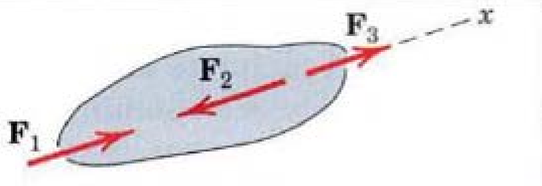
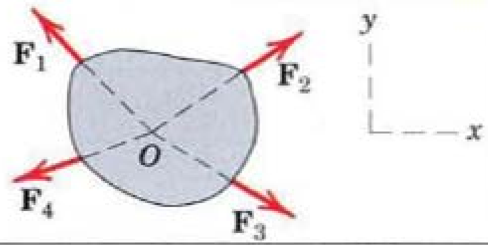
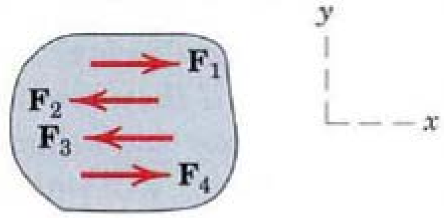
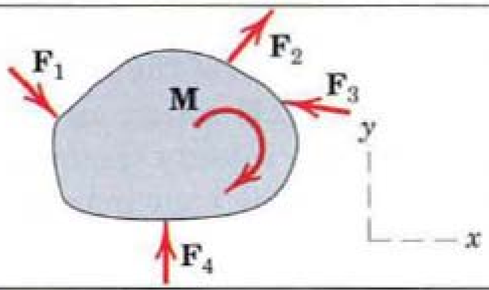
Lecturer: Luay Hashem Abbud
E-mail: LuayHashemAbbud@mustaqbal-college.edu.iq

EQUILIBRIUM

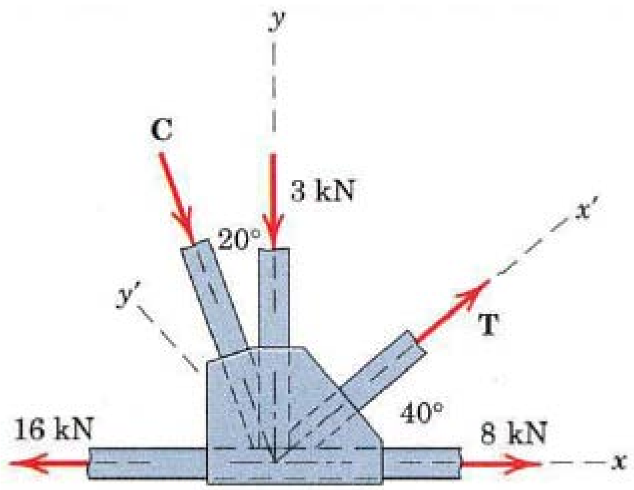
we defined equilibrium as the condition in which the result ant of all forces and moments acting on a body is zero.

$$\Sigma F_x = 0 \qquad \Sigma F_y = 0 \qquad \Sigma M_O = 0$$

CATEGORIES OF EQUILIBRIUM IN TWO DIMENSIONS		
Force System	Free-Body Diagram	Independent Equations
1. Collinear		$\Sigma F_x = 0$
2. Concurrent at a point		$\Sigma F_x = 0$ $\Sigma F_y = 0$
3. Parallel		$\Sigma F_x = 0 \quad \Sigma M_z = 0$
4. General		$\Sigma F_x = 0 \quad \Sigma M_z = 0$ $\Sigma F_y = 0$

Problem 1

Determine the magnitudes of the forces C and T, which, along with the other three forces shown, act on the bridge truss joint.



