12th September, 2022

Mechanics

* Newton's First Law : A body will remain in state of rest / motion unless a force is applied on it.

Define Force

Ans Force is the physical quantity which changes the state of rest or uniform motion

13th September, 2022

Lesson Plan

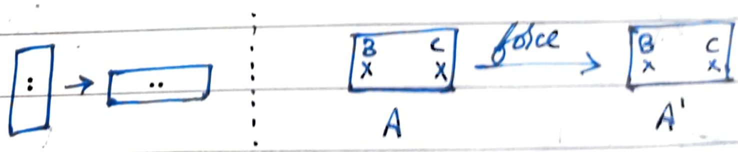
Unit-1 Definitions - Space, Time, Mass, Force, Particle, Rigid body, Scalar quantity & Vector quantity

pdf pg 19 q: What is the rigid body?

Ans. A body is considered rigid when the change in distance between any two of its points is negligible for the purpose at hand.

q: . . . . . purpose at hand meaning.

Ans. * First preference to answer a question is to draw diagram



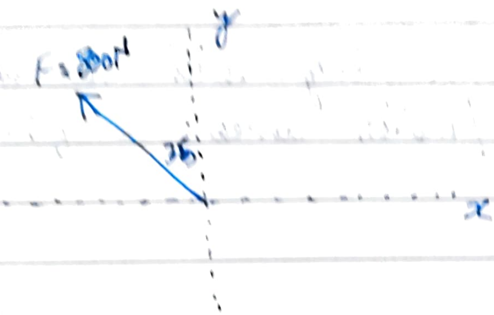
- External and internal effects

Unit 1 [ch. 1. Mechanics, Scalars & Vectors, Basic Concepts
ch 2. ~~Mechanics~~ Force Systems - Introduction, Force, Rectangular components, Moment and the numericals
Numericals - 2/1 to 2/57.

16th September, 2022

Problems pg 16 (pdf)

2/1.



$F_x = 800 \sin 35 (\leftarrow)$
$F_y = 800 \cos 35 (\uparrow)$

F_x = Scalar component = $-456\,N$
$F_y = 655\,N$

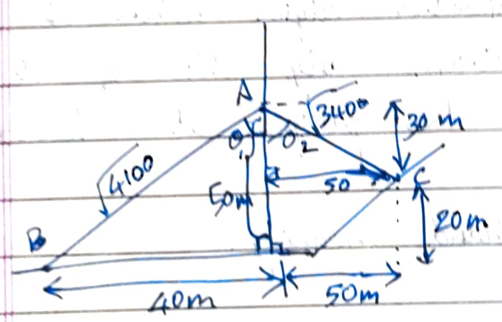
$F = F_x + F_y$
$=$

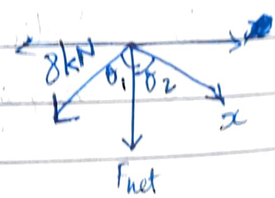
* pg. 5 → Free Vector
~~Every vector~~ Sliding Vector
Fixed Vector

pg. 7 → Newton's I, II, III

Newton's II Law: Rate of change of momentum is directly proportional to Force

2/12.





$8 \sin\theta_1 = x \sin\theta_2$

$8 \times \frac{40}{\sqrt{4100}} = x \times \frac{50}{\sqrt{3400}}$

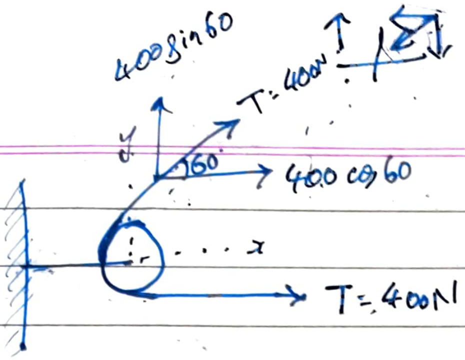
$\cos\theta_1 = \frac{5}{\sqrt{41}}$

$\cos\theta_2 = \frac{3}{\sqrt{34}}$

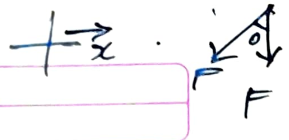
$8 \times \frac{4}{6.4} = x \times \frac{5}{5.83}$

