$$\eta = (28/30) \times 100$$ 1M

$$\eta = 93.33\%$$

4.Ideal Effort $P_i = \frac{W}{V.R}$

= 1400/30

= 46.66 N

c) **Law of a machine**

The law of a machine gives the relationship between the effort applied and the load lifted. It states that ,for any machine if a graph is plotted between effort (P) and load lifted (W) it will be found that it follows a straight line relationship. 1M

This graph does not pass through O but makes an intercept C on the y-axis which shows the effort is lost in overcoming frictional resistance only. The constant 'm' shows the slope of the graph. 2 M

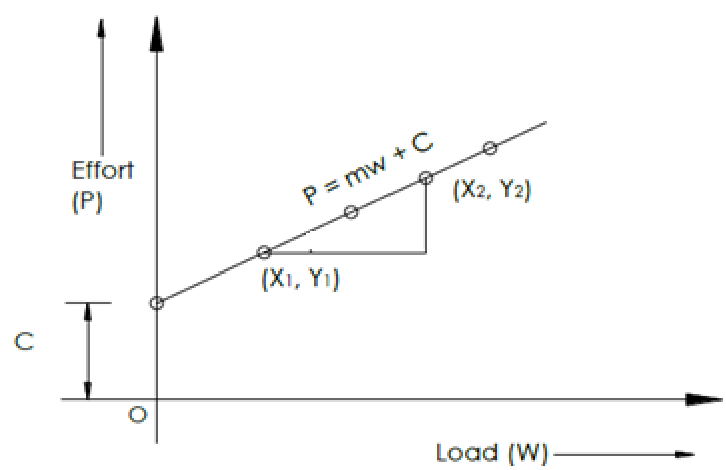


Fig.: Law of a machine

The equation P = mW + C is known as the law of machine. ……. (1)

Maximum Mechanical advantage and maximum Efficiency

We know that,

		Mechanical advantage, $M.A = \frac{W}{P}$ $M.A = \frac{W}{mW+C}$ $(\because P = mW+C)$ $= \frac{1}{m+\frac{C}{W}}$ Value of W is extremely high hence, $\frac{C}{W}$ will tend to be zero and corresponding M.A will be maximum. **Mechanical advantage, $M.A_{max} = \frac{1}{m}$. ……………………………………........(2)** We know that, $M.A = \eta \times V.R.$	
		$\eta = \frac{M.A}{V.R} = \frac{1}{m+\frac{C}{W}} \times \frac{1}{V.R}$	1M
		The velocity ratio in any machine is fixed. Thus, η is directly proportional to M.A For maximum M.A, the efficiency will also be Maximum Maximum efficiency, $\eta_{max} = \frac{M.A\ max}{V.R}$	
		$\boldsymbol{\eta_{max} = \frac{1}{m \times V.R}}$**…………………………………... ……..(3)**	1
	d)	**Laws of friction** Following are the laws of friction (One mark for each)	
		1. The frictional force always acts in a direction, opposite to that in which the body is moving.	1M
		2. The frictional force is independent on the area of the surfaces which is in contact.	1M
		3. Frictional force depends on the roughness of surface.	1M
		4. The ratio of frictional force to the normal reaction remains constant. 5. The static friction is always greater than the dynamic friction.	1M
		6. In kinetic or dynamic friction for moderate speeds, the frictional force remains constant. But it decreases slightly with the increase of speed.	

Q.3 **Attempt any <u>THREE</u> of the following** **Marks:12**

a) Find the magnitude and direction of the resultant force as shown in Fig. No. 1.

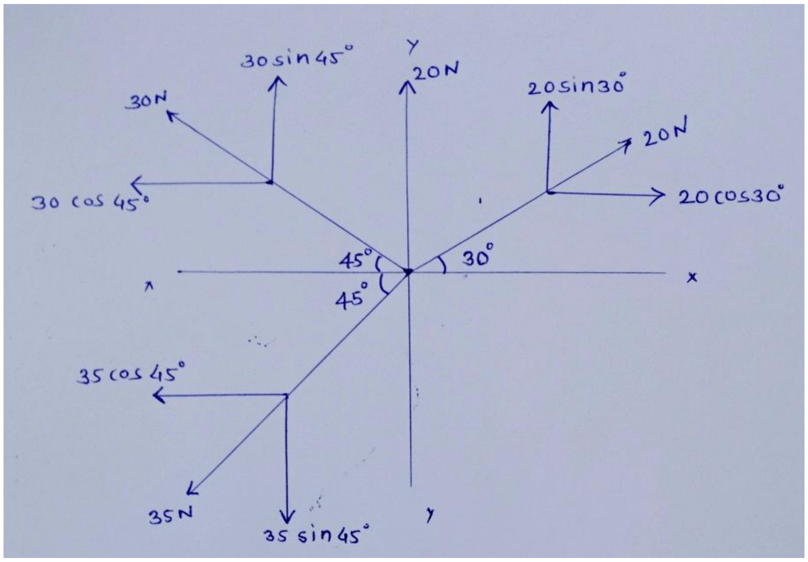
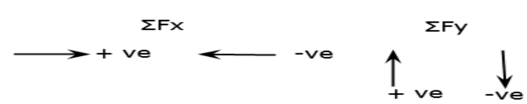


