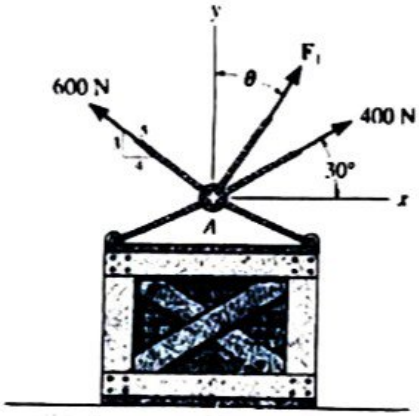
INDIAN INSTITUTE OF TECHNOLOGY JODHPUR
Mid Term Examination 01 (06th September 2023)

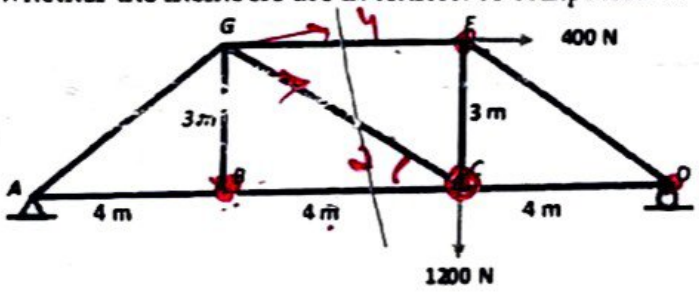
Program: B. Tech | **Semester: First (1st)**
Course Code: MEL1010 | **Course Name: Engineering Mechanics**
Total Marks: 15 | **Duration: 01 hours**

Instructions: 1. Attempt all the questions
2. Provide diagram wherever necessary
3. Write each step of the problem solving clearly

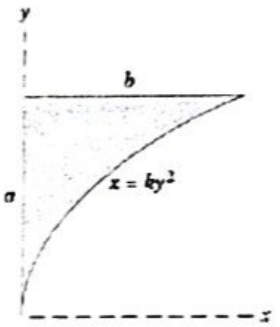
Question 1: Determine the magnitude and direction measured counterclockwise from the positive x axis of the resultant force of the three forces acting on the ring A. It is give that $F_1 = 500$ N and $\theta = 20°$ **(5 Marks)**



Question 02: Determine the force in members GE, GC and BC of the truss shown in figure. Mention whether the members are in tension or compression. **(5 Marks)**



Question 03: Determine the coordinates of the centroid of the shaded area. **(5 Marks)**



INDIAN INSTITUTE OF TECHNOLOGY JODHPUR

Session: 2023/24

MEL1010 Engineering Mechanics - Minor Test 1

February 10th, 2024 Time (8:00 - 9:30 PM) **Total: 30 Marks**

Instructions

1. **Question paper consists of 4 questions in two printed pages. Make sure all the questions are printed**
2. **Answer all the questions no optional question is provided**
3. **All steps must be presented**
4. **Please draw Free Body Diagram (FBD) neatly and indicate the axes properly**
5. **Scientific Calculators are allowed and any other device is NOT allowed.**

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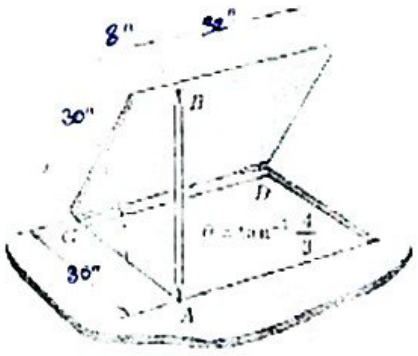
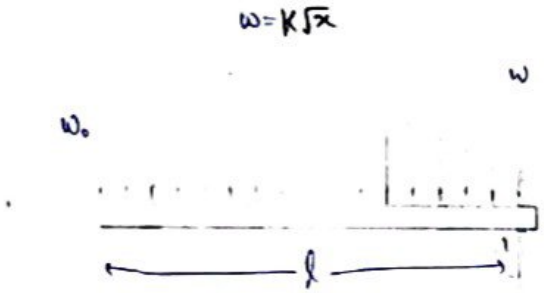
1. A 10 lb-weight is supported by the cord AC and roller and by a spring. If the spring has an unstretched length of 8 inches and the weight is in equilibrium when d is 4 inches determine the stiffness of the spring. **(6 marks)**

