Problem I:

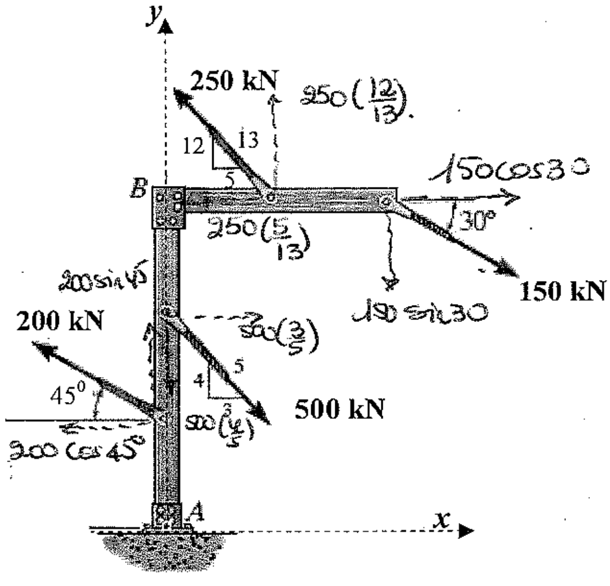


Fig. 1.1

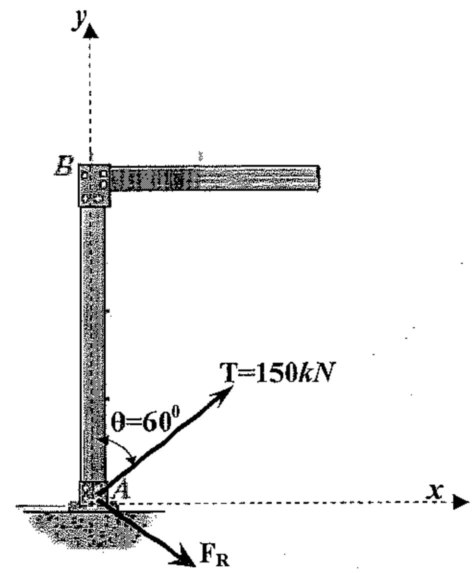


Fig. 1.2

1) Determine the magnitude and direction of the resultant force for the system of forces shown in **Fig. 1.1**.
2) Refer to **Fig. 1.2**, If $\theta=60^0$ and T=150 kN, determine the magnitude of the resultant force for T and F_R and its direction measured clockwise from the positive x axis (where F_R is the resultant force determined from part 1) "use the parallelogram law". *(35points)*

Note: FBD must be included

Calculations:

$\overset{+}{\rightarrow} \sum F_x = 0 \qquad 150\cos30 - 250\left(\frac{5}{13}\right) + 500\left(\frac{3}{5}\right) - 200\cos45 = 0$

$\Rightarrow F_{Rx} = 192.32 \text{ KN} \rightarrow$

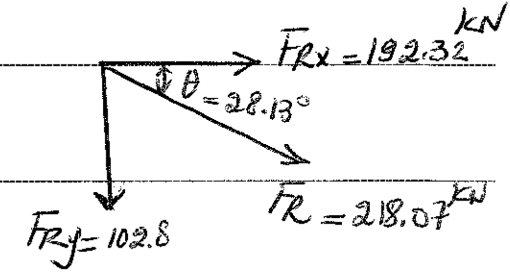
$+\uparrow \sum F_y = 0 \qquad -150\sin30 + 250\left(\frac{12}{13}\right) - 500\left(\frac{4}{5}\right) + 200\sin45 = 0$

$\Rightarrow F_{Ry} = -102.8 \text{ KN} = 102.8 \text{ KN} \downarrow$

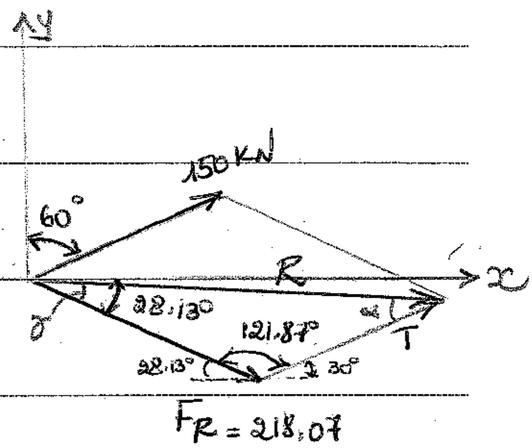
$F_R = \sqrt{(192.32)^2 + (-102.8)^2} = 218.07 \text{ KN}$

Direction :

$$\tan\theta = \left|\frac{F_{Ry}}{F_{Rx}}\right| = \left|\frac{102.8}{192.32}\right| \Rightarrow \theta = 28.13^\circ$$



2.