Fig.No.-01

Find **ΣFx** and ΣFy

1M



Sign Convention for Resolution of Forces

Let us first find ΣFx

$\Sigma Fx = 20\cos 30 - 30\cos 45 - 35\cos 45$

$\Sigma Fx = 17.32 - 21.21 - 24.74$

$\Sigma Fx = -28.63\ N$

1M

Find ΣFy

$\Sigma Fy = 20 + 20\sin 30 + 30\sin 45 - 35\sin 45$

$\Sigma Fy = 20 + 10 + 21.21 - 24.74$

$\Sigma Fy = 26.46\ N$

We have,

$R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2}$

$R = \sqrt{(-28.63)^2 + (26.46)^2}$

R= 38.98 N…… (Ans.)

Direction of Resultant ($\theta) = \tan^{-1}\left|\frac{\Sigma Fy}{\Sigma Fx}\right|$

$\theta = \tan^{-1}\left|\frac{26.46}{-28.63}\right|$

1M

		$\theta = \tan^{-1}\lvert -0.9242\rvert$ $\theta = \mathbf{42.74^0}$ **.............(Ans.)** As ΣFx is negative and ΣFy is positive so Resultant (R) will be in second Quadrant making an angle of 42.74^0 with x-axis.	1M
	b)	State four properties of couple (any four- One mark each) • The resultant of the forces of couple is zero • The resultant of couple is equal to the product of one of the force and arm of couple. • Moment of a couple about any point is constant. • A couple can be balanced by only by another couple of equal and opposite movement. • Two or more couple are said to be equal when they have same sense and moment. • Any number of coplanar couples can be represented by a single couple, the moment of which is equal to the algebraic sum of the moment of all the couples.	4M
	c)	In a differential axle and wheel, the diameter of wheel is 40 cm and diameters of axle are 10 cm and 8 cm. If an effort of 50 N can lift a load of 1500 N, find the efficiency of the machine. **Solution.** **Given Data-:** Diameter of Effort Wheel (D) = 40 cm Diameter of bigger axle (d_1) = 10 cm Diameter of smaller axle (d_2) = 8 cm Effort (P) = 50 N Load (W) = 1500 N **Calculate Velocity Ratio (V.R)** $VR = \frac{2D}{d1-d2} = \frac{2 \times 40}{10-8} = 40$ **Calculate Mechanical Advantage (M.A.)** $MA = \frac{W}{P} = \frac{1500}{50} = 30$ We know that, $\eta = \frac{MA}{VR} \times 100$	1M 1M

$\eta = \frac{30}{40} \times 100$

η = 75 % (Ans.) 2M

d) Certain machine follows the law P = (0.02W + 14) N.When the load is lifted by 2cm,the effort has to move 150cm.State with reason ,whether the machine is reversible or not.

Solution.

Distance moved by the effort, y = 150 cm

Distance moved by the load, x = 2 cm

The law machine is P = (0.02W + 14) N

So, m = 0.02

Mechanical advantage,

max M.A $= \frac{1}{m}$ 1M

$= \frac{1}{0.02}$

$= 50$

Calculate Velocity ratio (V.R)

$V.R = \frac{y}{x} = \frac{150}{2} = 75$ 1M

Calculate Efficiency η %

$\eta = \frac{max.M.A}{V.R} \times 100$ 1M

$\eta\,\% = \frac{50}{75} \times 100$

η = 66.67 % 1M

Here obtained efficiency is greater than 50 %, so given machine is reversible.

Q.4 a) **Attempt any <u>THREE</u> of the following** **Marks:12**

A square ABCD of 2m side is subjected to forces as shown in Fig. No. 2.Find the magnitude, direction and position of resultant with respect to A.