2. The uniform 30 X 40 inch trap door weighs 200 lb and is propped open by the light strut AB at the angle θ, where tan θ=4/3. Calculate the compression F_B in the strut and the force supported by the hinge D normal to the hinge axis. Assume that the hinges act at the extreme ends of the lower edge. **(4.5+4.5 marks)**



3. Determine the force in members CD, CF, and FG of the truss. Indicate if the members are in tension or compression. You may use either method of joints or method of sections. **(8 marks)**

4. Determine the force Fy, Fz and moment reactions M_x at the support A of the cantilever beam subject to the load distribution **(7 marks)**



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5. **Scientific Calculators are allowed and any other device is NOT allowed.**

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1. A 10 lb-weight is supported by the cord AC and roller and by a spring. If the spring has an unstretched length of 8 inches and the weight is in equilibrium when d is 4 inches determine the stiffness of the spring. **(6 marks)**

2 Marks

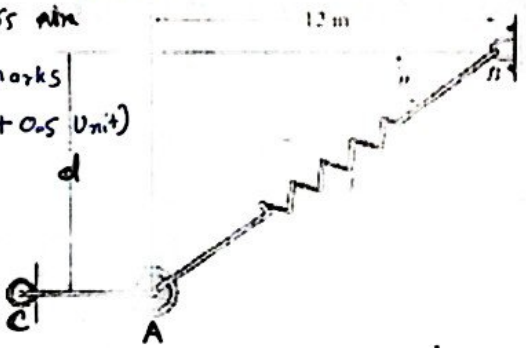
Change in length $\Delta L = 4.65$ in

Tension ≈ 31.62 lb 2 Marks (1.5 Cal + 0.5 Unit)

FBD 1 Marks

Stiffness - $k \approx 6.85$ lb/in

2 Marks [1.5 Cal + 0.5 Unit]

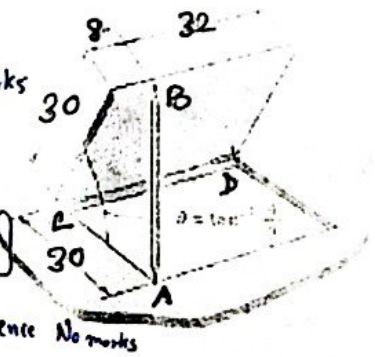


Total - 6 Marks

2. The uniform 30 X 40 inch trap door weighs 200 lb and is propped open by the light strut AB at the angle θ, where tan θ=4/3. Calculate the compression FB in the strut and the force supported by the hinge D normal to the hinge axis. Assume that the hinges act at the extreme ends of the lower edge. **(4.5+4.5 marks)** Total- 9 Marks

FBD 2 Marks

$\vec{F}_{AB} = [-3i + 2j + 6k]\frac{F_{AB}}{7}$ 0.5 Marks



$\vec{r}_{CA} = 30i$

$\vec{r}_{CE} = 9i + 20j + 0k$

$\vec{r}_{CO} = 0i + 40j + 0k$

} 0.5 Marks

$F_{AB} \approx 70$ lb 2 Marks [1.5 Cal + 0.5 Unit]

$D_y = 0$ ← No calculation required Hence No marks

$D_x = 15$ lb 1.5 Marks [1 Cal + 0.5 Unit]

$D_z = 100$ lb 1.5 Marks [1 Cal + 0.5 Unit]

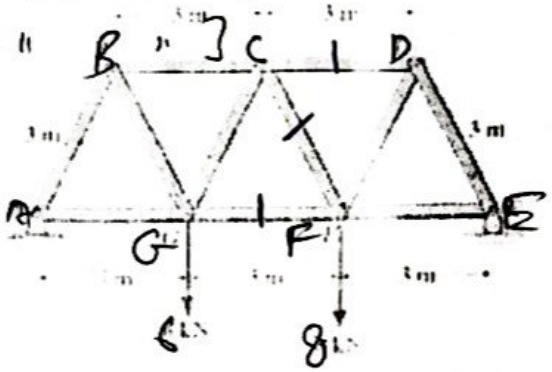
$D \approx \sqrt{D_x^2 + D_y^2 + D_z^2}$

≈ 101.12 lb 1 Marks [0.5 Cal + 0.5 Unit]