$T_2 = x = 5.83\,kN$

$F_{net} = 8\cos\theta_1 + 5.83\cos\theta_2$
$= 8\left(\frac{5}{\sqrt{41}}\right) + 5.83\left(\frac{3}{\sqrt{34}}\right) = 6.25 + 3 = 9.25\,kN$



2/13.



$$400\left(\frac{\sqrt{3}}{2}\right)\hat{j} + (400+200)\hat{i}$$

$$R = 600\hat{i} + 346\hat{j}$$

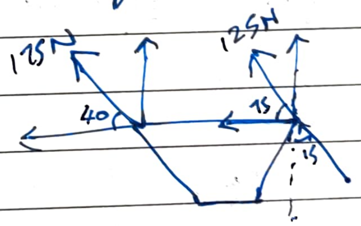
$$R = \sqrt{(600)^2 + (346)^2} =$$

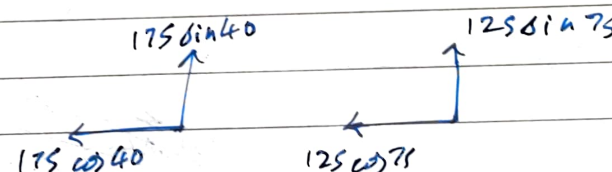
$$= \sqrt{360\,000 + 119716}$$

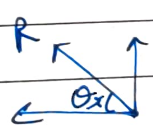
$$= \sqrt{479716} = 692N$$

* Parallelogram law of forces: When two adjacent forces are represented by two adjacent sides of a parallelogram in magnitude & direction then diagonal of the parallelogram represents the resultant ~~of fo~~

2/14.







$$112.48\hat{j} + 120\hat{j} = 233.22\hat{j}$$

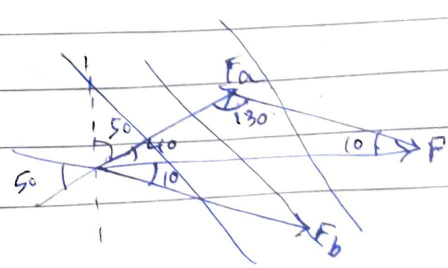
$$134\hat{i} + 32.35\hat{i} = 166.35\hat{i}$$

$$R = 166.35\hat{i} + 233.22\hat{j}$$

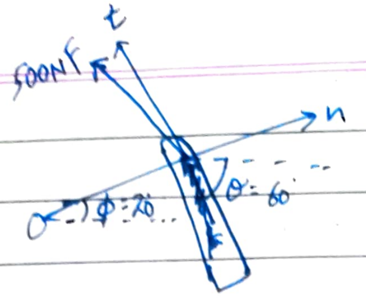
$$\theta_x = \tan^{-1}\left(\frac{233.22}{166.35}\right) \qquad \theta = 54.46^\circ$$

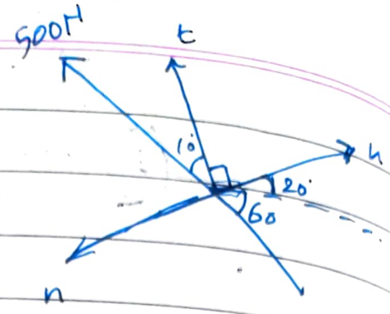
$$\theta_y = 90 - 54.46 = 35.54^\circ$$

2/15.



2/15.

