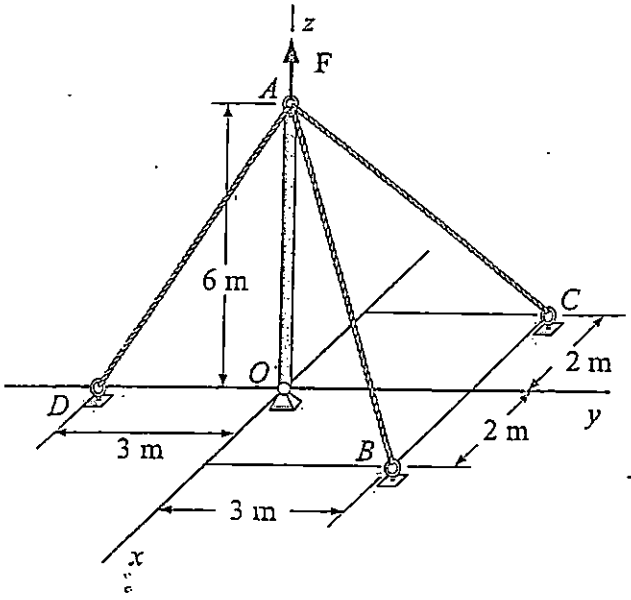
Model Answer

Mansoura University
Faculty of Engineering
MTE, BCE, BME, CIE Level: 000 Final Term Exam.

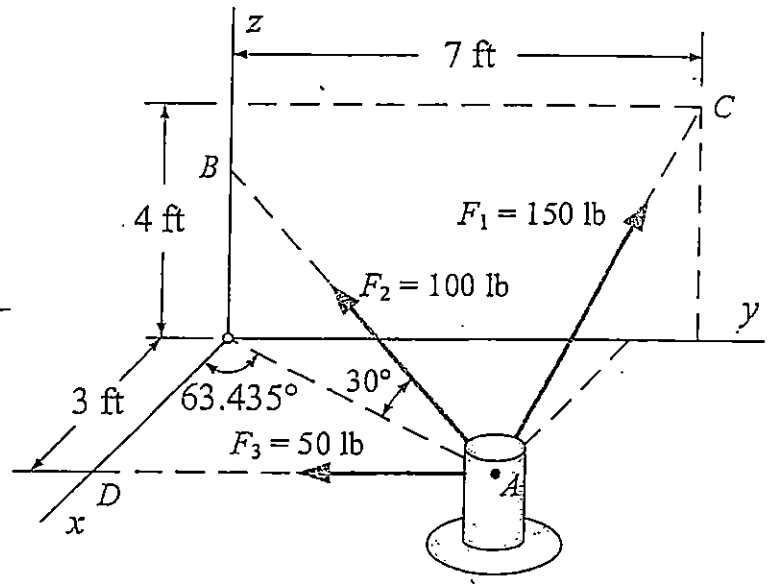
Date: 14/1/2020
Mechanics 1
Time: 2 hr

Answer all six Problems:

1] The mast OA exerts a vertical force of $F = 600$ N on the collar at A. Determine the tension in cables AB, AC, and AD for equilibrium. [8 degrees]



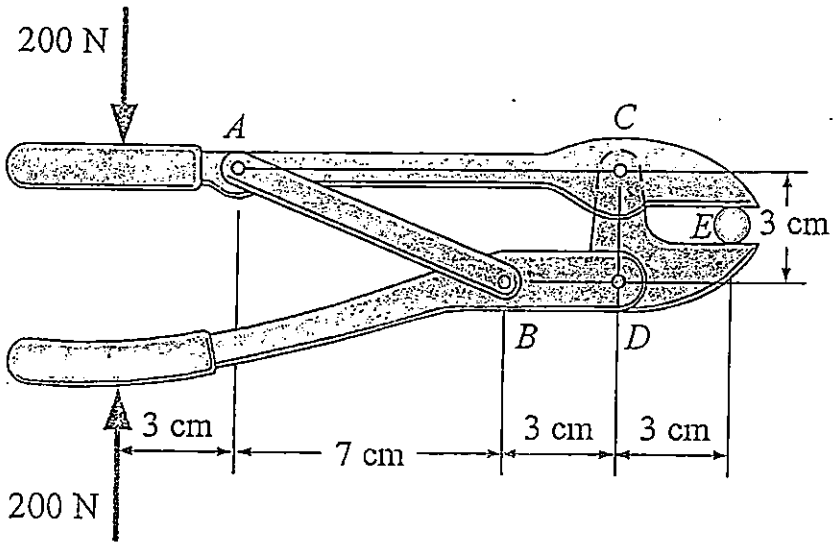
Prob. (1)