1/2M

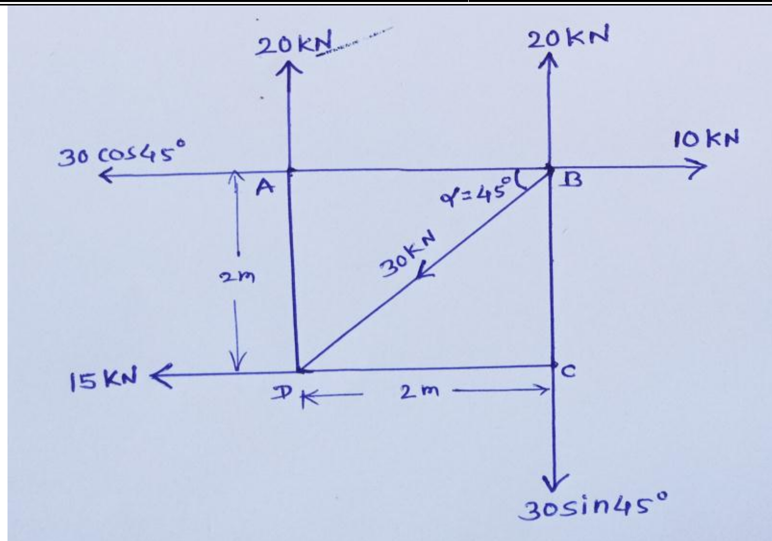


Fig.No.-02

Let us first find ΣFx

$\Sigma Fx = 10 - 15 - 30\cos 45$ 1/2M

$\Sigma Fx = -26.21\ N$ 1/2M

find ΣFy

$\Sigma Fy = 20 + 20 - 30\ Sin45$

$\Sigma Fy = 18.78\ N$

$R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2}$

$R = \sqrt{(-26.21)^2 + (18.78)^2}$

R= 32.24 N…… Magnitude of Resultant

Direction of Resultant (θ) = $\tan^{-1}\left|\frac{\Sigma Fy}{\Sigma Fx}\right|$

$\theta = \tan^{-1}\left|\frac{18.78}{-26.21}\right|$ 1/2M

$\theta = \tan^{-1}|-0.7165|$

$\theta = 35.62^0$**…………Direction of Resultant.**

ΣFx is negative and ΣFy is positive so Resultant is lies in Second quadrant. 1/2M

Taking moment about point A

$\Sigma M_A = -(20\times 2) + (15 \times 2) + (30\ Sin\ 45\times 2)$

= 32.42 kN-m 1/2M

Let x be the perpendicular distance of R from point A,

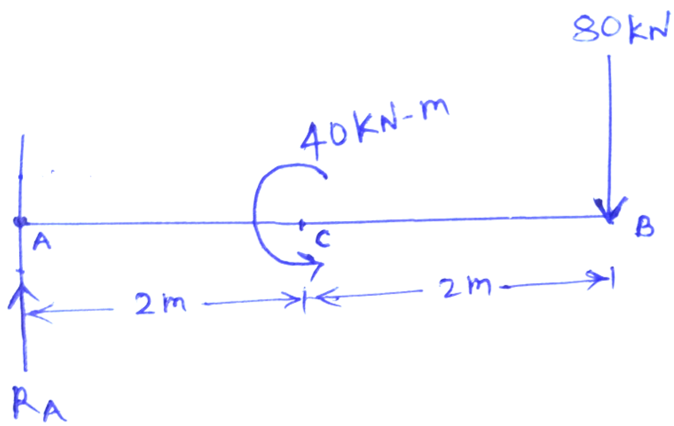
Using Varignons theorem of moment,

$\Sigma M_A = R \times x$ 1M

$32.42 = 32.34 \times x$

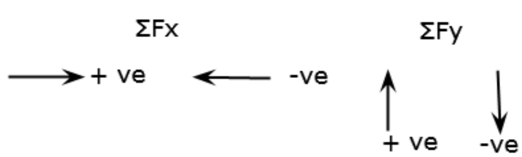
$x = 1.002$ ………..Position of the resultant from point A.

b) A cantilever is loaded as shown in Fig. No. 3. Find the support reaction.