3. Determine the force in members CD, CF, and FG of the truss. Indicate if the members are in tension or compression. You may use either method of joints or method of sections. **(8 marks)**

R_A = 6.67 kN 1 Marks [0.5 Col + 0.5 Unit]

R_E = 7.73 kN 1 Marks [0.5 Col + 0.5 Unit]



F_{CD} = 8.46 kN (C)

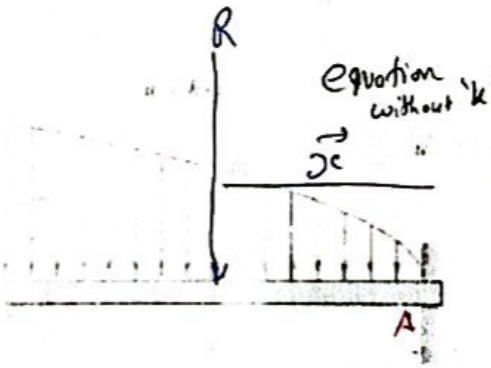
F_{FC} = 0.77 kN (T)

F_{GF} = 8.075 kN (T)

2 Marks for each

[1 Col + 0.5 Unit + 0.5 Type/Nature]

4. Determine the force Fy, Fz and moment reactions M_A at the support A of the cantilever beam subject to the load distribution (7 marks)



$k = \frac{w_0}{\sqrt{L}}$

equation without 'k'

$w = \frac{w_0}{\sqrt{L}}\sqrt{x}$ 0.5 Marks

$R = \frac{2}{3} w_0 l$ 1 Marks

$\bar{x} = \frac{3}{5} l$ 1 Marks

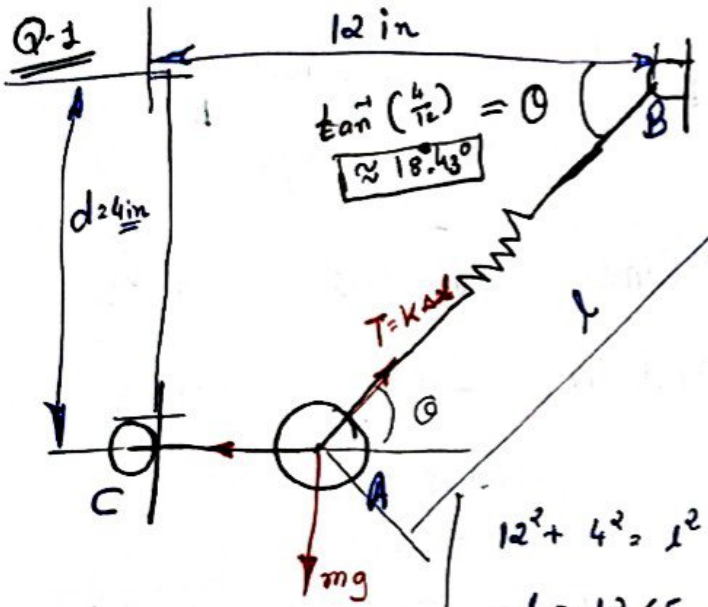
$A_x = 0$ 1 Marks

$A_y = \frac{2}{3} w_0 l$ 1 Marks

$M_A = \frac{2}{5} w_0 l^2$ (CW) 2.5 Marks [2 Marks for Calculation + 0.5 Marks direction]

	budgetary quotations & justification. Annexure IX: Facilities available for carrying out the proposed research work in Applicant's (a) Group (b) Institution (c) Department and (d) co-located DRDO lab. **Certificate:** a. HRA Certification b. Certificate from PI and from DRDO Lab that DRDO facility is not available for project work. c. Reasonability certificate provided by PI for the budgetary quotes

Q-1



l_1 Unstretched string length = 8 in

Equillibrium at A

$12^2 + 4^2 = l^2$

$l = 12.65$ in

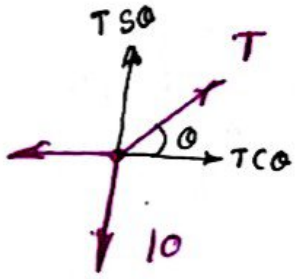
$\Delta l = l - l_1$

$\Delta l = 4.65$ in (1)

$T = k\Delta l$

$k = \frac{31.62 \times 12}{4.65}$

$k \approx 81.6$ lb/ft or 6.85 lb/in (2) (1.5+0.5 Unit)



