ENGINEERING MECHANICS - STATICS

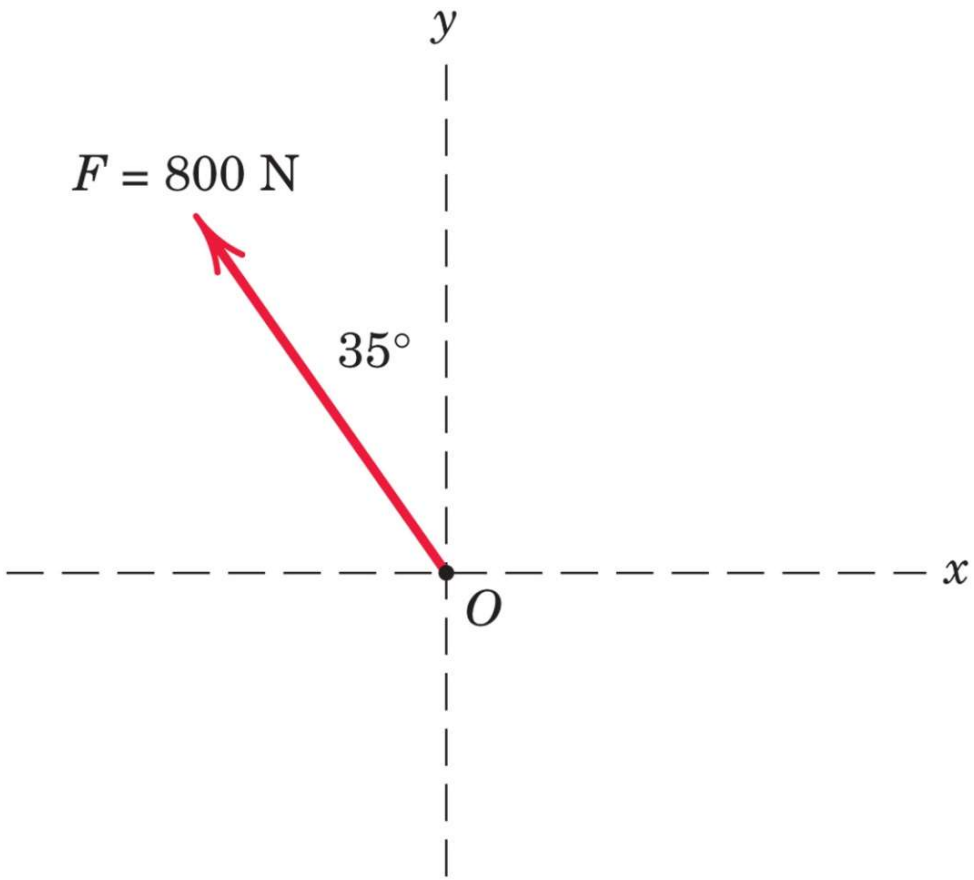
Vinay Papanna

Department of Mechanical Engineering

ENGINEERING MECHANICS- STATICS: UE24CV141A/B

Vinay Papanna
Department of Mechanical Engineering

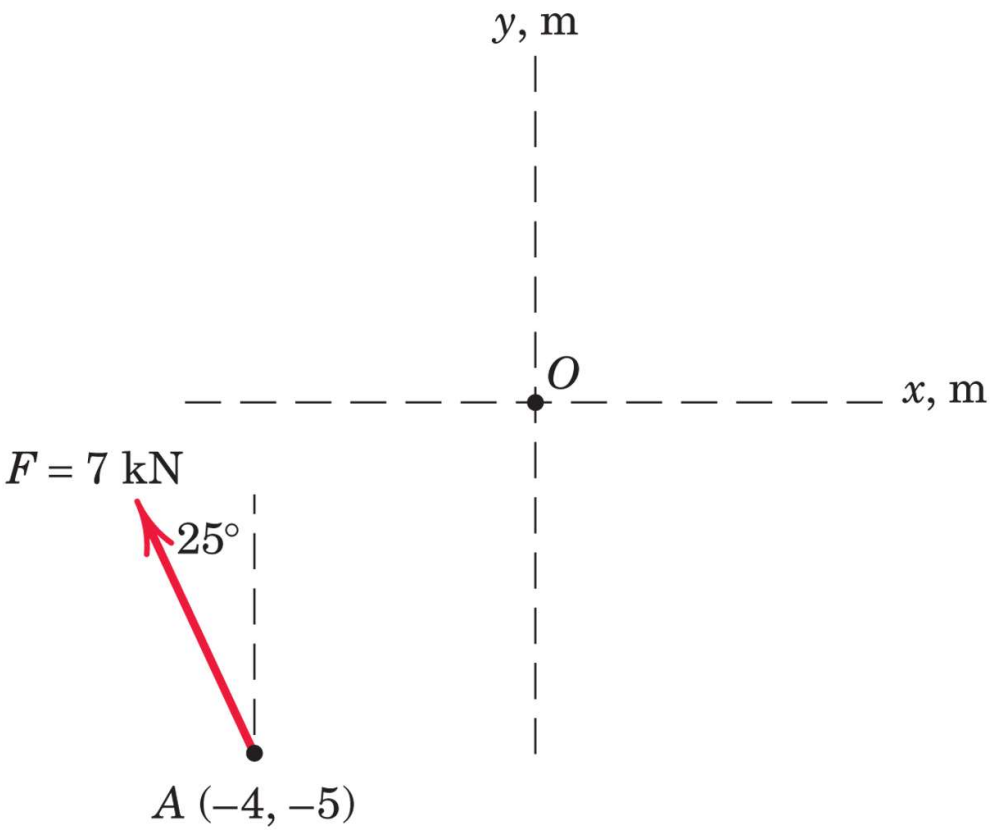
2/1) The force **F** has a magnitude of 800 N. Express **F** as a vector in terms of the unit vectors **i** and **j**. Identify the *x* and *y* scalar components of **F**.



$$\begin{cases} F_x = -800 \sin 35^\circ = -459 \text{ N} \\ F_y = 800 \cos 35^\circ = 655 \text{ N} \end{cases}$$

$$\underline{F} = -459\,\underline{i} + 655\,\underline{j} \text{ N}$$

2/2) The force **F** has a magnitude of 7 kN and acts at the location indicated. Express **F** as a vector in terms of the unit vectors **i** and **j**. Next, determine the x and y scalar components of **F.**