1M

Fig.No.-03



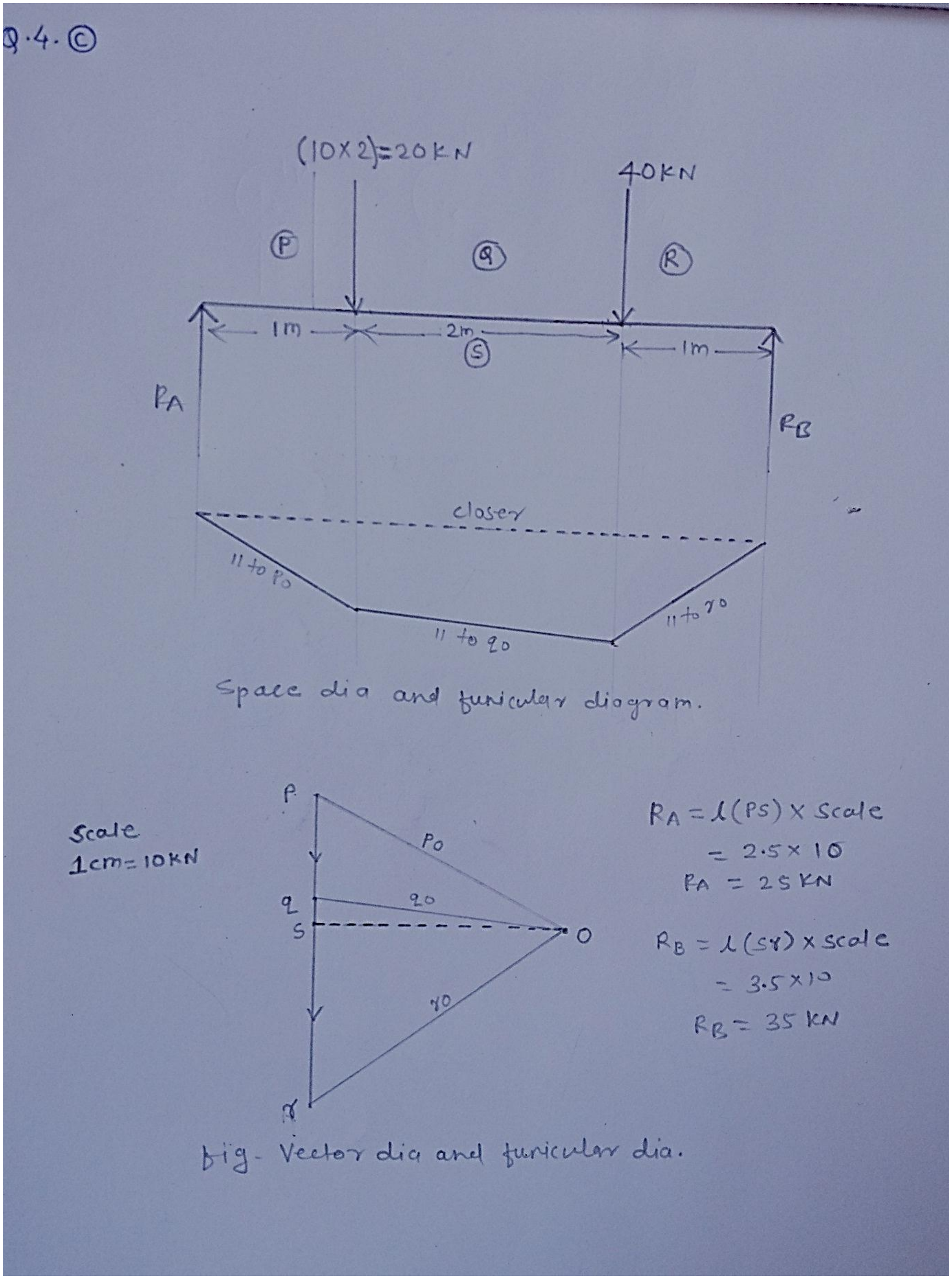
$\Sigma Fy = 0$ …….Conditions of equilibrium

$R_A - 80 = 0$

$\mathbf{R_A = 80\ kN}$ **…….Support reaction**

3M

c)



1M

1M

2M

d) A body of weight 12kN is lying on rough horizontal plane for which $\mu = 0.70$ as shown in Fig. No. 5. Determine normal reaction, limiting force of friction, horizontal force required to move it and angle of friction

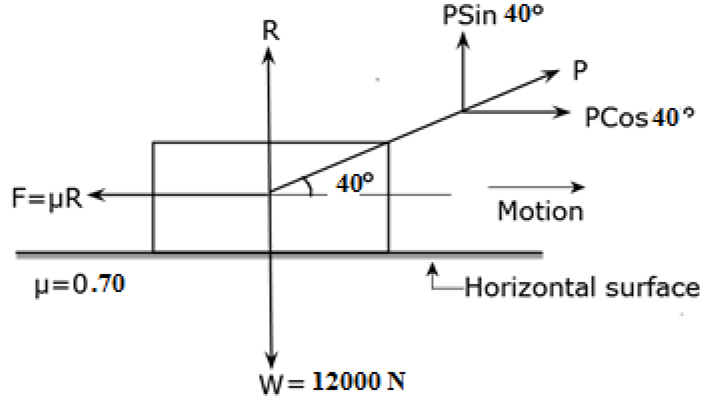
Given Data:

Weight of Body (W) = 12 kN = 12000 N

Coefficient of friction (μ) = 0.70

Applied force (P) = ?