FBD (1)

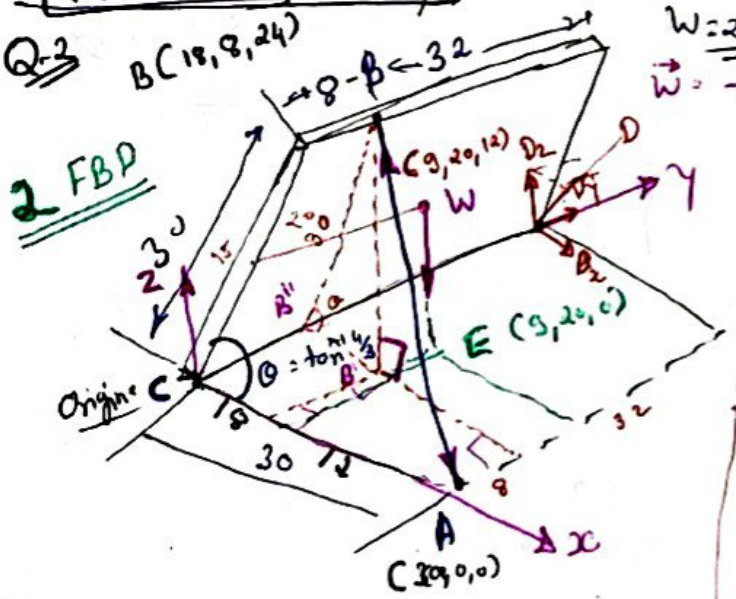
$\sum V = 0 \Rightarrow 10 = T S\theta$

$T \approx 31.62$ lb (2)

(1.5+0.5 Unit)

1190 N/m

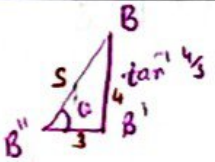
Q-3



2 FBD

W = 200 lb

$\vec{W} = -200k$



$\sin\theta = 0.8$

$\cos\theta = 0.6$

$B'B'' = BB'' \cos\theta = 18$

$BB' = BB'' \sin\theta = 24$

$\vec{AB} = [8^2 + 12^2 + 24^2]$

$|\vec{AB}| = 28$ in

$\vec{r}_{CA} = [30i + 0j + 0k]$

$\vec{r}_{CE} = [9i + 20j + 0k]$

$\vec{r}_{CO} = [0i + 40j + 0k]$

0.5

Direction Cosin for AB

$\vec{F}_{AB} = (-3i + 2j + 6k)\frac{F_{AB}}{7}$

$l = \frac{-12}{28} = \frac{-3}{7}$

$m = \frac{8}{28} = \frac{2}{7}$, $n = \frac{24}{28} = \frac{6}{7}$

0.5

$M_{CO} = 0 \rightarrow [(\vec{r}_{CA} \times \vec{BF}_{AB}) + (\vec{r}_{CE} \times W)] \cdot j = 0$

(Moment about y axis is zero)

$\left[30i \times [-3i + 2j + 6k]\frac{F_{AB}}{7} + [9i + 20j] \times [-200k]\right] \cdot j = 0$

$\left[[-180j + 60k]\frac{F_{AB}}{7} + 200[-20i + 9j]\right] \cdot j = 0$

$-\frac{180}{7} F_{AB} + 1800 = 0$

$F_{AB} = 70$ lb ← Ans

[9.Ta] 2 (1.5 + 0.5 Unit)

Q-2 Continue

$M_x = 0$

$[(r_{CO} \times D_x) + (r_{CE} \times W)] \cdot i = 0$

$[40j \times (D_x i + D_y j + D_z k) + (9i + 2j) \times (-200k)] \cdot i = 0$

$[-40 D_x k + 40 D_z i] + 200[2i + 9j] \cdot i = 0$

$40 D_z - 4000 = 0 \Rightarrow \boxed{D_z = 100 \text{ lb}}$

1.5 (1 + 0.5 Unit)

$M_z = 0 \quad [(r_{CO} \times D) + (r_{CA} \times r_{AB})] \cdot k = 0$

$[40j \times (D_x i + D_y j + D_z k) + 30i \times (-9i + 2j + 6k)10] \cdot k = 0$