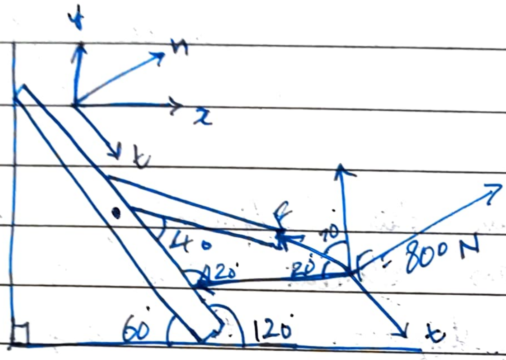


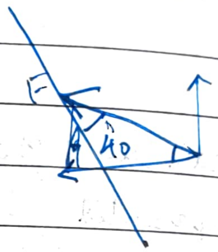


$F_t = 500\cos 10° = 492.4\ N$

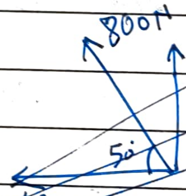
$F_n = 500 \sin 10 = -86.82\ N$

2/16.





10°
60
70

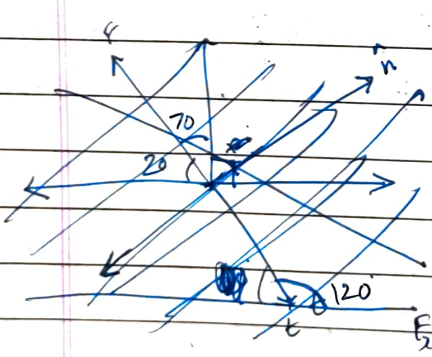


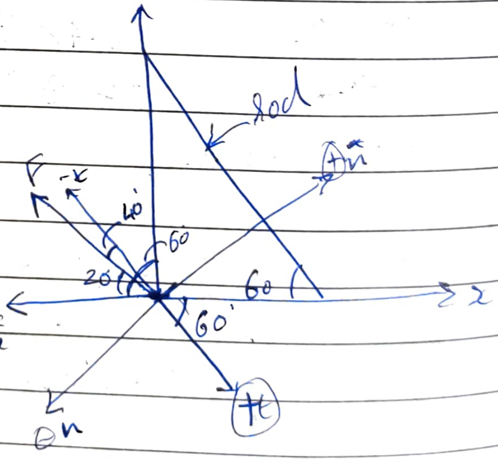
~~$F_y = 800 \sin 50 = 612.83N$~~

~~$800\cos 50 = 514.23\ N$~~

$F_y = -800\cos 20 = -751.7$

$F_x = -800 \sin 20 = 273.6$

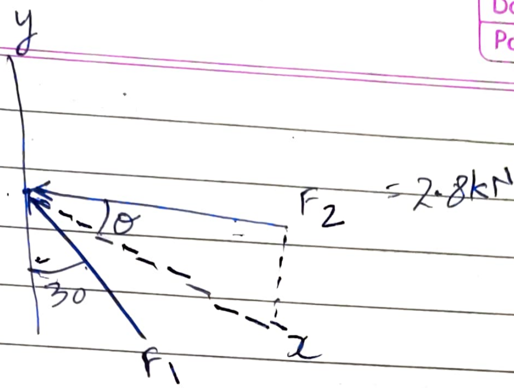




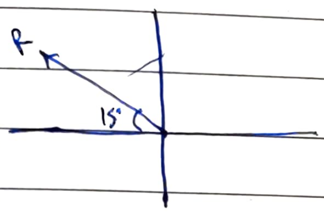
$F_t = -F\cos 40° = -800\cos 40° = -613\ N$

$F_n = -F \sin 40 = -800 \sin 40 = -514\ N$

2/17.