Given Condition: Body Kept over Horizontal plane and force is inclined at an angle to Horizontal (θ) = 40°



1/2M

Fig. No.-5

For Limiting Equilibrium:

$\sum Fx = 0$ $\longrightarrow$ +ve $\longleftarrow$ –ve

$\therefore$ + P cos40° – F = 0

$\therefore$ P (0.766) – μR = 0

$\therefore$ P (0.766) = 0.70R

$\therefore$ $R = \frac{0.766P}{0.70}$ 1/2M

$\therefore$ R = 1.094P .... (i)

For Limiting Equilibrium:

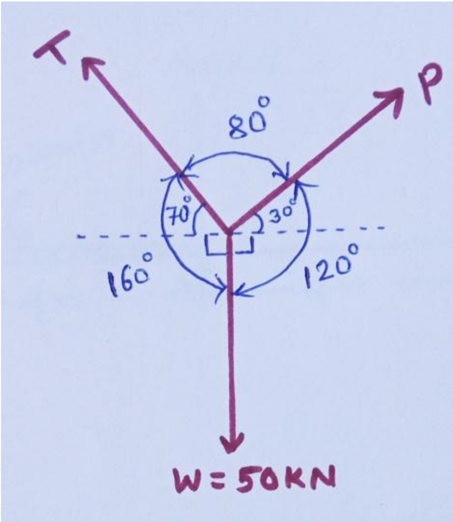
$\sum Fy = 0$ $\uparrow$ +ve $\downarrow$ –ve

$\therefore$ P sin40°+ R – 12000 = 0

$\therefore$ 0.6427P + R – 12000 = 0

$\therefore$ R = 12000 – 0.6427P .... (ii)

From Equation (i) and (ii), we get

		$1.0943P = 12000 - 0.6427P$ $\therefore \quad 1.0943P + 0.6427P = 12000$ $\therefore \quad 1.737P = 12000$ $\therefore \quad P = \frac{12000}{1.737}$ $\therefore$ **P = 6908.46 N** or 69.08 kN ....Applied force From equation (i) $R = 1.094P$ $= 1.094 \times 6908.46$ **R = 7557.85 N** …………………………Normal reaction Also, $F = \mu R$ $= 0.70 \times 7557.85$ **F = 5290.49 N** …………………Limiting force of friction We have, $\tan\emptyset = \mu$ $\emptyset = \tan^{-1}\lvert 0.70 \rvert$ **$\emptyset = 34.99^0$ …………………Angle of friction**	1/2M 1M 1/2M 1/2M
	e)	A body of weight 50kN is hung by means of string to ceiling .Determine the pull required and tension in the string when string has an inclination 70^0 with the ceiling and pull is applied at 30^0 with horizontal. Refer Fig. No.6.  **Fig.No.-06** $\alpha = 160^0$, $\beta = 120^0$ and $\gamma = 80^0$	1/2M 1M

By using Lamis theorem,

$$\frac{P}{\sin\alpha} = \frac{T}{\sin\beta} = \frac{W}{\sin\gamma}$$

$$\frac{P}{\sin 160} = \frac{T}{\sin 120} = \frac{50}{\sin 80}$$ 1M

Consider,

$$\frac{P}{\sin 160} = \frac{50}{\sin 80}$$

$$P = \frac{50 \text{ Sin } 160}{\sin 80}$$

P =17.36 kN 1M

Consider,

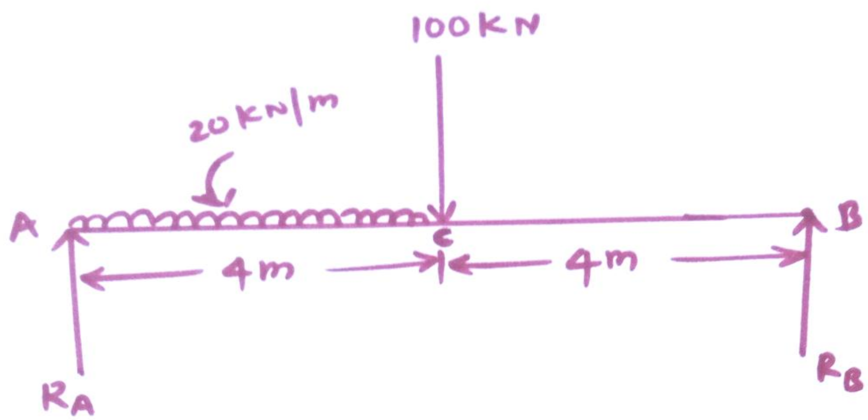
$$\frac{T}{\sin 120} = \frac{50}{\sin 80}$$

$$T = \frac{50 \text{ Sin } 120}{\sin 80}$$

T = 43.96 kN 1M

Q.5 a) **Attempt any TWO of the following** **Marks:12**

For the beam as shown in fig No. 7., calculate reaction at roller and hinge support by analytical method.