$[-40 D_x k + 40 D_z i + 600k - 1800j] \cdot k = 0$

$-40 D_x + 600 = 0$

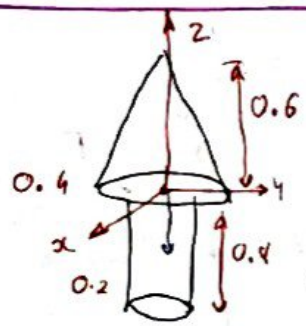
$\boxed{D_x = 15 \text{ lb}}$ 1.5 (1 + 0.5 Unit)

$D = \sqrt{D_x^2 + D_y^2 + D_z^2}$ ($D_y = 0$)

$= \sqrt{15^2 + 100^2}$

$\boxed{D \approx 101.12 \text{ lb}}$ ← ANS 1 [0.5 + 0.5 unit]

Q-4



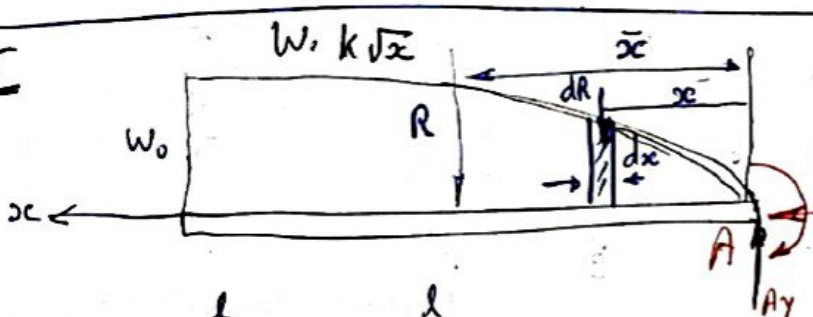
	$\bar{z}$	mass
① Cone	$\frac{h}{4} = 0.15$	904 kg
② Cylinder	-0.4	502 kg

$\bar{z} = \dfrac{904 \times 0.15 - 502 \times 0.4}{904 + 502}$

$\bar{z} = 0.046$ m From given Coordinate

$\bar{z} = 0.954$ m From Base of cylinder

Q-5



$w_0 = k\sqrt{l}$

$\boxed{k = \frac{w_0}{\sqrt{l}}}$

$\Rightarrow \boxed{w = \frac{w_0}{\sqrt{l}}\sqrt{x}}$ (1/2)

$R = \int dR = \int_0^l w\,dx = \int_0^l \frac{w_0}{\sqrt{l}}\sqrt{x}\,dx \Rightarrow \frac{2}{3}\frac{w_0}{\sqrt{l}}\left[x^{\frac{3}{2}}\right]_0^l \quad \frac{2}{3} w_0 l$

$\boxed{R = \frac{2}{3} w_0 l}$ ①

$\bar{x} = \dfrac{\int x\,dR}{\int dR} = \dfrac{\int x w\,dx}{\int w\,dx} = \dfrac{\int_0^l \frac{w_0}{\sqrt{l}} x^{\frac{3}{2}}\,dx}{\frac{2}{3} w_0 l} = \dfrac{\left[x^{\frac{5}{2}}\right]_0^l}{\sqrt{l} \times \frac{5}{2} \times \frac{2}{3} w_0 l} = \frac{3}{5} l \Rightarrow \boxed{\bar{x} = \frac{3}{5} l}$ ①

$\Sigma V = 0 \Rightarrow A_y - R = 0 \Rightarrow A_y = \frac{2}{3} w_0 l$ ✱ ①

$\Sigma H = 0 \Rightarrow \boxed{A_x = 0}$ ✱ ①

$\Sigma M_A = 0 \Rightarrow \frac{2}{3} w_0 l \left(\frac{3}{5} l\right) - M_A = 0$