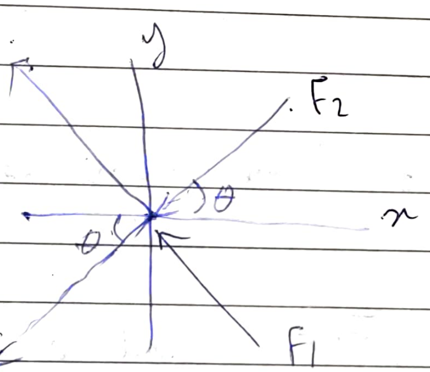


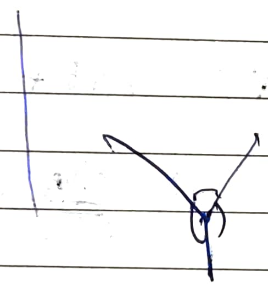
R = 3.5 kN



$F_y = F_1 \cos 30 - F_1 \sin 30$

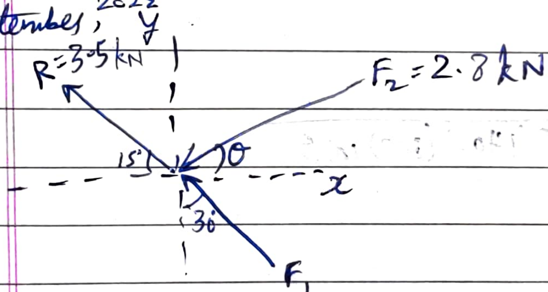
$F_x = 2.8 \cos 60 + 2.8 \sin\theta$





22nd September, 2022

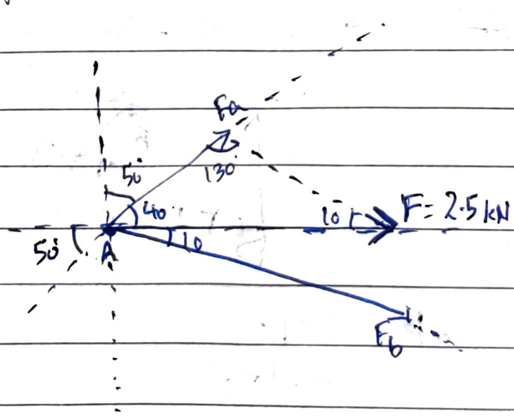
2/17



$R_x = -3.5 \cos 15 = -F_1 \sin 30 - 2.8 \cos\theta$

$R_y = 3.5 \sin 15 = F_1 \cos 30 - 2.8 \sin\theta$

2/22



$\frac{F_a}{\sin 10} = \frac{2.5}{\sin 130} = \frac{F_b}{\sin 40}$

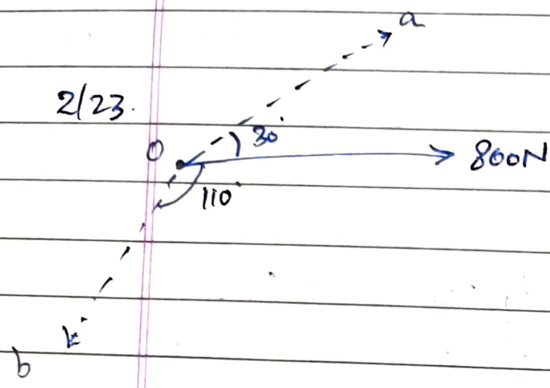
$F_a = \sin 10\,(3.26) = 0.566\ kN$

$F_b = \sin 40\,(3.26) = 2.097\ kN$

$R_a = 1170$
$R_b = 622$

2/1 → rectangular components
standa

2/23.



✱ $a\sin\theta + b\cos\theta = c$ (where a, b, c are numbers)

$$\frac{a\sin\theta}{\sqrt{a^2+b^2}} + \frac{b\cos\theta}{\sqrt{a^2+b^2}} = \frac{c}{\sqrt{a^2+b^2}}$$

let $a = r\sin\alpha$
$b = r\cos\alpha$

25

2/27 $R = \sqrt{(1400)^2 + (800)^2 + 2(1400)(800)\cos\theta}$

$2000 = $ "

$4000000 = 1960000 + 640000 + 2240000\cos\theta$

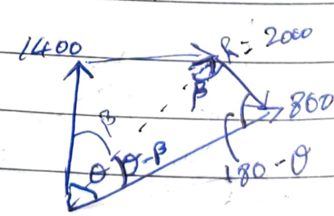
$14\cancel{0000} = 224\cancel{0000}\cos\theta$