Solution

$[\Sigma F_x = 0]$ $8 + T \cos 40 + C \sin 20 - 16 = 0$

$0.766T + 0.342C = 8$ --------------(1)

$[\Sigma F_y = 0]$ $T \sin 40 - C \cos 20 - 3 = 0$

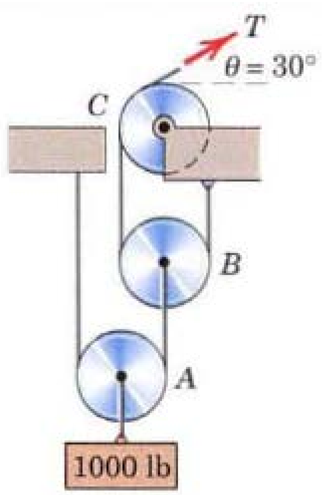
$0.643T - 0.940C = 3$ --------------- (2)

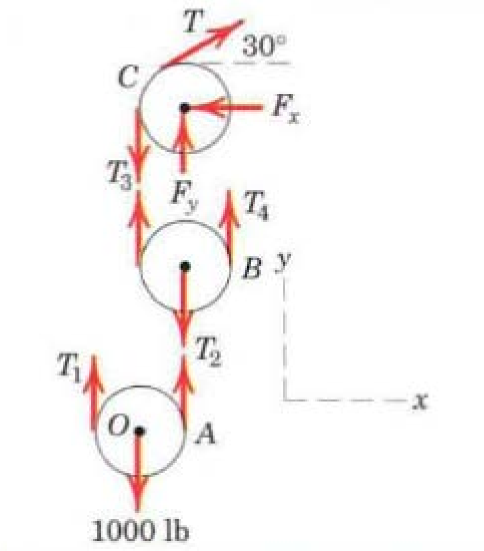
Simultaneous solution of Equations (1) and (2) produces

$T = 9.09$ kN $C = 3.03$ kN

Problem 2

Calculate the tension *T* in the cable which supports the 1000 lb load with the pulley arrangement shown. Each pulley is free to rotate about its bearing, and the weights of all parts are small compared with the load. Find the magnitude of the total force on the bearing of pulley C.





Solution

$M_o = 0$ $T_1 r - T_2 r = 0$ $T_1 = T2$

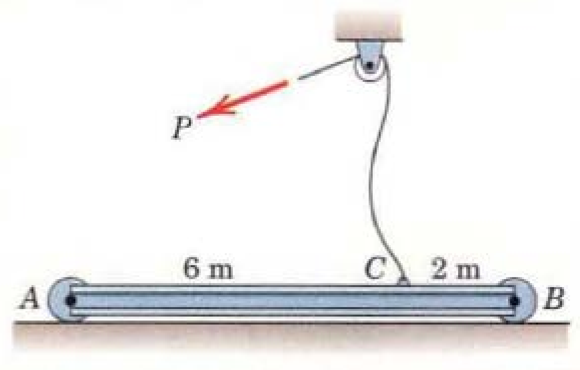
$\Sigma F_y = 0$ $T_1 + T_2 - 1000 = 0$ $2T_1 = 1000$ $T_1 = T_2 = 500$ Ib

$T_3 = T_4 = T_2 / 2 = 250$ Ib

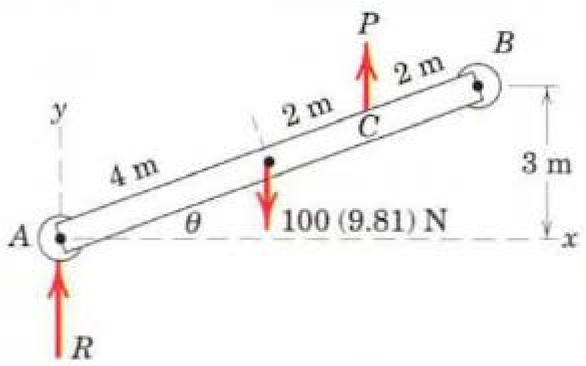
$T = T_3$ or $T = 250$ Ib

Problem 3

The uniform 100-kg I-beam is supported initially by its end roller s on the horizontal surface at A and B. By mean s of the cable at C it is desired to elevate end B to a position 3 m above end A. Determine the required tension P, the reaction at A, and the angle 8 made by the beam with the horizontal in the elevated position.