Prob. (2)

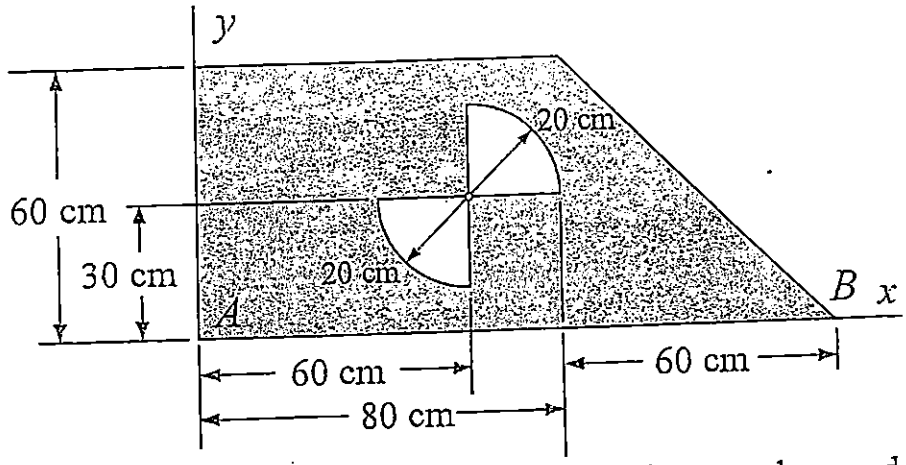
2] Three ropes are attached to the post at A as shown, determine (a) the magnitude of the force $\mathbf{R}$ that is equivalent to the three forces shown, and (b) the coordinates of the point where the line of action of $\mathbf{R}$ intersects the y-z plane. [10 degrees]

3] What forces are exerted on the bolt at E as shown in the figure as a result of the 200 N force on the pliers, and find the mechanical advantages η of the pliers? [8 degrees]