1M

Fig.No.-07

To find: Reaction at support R_A and R_B.

Now, $\Sigma F_y = 0$ (Sign Convention + ve ↑ –ve ↓)

$R_A + R_B - (20 \times 4) - 100 = 0$

$R_A + R_B - 180 = 0$ 1M

$R_A + R_B = 180$ ………equation (1)

Applying

$\Sigma M_A = 0$ ……………. Taking moment about point A, 1M

Considering clockwise moment is positive and anticlockwise moment is negative.

$(20 \times 4 \times 2) + (100 \times 4) - (R_B \times 8) = 0$

$160 + 400 + - 8R_B = 0$ 1M

$560 - 8R_B = 0$

$R_B = \frac{560}{8}$ 1M

$\mathbf{R_B = 70\ kN}$…………….. Support Reaction at point B

By putting $\mathbf{R_B = 70\ kN}$ in equation (1) we get,

RA + 70 =180 1M

RA= 110kN………………Support Reaction at point A

b) A Body of weight 600N is resting on rough inclined plane at an angle of 40°. If the Coefficient of friction is 0.58. What force is required to prevent the body from falling down the plane?

Given Data:

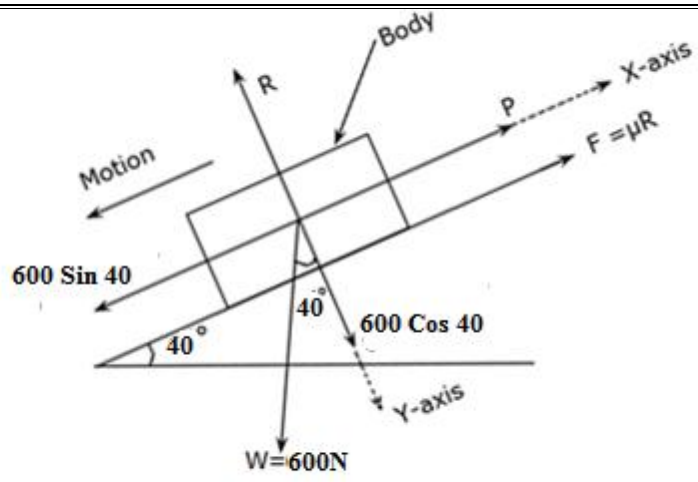
Weight of Body (W) = 600N

Coefficient of friction (μ) = 0.58

Angle made by inclined plane with horizontal $(\propto) = 40°$

Applied force (P) = ?

Given Condition: Body kept over inclined plane and force is parallel to plane.



1M

For Limiting Equilibrium:

$\sum Fy = 0$ ↑ +ve ↓ –ve 1M

∴ – 600 cos40° + R = 0

∴ – 459.62 + R = 0

∴ **R = 459.62 N** ....Normal Reaction 1M

But we know that,

∴ F = μR

∴ F = 0.58 × 459.62 1M

∴ **F = 266.57 N** ....Frictional force

For Limiting Equilibrium:

$\sum Fx = 0$ ⟶ +ve ⟵ –ve 1M

∴ – 600 sin40 + F + P = 0

∴ –385.67 + 266.57 + P = 0

∴ –119.10 + P = 0 1M

∴ **P = 119.10 N** ....Applied force

c) Calculate the resultant and locate its position w.r.t. point A for the force system as shown in Fig.No.8.