Solution



Moment equilibrium about A eliminates force *R* and gives

$\Sigma M_o = 0$ $P(6 \cos \theta) - 981(4 \cos \theta) = 0$ $P = 654$ N

Equilibrium of vertical forces requires

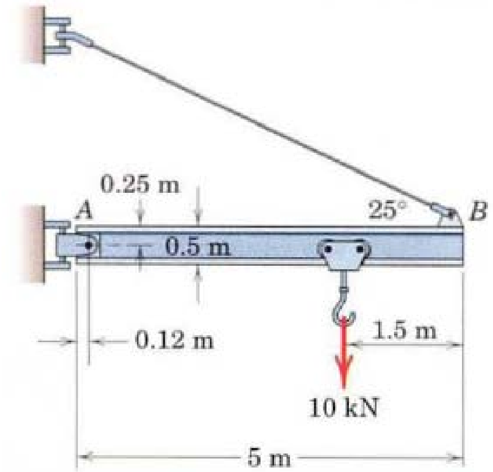
$\Sigma F_y=0$ $654 + R - 981 = 0$ $R = 327$ N

The angle θ depends only on the specified geometry and is

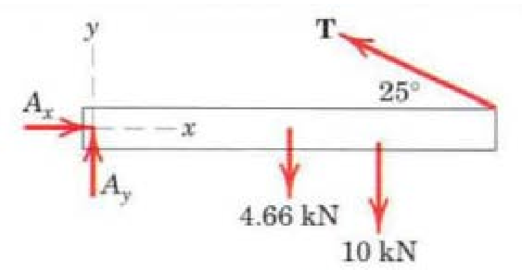
$\sin \theta = 3/8$ $\theta = 22^\circ$

Problem 4

Determine the magnitude *T* of the tension in the supporting cable and the magnitude of the force on the pin at A for the jib crane shown. The beam *AB* is a standard 0.5 m I-beam with a mass of 95 kg per mete r of length.



Solution



Free-body diagram

$$\sum M_A = 0$$

(T cos 25°) 0.25 + (T sin 25°)(5 - 0.12) - 10(5 - 1.5 - 0.12) - 4.66(2.5 - 0.12) = 0

T = 19.61 kN

Equating the sums of forces in the x- and y-directions to zero gives

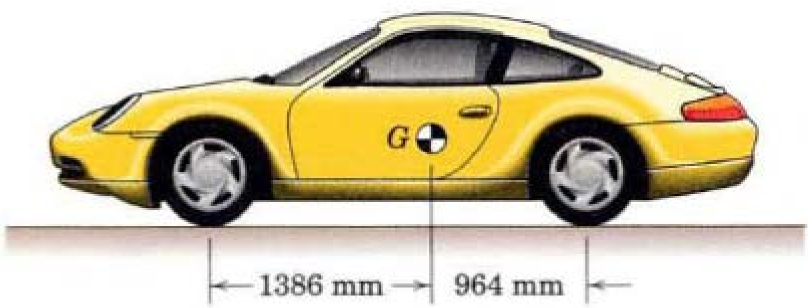
$\Sigma F_x=0$ $\quad$ A_x - 19.61 cos 25° = 0 $\quad$ A_x = 17.77 kN

$\Sigma F_y=0$ $\quad$ A_y + 19.61 sin 25° - 4.66 - 10 = 0 $\quad$ A_y = 6.37 kN

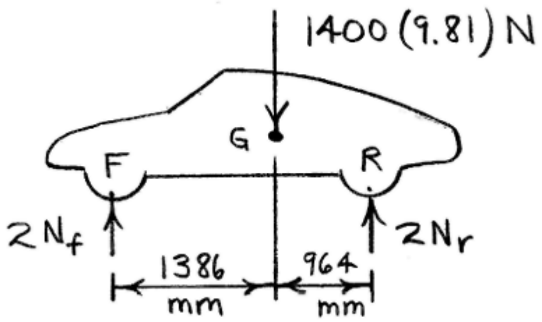
$A = \sqrt{A_x^2 + A_y^2}$ $\quad$ $A = \sqrt{17.77^2 + 6.37^2}$ $\quad$ A= 18.88 KN

Problem 5

The mass center G of the 1400-kg rear-engine car is located as shown in the figure. Determine the normal force under each tire when the car is in equilibrium. State any assumptions.



Solution



$$+\uparrow \Sigma F = 0: \quad 2N_f + 2N_r - 1400(9.81) = 0$$

$$\circlearrowleft + \Sigma M_F = 0: \quad -1400(9.81)(1386) + 2N_r(1386 + 964) = 0$$

Solution : $\begin{cases} N_f = 2820 \text{ N} \\ N_r = 4050 \text{ N} \end{cases}$