* Apply cosine Law: Magnitude

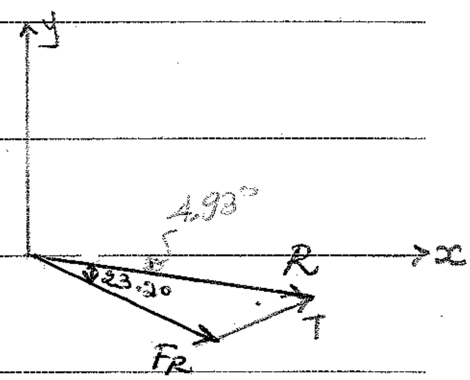
$$R = \sqrt{(218.07)^2 + (150)^2 - 2(218.07)(150)\cos 121.87^\circ}$$

$$= 323.4 \text{ KN}$$

* Direction: Apply sine Law

$$\frac{218.07}{\sin\cancel{\alpha}} = \frac{150}{\sin\gamma} = \frac{323.4}{\sin 121.87}$$

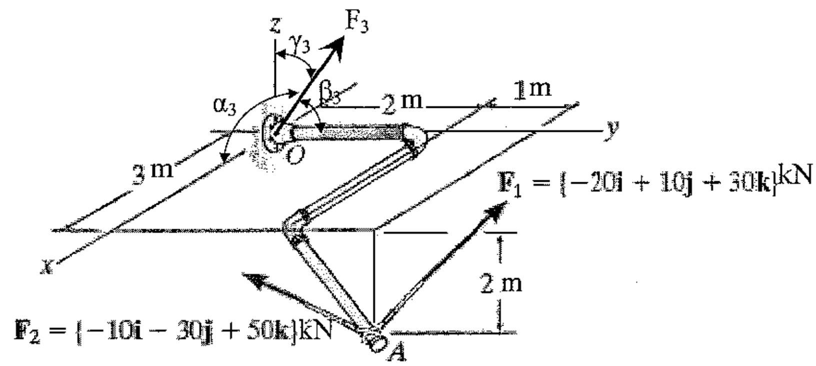
$$\Rightarrow \gamma = 23.2^\circ \Rightarrow \theta = 28.13 - 23.2$$
$$= 4.93^\circ$$



Resultant "R" forms an angle of 4.93°

with the x-axis

Problem II:



1) Determine the magnitude of the components of F_1 acting along and perpendicular to the line of action of force F_2.
2) Determine the coordinate direction angles of the force F_3 such that the resultant of the three forces F_1, F_2 and F_3 is zero. *(35 points)*

Note: FBD must be included

Calculations:

Use Dot product concept: Solution "1"

$$F_{1//} = \vec{F_1} \cdot \vec{u_2}$$

$$\vec{u_2} = \frac{-10\vec{i} - 30\vec{j} + 50\vec{k}}{\sqrt{(-10)^2 + (-30)^2 + (50)^2}} = -0.169\vec{i} - 0.507\vec{j} + 0.845\vec{k}$$

$$F_{1//} = \{-20\vec{i} + 10\vec{j} + 30\vec{k}\} \cdot \{-0.169\vec{i} - 0.507\vec{j} + 0.845\vec{k}\}$$

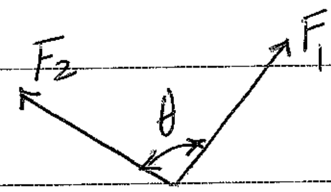
$$= 23.66 \text{ KN}$$

Use pythagorean theorem $F_1 = \sqrt{F_{1\perp}^2 + F_{1//}^2} \Rightarrow F_{1\perp} = \sqrt{F_1^2 - F_{1//}^2} = \sqrt{(37.42)^2 - (23.66)^2}$

$= 29$ KN

Or Solution "2"

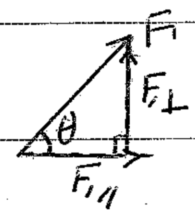
$\vec{F_1} \cdot \vec{F_2} = F_1 F_2 \cos\theta$

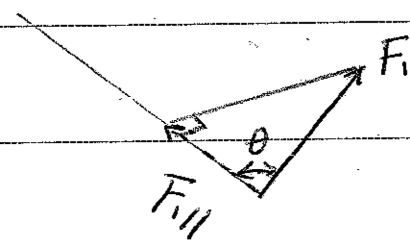


$F_1 = \sqrt{(-20)^2 + (10)^2 + (30)^2} = 37.42\ kN$

$F_2 = \sqrt{(-10)^2 + (-30)^2 + (50)^2} = 59.16\ kN$

$\Rightarrow \theta = \cos^{-1} \dfrac{\{-20\vec{i} + 10\vec{j} + 30\vec{k}\} \cdot \{-10\vec{i} - 30\vec{j} + 50\vec{k}\}}{(37.42)(59.16)} = \cos^{-1} \dfrac{1400}{2213.8} = 50.77^\circ$