$\boxed{M_A = \frac{2}{5} w_0 l^2}$ CW ✱ ②

+0.5 direction

Clockwise

Total 2.5 Marks

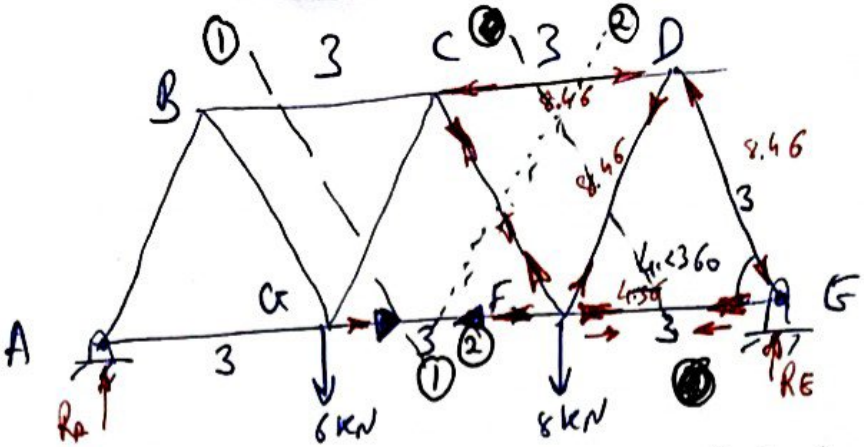
$M_A = 0 \quad 6\times3 + 8\times6 - R_E\times9 = 0$

$R_E\times9 = 18+48$

[0.5 to 0.5 Unit] ① $R_E = 7.33$ kN

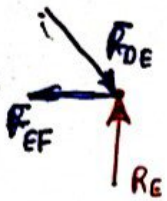
① $R_A = 6.67$ kN

F_{CD}, F_{CF}, F_{FG} ...



M.J.--

Joint E



$\Sigma V = 0$

$F_{DE}\sin60 = R_E$

$F_{DE} = 8.46$ kN C

$\Sigma H = 0$ 2 [1 + 1 Unit + 0.5 Type]

$F_{DE}\cos60 = F_{EF}$

$F_{EF} = 4.236$ kN T

Joint - D

$\Sigma V = 0 \Rightarrow$

$F_{DF}\sin60° = F_{ED}\sin60°$

$F_{DF} = F_{ED} = 8.46$ kN

T C T

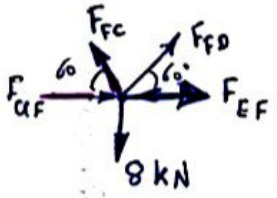
$\Sigma H = 0$

$F_{ED} = F_{DF}\cos60 + F_{DE}\cos60$

$F_{ED} = 8.46$ kN C Ans CD

2 [1 + 0.5 Unit + 0.5 Type dT]

Joint F



$\Sigma V = 0$

$F_{FD}\sin60 + F_{FC}\sin60 = 8$

$F_{FC} = 0.77$ kN T ANS CF

2 [1 + 0.5 Unit + 0.5 Type]

$\Sigma H = 0 \quad F_{GF} = F_{EF} + F_{FD}\cos60 - F_{FC}\cos60$

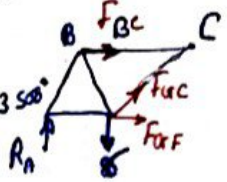
$4.236 + F_{FC}\cos60 = F_{FD}\cos60 + F_{GF}$

$F_{GF} = 8.07$ kN T ANS FG

2 [1 + 0.5 Unit + 0.5 Type]

Method of section

From section ① - ①



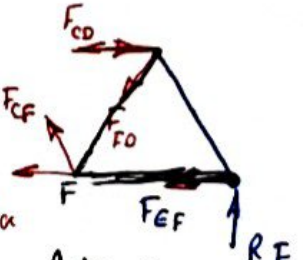
$M_E = 0 \Rightarrow R_A\times4.5 = 8\times1.5 + F_{GF}\times3\sin60°$

$\frac{21.015}{3\sin60} = F_{GF}$

$F_{GF} = 8.08$ kN T ANS GF

2 [1 + 0.5 Unit + 0.5 Type]

From section ② - ②



① $M_F = 0 \rightarrow R_E\times3 = F_{CD}\times3\times\sin60°$

$F_{CD} = \frac{7.33}{\sin60}$

$F_{CD} \simeq 8.46$ kN C ANS CD

2 [1 + 0.5 Unit + 0.5 Type]

② $\Sigma V = 0 \rightarrow +R_E + F_{CF}\sin60° + 8 = 0$

$F_{CF} = \frac{8 - R_E}{\sin60°}$

$F_{CF} = 0.77$ kN T Tension

ANS CF

2 [1 + 0.5 Unit + 0.5 Type]

Total 2.5 Marks

Clockwise