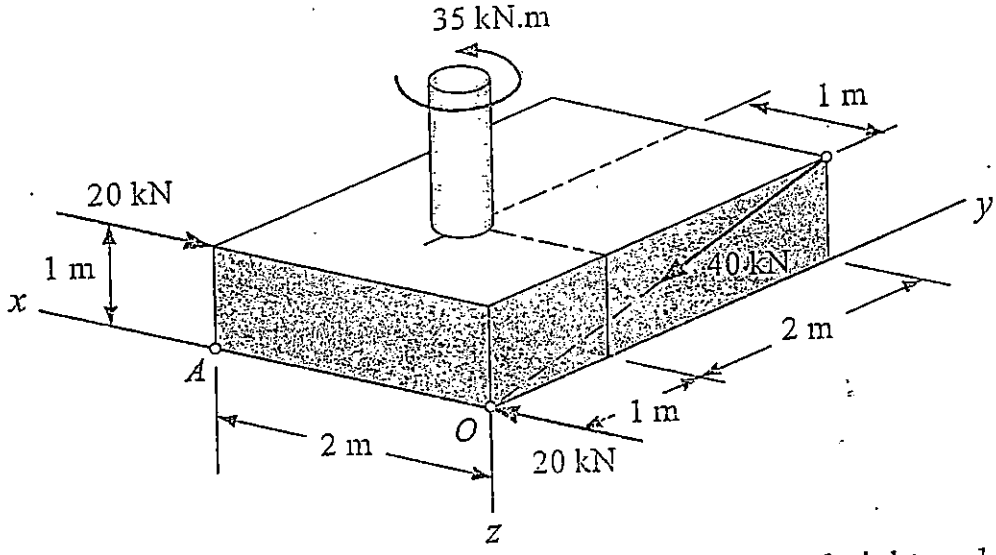


أقلب الورقة من فضلك

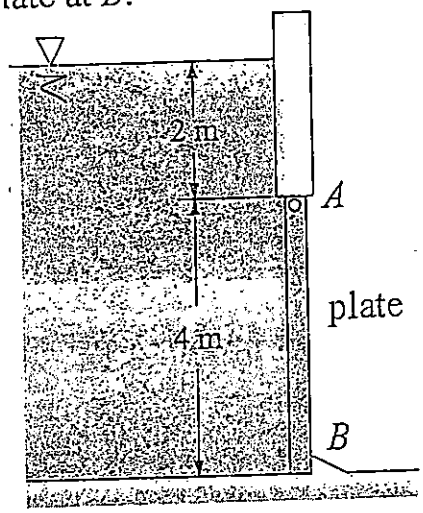
4] Locate the centroid of the plate area shown. [8 degrees]



5] Determine the sum of the couples applied to the machine member, and then determine the resultant moment about point A, and specify its coordinate direction angles. [8 degrees]

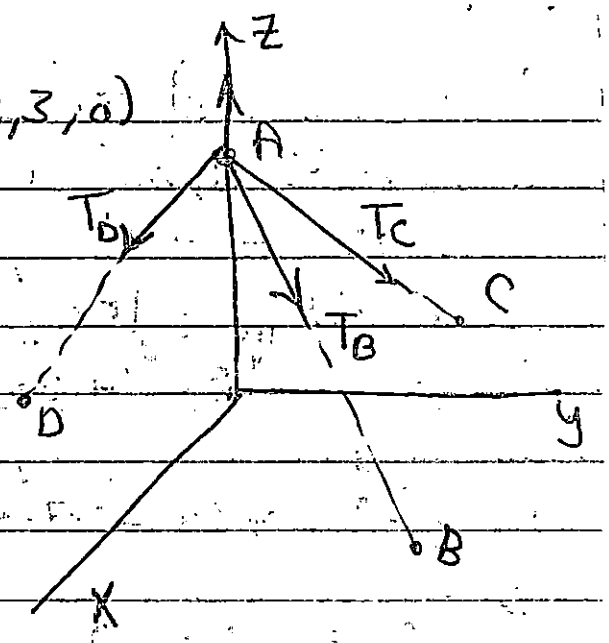


6] A vertical section AB of a submerged rectangular plate 4 m height and 6 m wide as shown in figure. The top edge of the plate is 2m below the free surface of fresh water. The plate is hinged about a horizontal axis through A and is restrained from opening by a stop at the lower end B. Knowing that $\gamma_w = 9.81$ kN/m^3. Determine (a) The magnitude and location of the hydrostatic force acting on the plate. (b) The force exerted by the stop on the plate at B. [8 degrees]



مع أطيب الأمنيات بالنجاح والتوفيق،

Q1 A(0,0,6), B(2,3,0), C(−2,3,0)
D(0,−3,0)



$$\vec{T_B} = T_B\left(\frac{2i + 3j - 6k}{7}\right) N$$

$$\vec{T_C} = T_C\left(\frac{-2i + 3j - 6k}{7}\right) N$$

$$\vec{T_D} = T_D\left(\frac{-3j + 6k}{6.71}\right) N$$

$$\vec{F} = 600k \quad N$$

$$\sum F_x = 0; \quad \frac{2}{7}T_B - \frac{2}{7}T_C = 0 \Rightarrow T_B = T_C \quad \text{eq 1}$$

$$\sum F_y = 0; \quad \frac{3}{7}T_B + \frac{3}{7}T_C - \frac{3}{6.71}T_D = 0 \quad \text{eq 2}$$

$$\sum F_z = 0; \quad -\frac{6}{7}T_B - \frac{6}{7}T_C - \frac{6}{6.71}T_D + 600 = 0 \quad \text{eq 3}$$