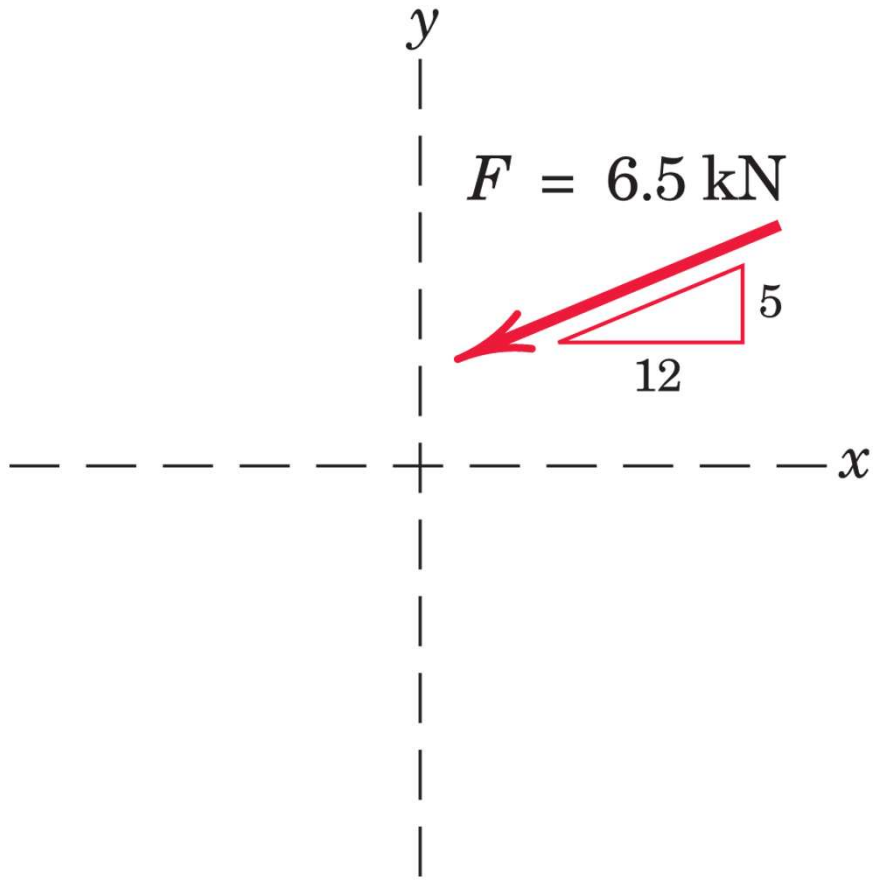
• SCALAR COMPONENTS

$F_x = -2.96$ kN

$F_y = 6.34$ kN

$\underline{F} = -2.96\,\underline{i} + 6.34\,\underline{j}$ kN

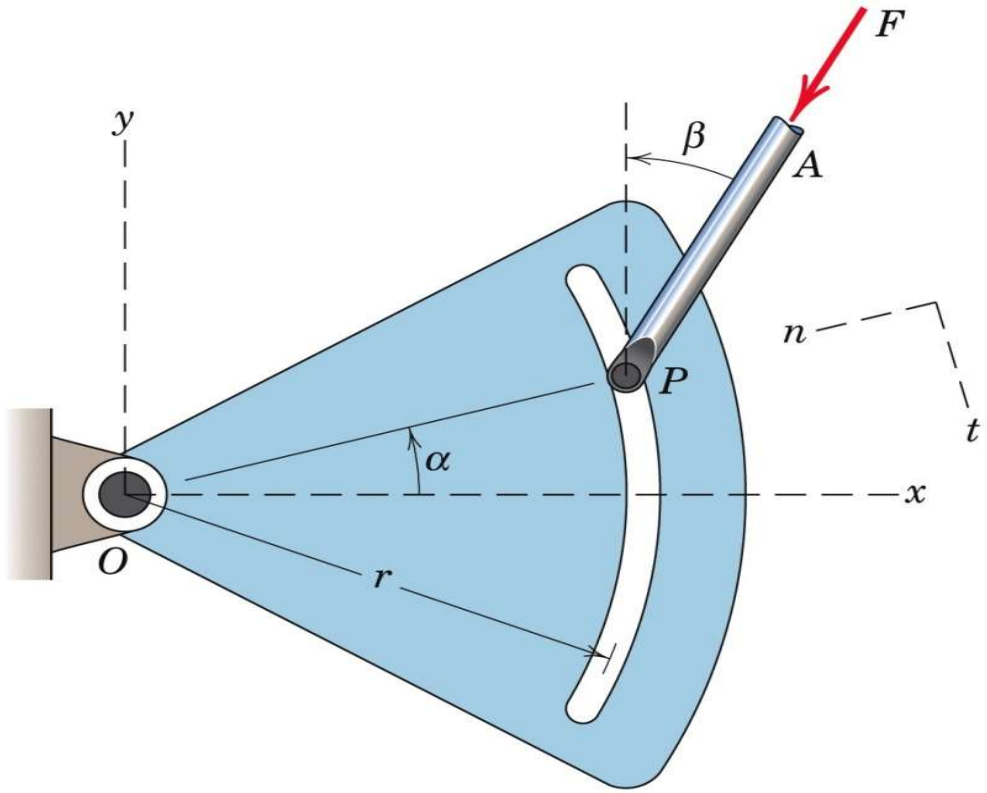
2/3) The slope of the 6.5-kN force F is specified as shown in the figure. Express F as a vector in terms of the unit vectors **i** and **j**.