$\cos\theta = 0.625$

$\beta = 18.19$

~~θ = 60°~~ $\theta = 51.31$

R eq: vertical



$$\frac{2000}{\sin(180-\theta)} = \frac{800}{\sin\beta}$$

$$\frac{20}{\sin\theta} = \frac{8}{\sin\beta}$$

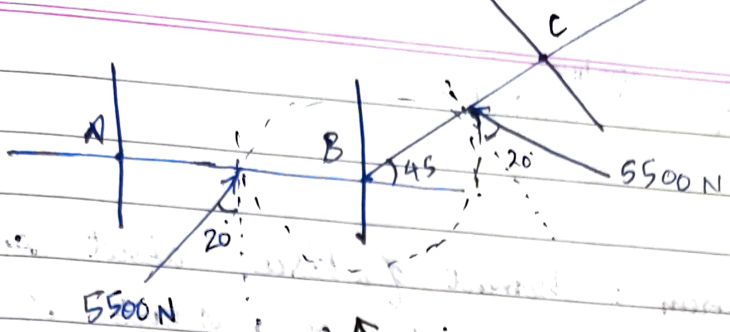
$\sin\beta = 0.312$

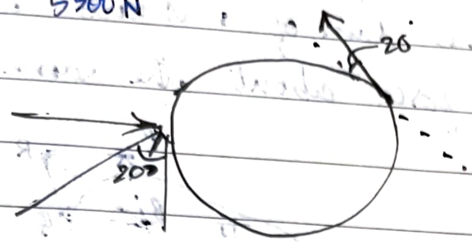
$\beta = 18.179°$

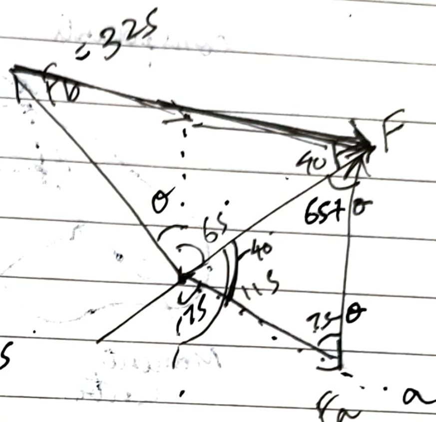
2/28.

Page

$$\begin{array}{r} 90 \\ -65 \\ \hline 25 \end{array}$$







$$\cancel{\frac{F}{\sin 75} = \frac{325}{\sin 40}}$$

$\cancel{F = 488.38}$

$\cancel{F_b =}$

$F_b = 325$

$F_a = 325$

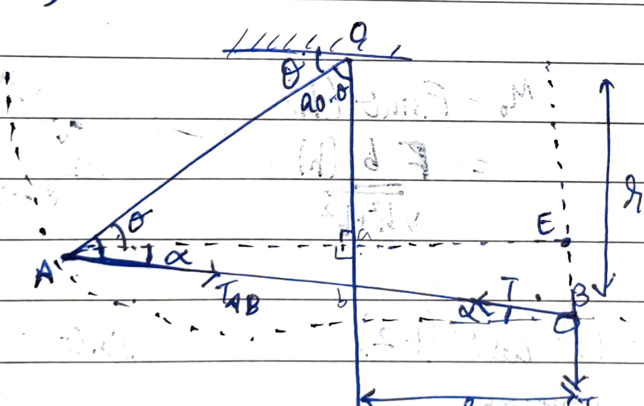
$F \cos 40 = 325$

$F = 424.28\,N$

$$\frac{424.28}{\sin(75-\theta)} =$$

Write step-by-step procedure

29th September, 2022.



$$\cos\alpha = \frac{Aa}{Ab}$$

$$\sin\alpha = \frac{ab}{Ab}$$

$$\sin\theta = \frac{Oa}{OA}$$

$$\cos\theta = \frac{Aa}{OA}$$

$$\cos\alpha = OA\cos\theta$$

assumptions: inelastic cable, frictionless pulley

$$\tan\theta = \frac{Oa}{Aa} \qquad \tan\alpha = \frac{ab}{Aa}$$

$$ab = Ob - Oa = r - r\cos(90-\theta) = r(1-\sin\theta)$$

$$AE = r + r\cos\theta = r(1+\cos\theta)$$

$$\sin\alpha = \frac{1-\sin\theta}{\sqrt{(1-\sin\theta)^2+(1+\cos\theta)^2}} = \frac{1-\sin\theta}{\sqrt{3+2\cos\theta-2\sin\theta}}$$