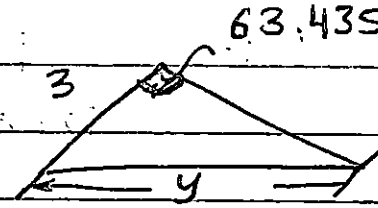
Solving eq. 1, 2, 3 yields:

$$T_B = T_C = 175 \quad N$$

$$T_D = 335.475 \quad N$$

Q2

(a) $B(0,0,3.46)$, $A(3,y,0)$, $C(0,7,4)$



$\vec{F_1} = 150\,u_{AC} = 150\left(\frac{-3i+j+4k}{\sqrt{26}}\right)$ lb $= \{-88.252i + 29.417j + 117.67k\}$ lb

$y = 3\tan(63.435)$

$y = 6$ ft

$\vec{F_2} = \{-38.73i - 77.46j + 50k\}$ lb

$\vec{F_3} = \{-50j\}$ lb

$F_{2z} = 100\sin(30)$

$F_{2xy} = 100\cos(30)$

$F_x = -F_{2xy}\cos(63.43)$

$F_y = -F_{2xy}\sin(63.43)$

$\vec{R} = \{-126i - 98.043j + 167.67k\}$

$|R| = 232.056$ lb

(b) $u_R = u_{AE} \Rightarrow \frac{\vec{R}}{|R|} = \frac{r_{AE}}{|r_{AE}|}$, $E(0,y,z)$

$-0.547i - 0.422j + 0.722k = \frac{-3i + (y-6)j + zk}{\sqrt{(3)^2 + (y-6)^2 + z^2}}$ $= \frac{-3i + (y-6)j + zk}{l}$

$\Rightarrow -0.547 = \frac{-3}{l}$

$-0.422 = \frac{y-6}{l}$

$0.722 = \frac{z}{l}$

So: $l = 5.484 \Rightarrow y = 3.686$ ft

$z = 3.959$ ft

intersection Point $E(0, 3.686, 3.959)$ ft

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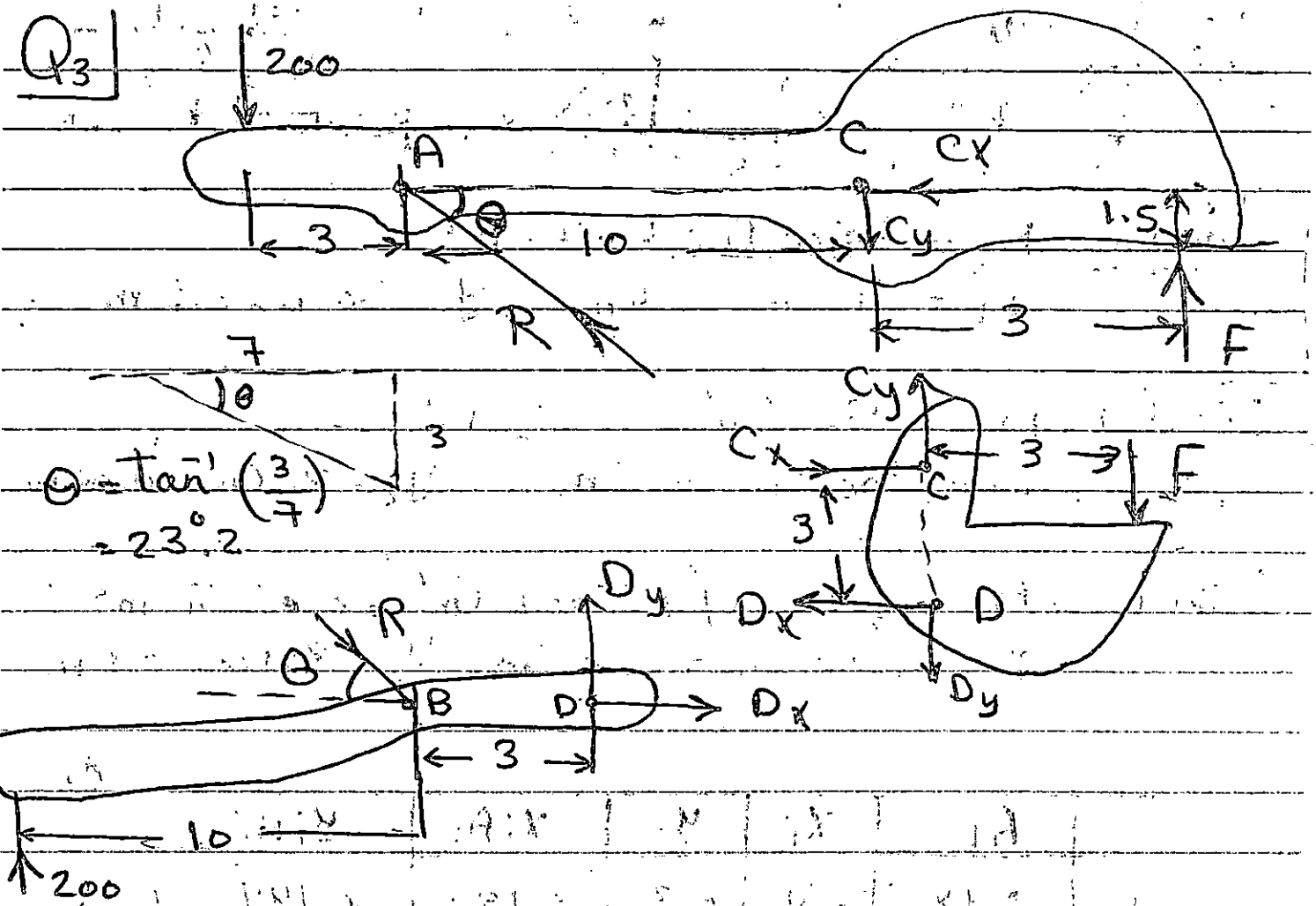
Q3



