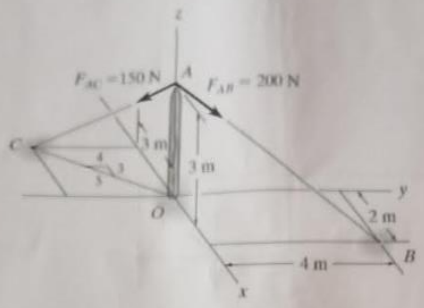
Question 1: Cartesian Vector Addition

Consider the post displayed below, for which the coordinates for points A, B and C are A(0, 0, 3) m, B(2, 4, 0) m and C(-3, -4, 0) m respectively



a) (2 marks) Describe the unit vector u_{AB} in Cartesian format: xi + yj + zk

$$\frac{2i+4j-3k}{\sqrt{2^2+4^2+(-3)^2}} = \frac{2}{\sqrt{29}}i + \frac{4}{\sqrt{29}}j - \frac{3}{\sqrt{29}}k$$

b) (2 marks) Describe the unit vector u_{AC} in Cartesian format: xi + yj + zk

$$UAC = \frac{-3i-4j-3k}{\sqrt{(-3)^2+(-4)^2+(-3)^2}} = \frac{3}{\sqrt{34}}$$

c) (1 mark) Use the result from part a to write F_{AB} in Cartesian format.

$$F_{AB} = 200\left(\frac{2}{\sqrt{29}}i + \frac{4}{\sqrt{29}}j - \frac{3}{\sqrt{29}}K\right) = 74.28i + 148.56j - 111.42K\ N$$

d) (1 mark) Use the result from part b to write F_{AC} in Cartesian format.

$$F_{AC} = 150\left(-\frac{3}{\sqrt{34}}i + \frac{4}{\sqrt{34}}j - \frac{3}{\sqrt{29}}K\right) = -77.17i - 102.90j - 77.17K\ N$$

e) (2 marks) Give the resultant force F_R in Cartesian format.

$F_R = -2.896i + 45.66j - 188.59K\ N$

(i) $74.28i + -77.171 = -2.896$ (j) $148.56j + -102.90j = 45.66j$

(K) $-111.42K + -77.17K = -188.59K$

f) (2 marks) Give the magnitude of F_R.

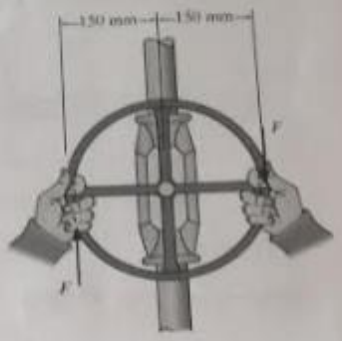
$$F_R = \sqrt{(F_R)_x^2 + (F_R)_y^2 + (FR)^2}$$

$$F_R = \sqrt{(-2.896)^2 + 45.66^2 + (188.59)^2}$$

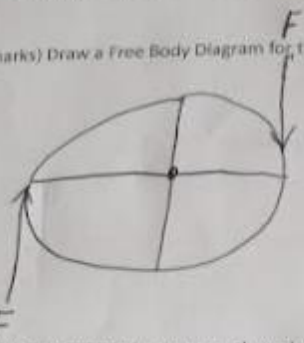
$$= 194.06N$$

Question 1: Moments and Couples

Consider the valve shown to the right.



a) (2 marks) Draw a Free Body Diagram for the system of forces.



b) (4 marks) If the man tries to open the valve by applying the couple forces of F = 75 N to the wheel. Determine the couple moment produced.

$75_N(0.15m + 0.15m) = 22.5N.m$

$0.15m = 150mm$

$M = F \times D$

c) (4 marks) If the valve can be opened with a couple moment of 25 N · m, determine the required magnitude of each couple force which must be applied to the wheel.

$F = \frac{M}{D}$

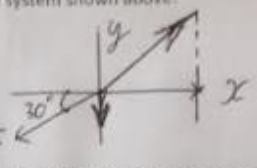
$25N.m \div 0.3_m = 83.3N$

$F = 83.3N$

$0.3_m = 0.15m + 0.15m$

Question 2: Coplanar Force Systems

a) (2 marks) Draw a Free Body Diagram for the system shown above.



b) (2 Marks) Write the equation for equilibrium in the y-direction and reduce to give T_{AB} in terms of F (It should look something like this: $T_{AB} = 7.2F$). Note: the answer is not 7.2

$-F_x \times \sin(30°) + \left(\frac{4}{5}\right) AB = 0$

$\frac{4}{5} AB = F_x \times \sin(30°)$ ÷

$T_{AB} = 1.6F0.625F$

c) (2 Marks) Write the equation for equilibrium in the y-direction and reduce to give T_{AC} in terms of F

$\frac{3}{5} T_{AB} + T_{AC} = F_x \times \cos(30°)$ ÷

$T_{AC} = 0.4910$

$0.625 \frac{3}{5} - \cos(30°) = 0.4910$

d) (4 marks) If the maximum force either chain can withstand is 600 N, determine the maximum force F that can be supported in the position shown.

$AB = 600N$

$\frac{4}{5} AB = F_x \times \sin(30°)$

$\frac{4}{5}(600N) = F_x \times \sin(30°)$

$F_x \times \sin(30°) = 480N$

$F_x = \frac{480N}{\sin(30°)}$

$F = 960N$

$\frac{3}{5} AB + AC = F_x \times \cos(30°)$

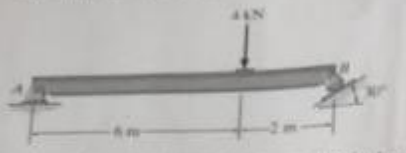
$\frac{3}{5}(600N) + AC = 960N \times \cos(30°)$

$360N + AC = 831.3844N$

$AC = 471.3844N$

$AC = 471N$

Question 2: Rigid Body Equilibrium

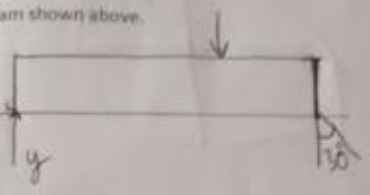


a) (2 marks) Draw a Free Body Diagram for the beam shown above.

~~Point A~~

~~4KN X 6m = 20 KNm~~

~~M = F x d~~



b) (2 marks) Write the moment equation of equilibrium about point A and use it to find the magnitude of the normal force at point B.

$\cos 30°(B) - 4(6) = 0$

$B = 3.46\,KN$

c) (3 marks) Use the force equation of equilibrium along the x-axis to find A_x.

$-3.46 \sin(30°) = 1.73\,KN$

d) (3 marks) Use the force equation of equilibrium along the y-axis to find A_y.

$3.46 \cos(30°) = 1.00\,KN$