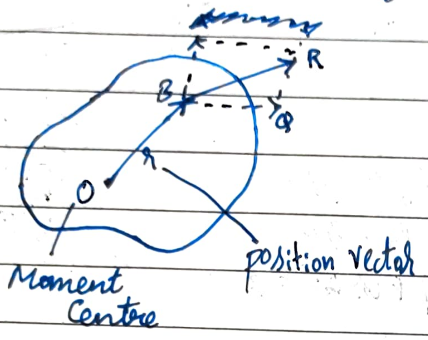
$$\cos\alpha = \frac{1+\cos\theta}{\sqrt{3-2\sin\theta+2\cos\theta}}$$

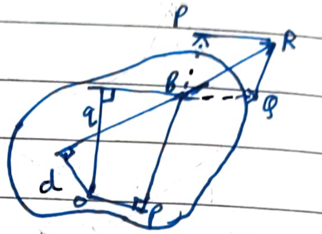
$T_y = T\sin\alpha \qquad T_x = T\cos\alpha$

q: Can there be a negative projection

6th October, 2022

Varignon's Theorem : Moment of a Force about any point is equal to the sum of moments of the components of the force about the same point



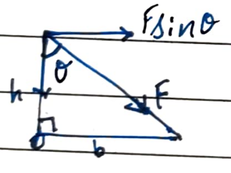


2/31.

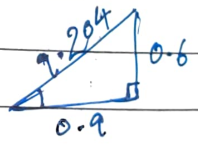
$M_O = 5\cos 60(12) - 5\sin 60(15)$

$M_B = -5\cos 60(4) - 5\sin 60(15)$

2/32.



$$M_O = F\sin\theta\,(h) = F\frac{b}{\sqrt{h^2+b^2}}(h)$$



2/33 $150\sin\theta(0.3) - 150\cos\theta(1.2)$

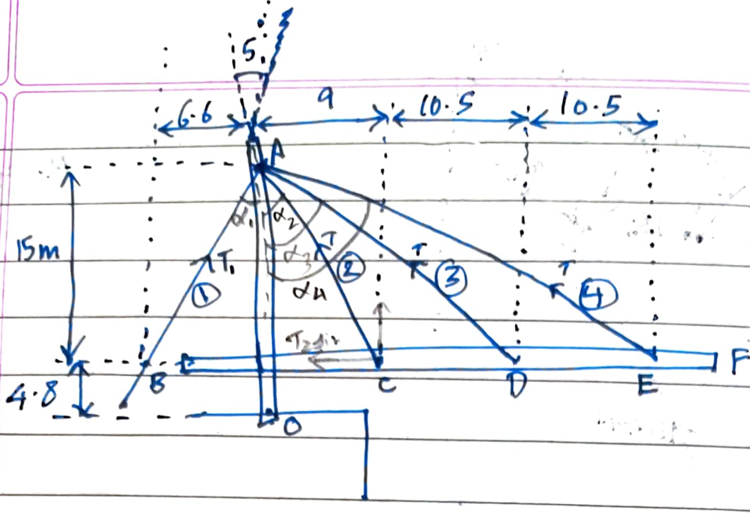
$22.42 - 134.55$

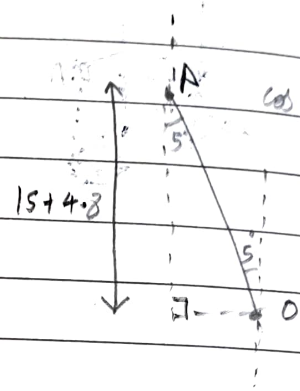
112.13 Nm CW.

$\sin\theta = \frac{0.6}{1.204}$

$\cos\theta = \frac{0.9}{1.204}$

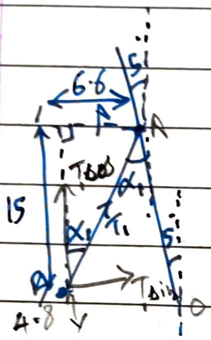
2/57.