$\theta = \tan^{-1}\left(\frac{3}{7}\right)$

$= 23^\circ.2$

Part (BD):

$\sum M_D = 0; \quad R\sin(\theta)[3] - 200[13] = 0$

$$R = 2200\ N$$

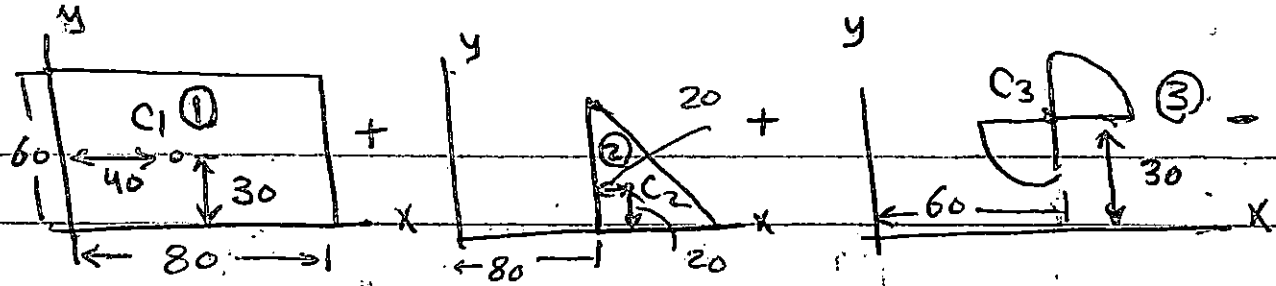
Part (AC):

$\sum M_C = 0; \quad 200[13] - R\sin(\theta)[10] + F[3] = 0$

$$F = 2022.24\ N$$

$$\eta = \frac{F}{200} = 10.11$$

Q4



Part (1) $A_1 = 4800\ Cm^2 = 0.48\ m^2$

$X_1 = 40\ Cm = 0.4\ m$, $Y_1 = 30\ Cm = 0.3\ m$

Part (2) $A_2 = 1800\ Cm^2 = 0.18\ m^2$

$X_2 = 100\ Cm = 1\ m$, $Y_2 = 20\ Cm = 0.2\ m$

Part (3) $A_3 = \frac{1}{2}\pi(2.0)^2 = 200\pi\ Cm^2 = 0.02\pi\ m^2$

$X_3 = 60\ Cm = 0.6\ m$, $Y_3 = 30\ Cm = 0.3\ m$

	A_i	X_i	Y_i	$X_i A_i$	$Y_i A_i$
1)	0.48	0.4	0.3	0.192	0.144
2)	0.18	1	0.2	0.18	0.036
3)	-0.02π	0.6	0.3	-0.037	-0.0188
Σ	0.5972			0.3345	0.1612