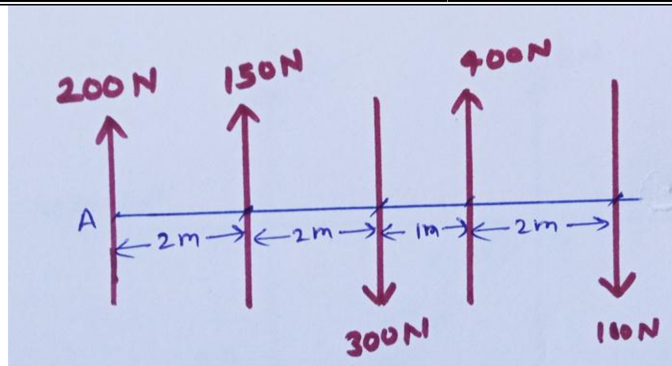


Fig.No-08

Taking moment about point A

ΣM_A = - (150 × 2) + (300× 4)−(400×5) + (100×7) **or** + (150 × 2) − (300 × 4) + (400× 5) - (100 × 7) 2M

= - 400 N-m = 400 N-m

= 400 N-m (anticlockwise moment)

ΣR = 200 +150−300 + 400−100

R = 350N

By using varignons theorem, 2M

$\Sigma M_A = R \times x$

350 = 400 × x

$x = \frac{350}{400}$ 2M

x = 0.875 …………Position of the resultant from point A.

Q.6 a)

Attempt any TWO of the following **Marks:12**

Find the position of Centroid for T- section as shown in fig.No.-09

Solution:

1M

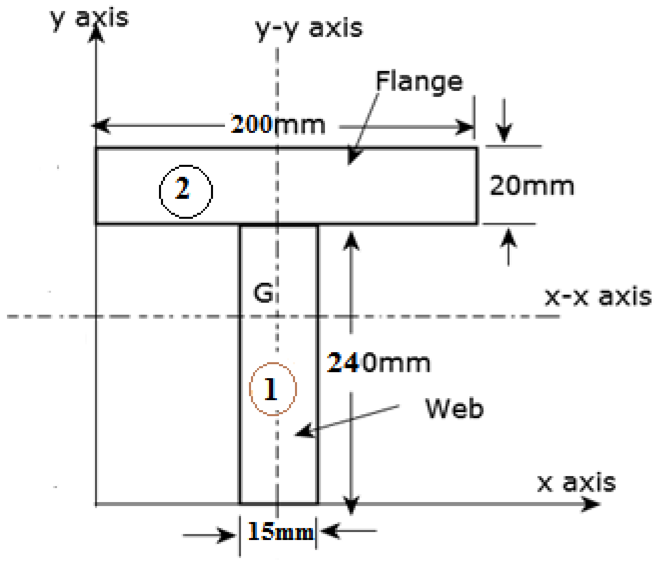


Fig.No.-09

1M

Area calculation:

1M

Area of web (A_1) = 240 × 15 = 3600 mm^2

Area of flange (A_2) = 200 × 20 = 4000 mm^2

Note: **Vertical** Part is called as **Web** or **Rib** and **Horizontal** Part is called as **Flange**.

To calculate centroidal position $\bar{x}$ from y -axis: 1M

Given T section is symmetrical to y-y Axis

$$\bar{x} = \frac{\text{Maximum length of Tsection}}{2}$$

$$\bar{x} = \frac{200}{2}$$

$\bar{x}$ **= 100 mm (Ans.)**

To calculate centroidal position of $\bar{y}$ from x- axis:

$$y_1 = \frac{240}{2}$$ 1M

y_1 = 120 mm

$$y_2 = 240 + \frac{20}{2}$$

y_2 = 250 mm

$$\bar{y} = \frac{A1\ y1 + A2\ y2}{A1 + A2}$$

$\bar{y} = \frac{(3600 \times 120) + (4000 \times 250)}{(3600 + 4000)}$

$\bar{y}$ = 188.421 mm (Ans.)

Centroid ($\bar{x}$, $\bar{y}$) = (100mm, 188.421mm) (Ans.) 1M

b) ABCD is a square plate of uniform thickness having each side of 300 mm.With A as a center and 300mm as radius, a quarter circular portions ABD is removed as shown in Fig. No. 10. Locate the centroid of the remaining plate.

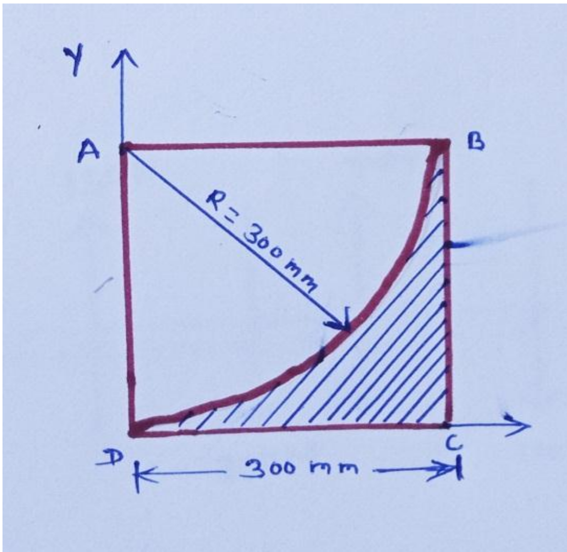


Fig.No.-'10

Area calculation:

Area of Square (A_1) = $(Side)^2 = (300)^2 = 90000\ mm^2$ 1M

Area of Quarter circle (A_2) = $\frac{1}{4} \times \pi r^2$

$= \frac{1}{4} \times \pi \times 300^2$

$= 70685.83\ mm^2$

To calculate centroidal position $\bar{x}$ from y axis:

$x_1 = \frac{300}{2}$ 1M

$x_1 = 150$ mm

$x_2 = \frac{4r}{3\pi} = \frac{4 \times 300}{3\pi}$

$x_2 = 127.32$ mm 1M

$\bar{x} = \frac{A1\ x1 - A2\ x2}{A1 - A2}$

$$\bar{x} = \frac{(90000 \times 150) - (70685.83 \times 127.32)}{(90000 - 70685.83)}$$

$\bar{x}$ **= 233 mm**

To calculate centroidal position of $\bar{y}$ from x- axis:

$$y_1 = \frac{300}{2}$$

y_1 = 150mm 1M

$$y_2 = r - \frac{4r}{3\pi} = 300 - \frac{4 \times 300}{3\pi}$$

y_2 = 172.67 mm

$$\bar{y} = \frac{A1\,y1 - A2\,y2}{A1 - A2}$$

$$\bar{y} = \frac{(90000 \times 150) - (70685.83 \times 172.67)}{(90000 - 70685.83)}$$

1M

$\bar{y}$ **= 67.032 mm**

Centroid ($\bar{x}$, $\bar{y}$) = (233mm, 67.032mm) (Ans.)

c)

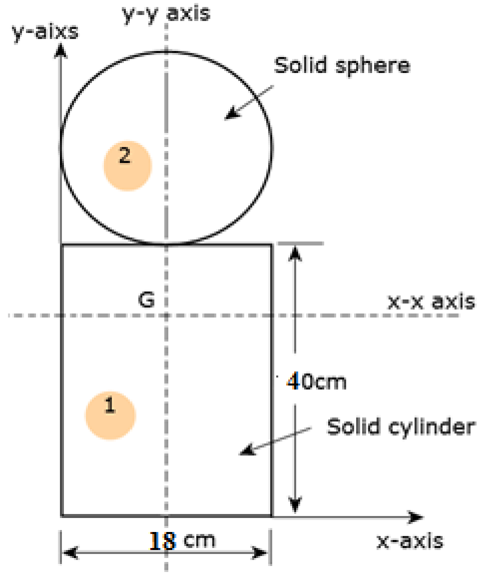
A solid sphere of 18cm in diameter 20 cm is placed on th6e top of a cylinder which is also 18cm in diameter and 40cm high such the their axis coincides. Find the center of gravity of combination. Refer Fig No-11

Solution:

Radius of solid cylinder (R) = $\frac{\text{Diameter of Solid cylinder}}{2} = \frac{18}{2} = 9$ cm 1M

Radius of solid sphere (r) = $\frac{\text{Diameter of Solid sphere}}{2} = \frac{18}{2} = 9$ cm

Height of solid cylinder (H) = 40 cm



1M

Fig.No-11

Volume calculation:

Volume of Solid cylinder (V_1) = $\pi \times R^2 \times H$

$= \pi \times (9)^2 \times 40$

$= 10178.76 cm^3$ 1M

Volume of solid sphere (V_2) = $\frac{4}{3} \times \pi \times r^3$

1M

$= \frac{4}{3} \pi \times (9)^3$

$= 3053.62 cm^3$

Center of gravity position of $\bar{x}$ from y- axis:

Given composite solid is symmetrical to y-y axis:

$\bar{x} = \frac{\text{Maximum length of composite solid}}{2}$

$\bar{x} = \frac{18}{2}$

$\bar{x}$ = 9 cm

Center of gravity position of $\bar{y}$ from x- axis:

1M

$y_1 = \frac{h}{2}$

		$y_1 = \frac{40}{2}$ $y_1 = 20$ cm $y_2 = 40 + r$ $y_2 = 40 + 9$ $y_2 = 49$ cm We know that, $\bar{y} = \frac{V1\ y1 + V2\ y2}{V1 + V2}$ $\bar{y} = \frac{(10178.76 \times 20) + (3053.62 \times 49)}{(10178.76 + 3053.62}$ **$\bar{y}$ = 26.69m** Center of gravity G(**$\bar{x}$, $\bar{y}$) = (9 cm, 26.69m)**	1M 1M