$\cos 5^\circ = \dfrac{19.48}{AO}$

$AO = \dfrac{19.48}{\cos 5^\circ}$



$\alpha_1 = \tan^{-1}\left(\dfrac{6.6}{15}\right) = 23.7^\circ$

$\alpha_2 = \tan^{-1}\left(\dfrac{9}{15}\right) = 30.9^\circ$

$\cancel{\alpha_3 = \tan^{-1}\left(\dfrac{10.5}{15}\right)} = \quad \alpha_3 = \tan^{-1}\left(\dfrac{9+10.5}{15}\right) = 52.4^\circ$

$\alpha_4 = \tan^{-1}\left(\dfrac{10.5+10.5+9}{15}\right) = \cancel{26.56} \; 63.43^\circ$

$M_O = 0$

$\left(-T_1 \sin(\alpha_1 + 5^\circ) + T\sin(\alpha_2 - 5^\circ) + T\sin(\alpha_3 - 5^\circ) + T\sin(\alpha_4 - 5)\right)\dfrac{19.48}{\cos 5^\circ} = 0$

$T_1 \sin(28.7) = T\sin(25.9) + T\sin(47.4) + T\sin(58.4)$

$T_1(0.48) = T(2.024)$

$\cancel{T_1 = 3.35\,T} \quad T_1 = 4.21\,T$

compression about P

$P = T_1\cos(\alpha_1 + 5^\circ) + T\left[\cos(\alpha_2 - 5) + \cos(\alpha_3 - 5) + \cos(\alpha_4 - 5)\right]$

$P = 5.79\,T$

4 1mark
4 2mark
2 4mark

Date
Page

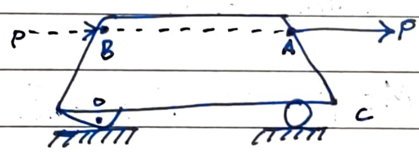
Free vector : A free vector is one whose action is not confined to or associated with a unique line in space.

	Free Vector	Sliding Vector	Fixed Vector
Unique Point of Action	×	×	✓
Unique Line of Action	×	✓	✓

11th October, 2022

q. How do we get $g = 9.81 m/s^2$

Principle of Transmissibity → Similar to sliding vector.
↓
states that a force may be applied at any point on its given line of action without alternating the resultant effects of the force external to the rigid body on which it acts.



6.9

* Vector is a generalised form of a force.

* Moment → Scalar method
→ Vector method

17th October, 2022

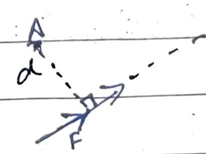
Moment

– definition - Rotational tendency of force
– diagram
– Vector & scalar

$\vec{r}' \times \vec{F}$ Fd

position vector from the moment centre to any point on the line of action of force

dist. b/w point of app of force & moment centre



& can easily determine

If we know perpendicular dist b/w the line of action of force & moment centre then scalar is better.

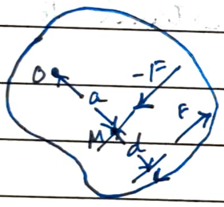
However if F & r are not perpendicular then vector is better.

UNIT-2

COUPLE

The moment produced by two equal, opposite and non collinear forces is called a couple.

Unique property of a couple : * Moment of the couple is same for all moment centres.



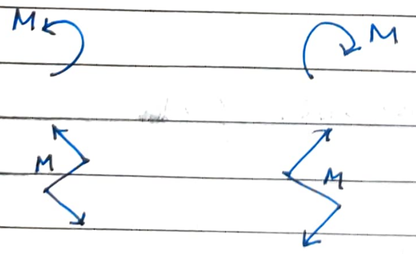
$(M_{F_k})_O = F(a+d)$

$(M_{F_M})_O = -F(a)$

$M = F(a+d) - F(a) = Fd$

* Couple is a free vector

→ Sign convention: Right hand rule



Equilibriant ?

Equilibrium: set of forces whose resultant is 0