$$X_c = \frac{\sum X_i A_i}{\sum A_i} = 0.5598 \simeq 0.56\ m \simeq 56\ Cm$$

$$Y_c = \frac{\sum Y_i A_i}{\sum A_i} = 0.2698 \simeq 0.27\ m \simeq 27\ Cm.$$

$C(56, 27)\ cm$

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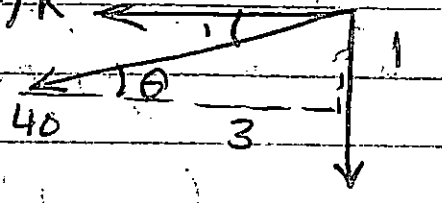
Q5| $\vec{M}_1 = \{20j\}$ kN.m

$\vec{M}_{c2} = \{-50k\}$ kN.m

$\vec{M}_c = \{20j - 50k\}$ kN.m

$\vec{F} = -40\left(\frac{3}{\sqrt{10}}\right)j + 40\left(\frac{1}{\sqrt{10}}\right)k$

$= -37.95j + 12.65k$



$$\vec{M}_A = \begin{vmatrix} i & j & k \\ -2 & 0 & 0 \\ 0 & -37.95 & 12.65 \end{vmatrix} + \{20j - 35k\}$$

$\vec{M}_A = \{45.3j + 40.9k\}$

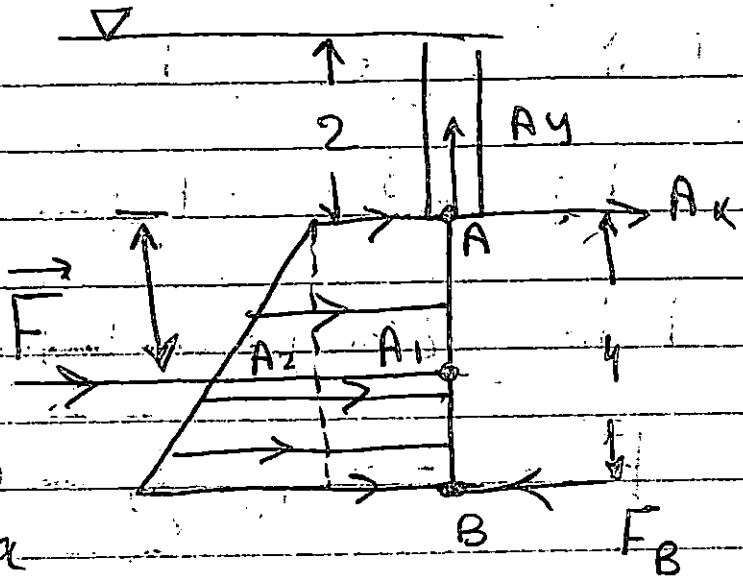
$|\vec{M}_A| = \{61.032\}$ kN.m

$\theta_x = 90^\circ$

$\theta_y = 42.1^\circ$

$\theta_z = 47.9^\circ$

Q6



$\gamma_w = 9.81 \text{ kN/m}^3$

width = 6

$\vec{F} = \gamma_w h_{c.g.} \text{ Area}$

$= (9.81)(4)(24) = \underline{941.76 \text{ kN}}$

$h_{c.p.} = \dfrac{h_1 A_1 + h_2 A_2}{A_1 + A_2}$ (From the surface)

$A_1 = \gamma_w h_A (4) = 8\gamma_w$

$A_2 = \frac{1}{2}\gamma_w (h_B - h_A)(4) = 8\gamma_w$

$h_1 = 4$, $h_2 = 2 + \frac{2}{3}(4) = 4.67$

$h_{c.p.} = \underline{4.33 \text{ m}}$

$\sum M_A = 0$; $F(h_{c.p.} - 2) - R_B(4) = 0$

$\{F_B = 549.75 \text{ kN}\}$