PLAN VIEW

Use trigonometry:

$\cos\theta = \dfrac{F_{1//}}{F_1} \Rightarrow F_{1//} = F_1 \cos\theta = 37.42 \cos 50.77 = 23.66\ kN$

$\sin\theta = \dfrac{F_{1\perp}}{F_1} \Rightarrow F_{1\perp} = F_1 \sin\theta = 37.42 \sin 50.77 = 29\ kN$

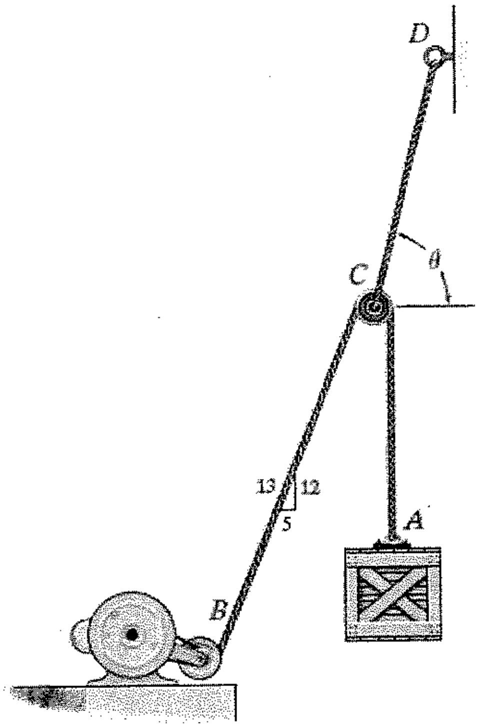
2) $F_{Rx} = -20 - 10 + F_3 \cos\alpha_3 = 0 \Rightarrow F_3 \cos\alpha_3 = 30 \ldots ① \Rightarrow \alpha_3 = \cos^{-1} \dfrac{87.75}{30} = 70^\circ$

$F_{Ry} = 10 - 30 + F_3 \cos\beta_3 = 0 \Rightarrow F_3 \cos\beta_3 = 20 \ldots ② \Rightarrow \beta_3 = \cos^{-1} \dfrac{20}{87.75} = 76.83^\circ$

$F_{Rz} = 30 + 50 + F_3 \cos\gamma_3 = 0 \Rightarrow F_3 \cos\gamma_3 = -80 \ ③ \Rightarrow \gamma_3 = \cos^{-1} \dfrac{-80}{87.75} = 155.74^\circ$

$F_3 = \sqrt{(30)^2 + (20)^2 + (-80)^2} = 87.75\ kN$; substitute in ①, ② & ③

Problem III:



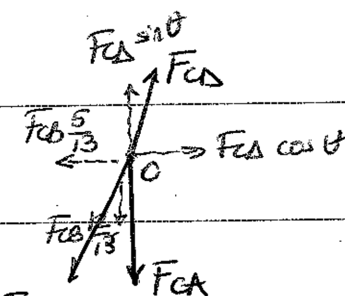
The cords BCA and CD can each support a maximum load of 0.5 kN. Determine the maximum weight of the crate and the angle θ for equilibrium. *(30 points)*

Note: FBD must be included

Calculations:

Friction less pulley ⇒ $F_{CA} = F_{CB}$

F.B.D



where $F_{CA} = W$

Equations of Equilibrium:

$\xrightarrow{+} \sum F_x = 0 \quad F_{CD}\cos\theta - F_{CB}\frac{5}{13} = 0$ (1) $\xrightarrow{F_{CB}}$ $F_{CD}\cos\theta = \frac{5}{13}W$

$+\uparrow \sum F_y = 0 \quad F_{CD}\sin\theta - F_{CA} - F_{CB}\frac{12}{13} = 0 \Rightarrow F_{CD}\sin\theta = \frac{25}{13}W$ (2)

$\frac{(1)}{(2)} \Rightarrow \tan\theta = \frac{25}{5} \Rightarrow \theta = 78.69^\circ$

Eq. (1) $\Rightarrow$ $F_{CD} \cos 78.69 = \frac{5}{13} w$

$\Rightarrow$ $F_{CD} = 1.96 w$

$\therefore$ F_{CD} will reach 0.5 KN before the other two cables

$\therefore \Rightarrow F_{CD} = 0.5$ KN & $w = \frac{0.5}{1.96} = 0.255$ KN

Good Luck!