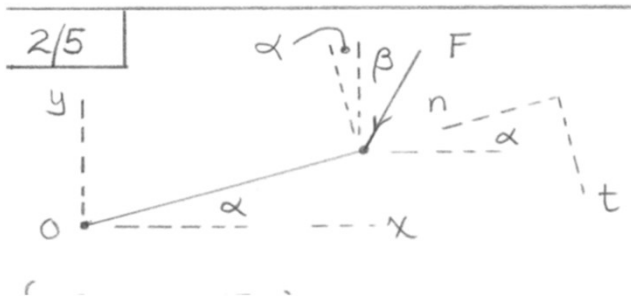
$$\underline{F} = 6.5\left(-\frac{12}{13}\underline{i} - \frac{5}{13}\underline{j}\right)$$

$$= -6\underline{i} - 2.5\underline{j} \text{ kN}$$

2/5. The control rod AP exerts a force F on the sector as shown. Determine both the x-y and the n-t components of the forces.



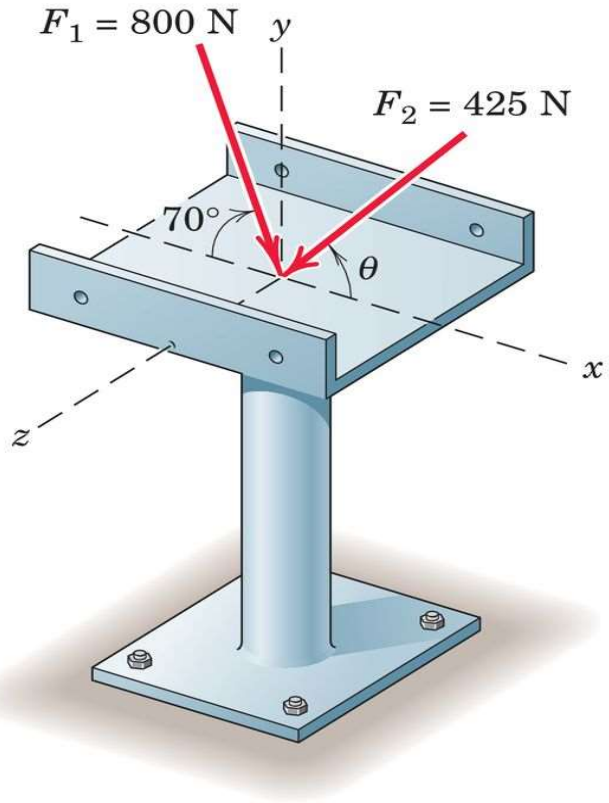
Problem 2-6

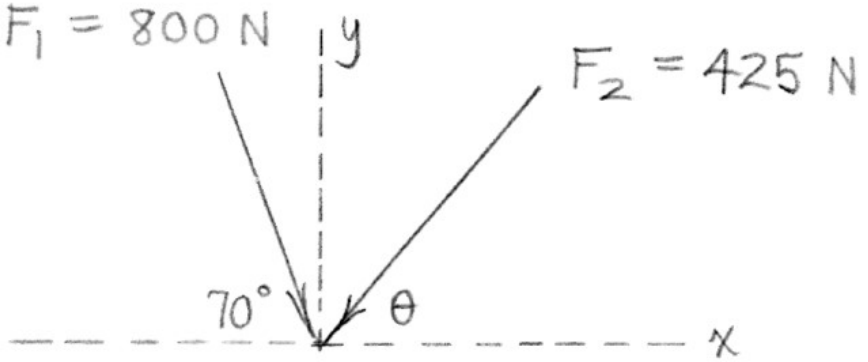


$$\begin{cases} F_x = -F\sin\beta \\ F_y = -F\cos\beta \end{cases}$$

$$\begin{cases} F_n = F\sin(\alpha+\beta) \\ F_t = F\cos(\alpha+\beta) \end{cases}$$

2/6) Two forces are applied to the construction bracket as shown. Determine the angle which makes the resultant of the two forces vertical. Determine the magnitude R of the resultant.





$R_x = \Sigma F_x = 800 \cos 70° - 425 \cos\theta = 0$

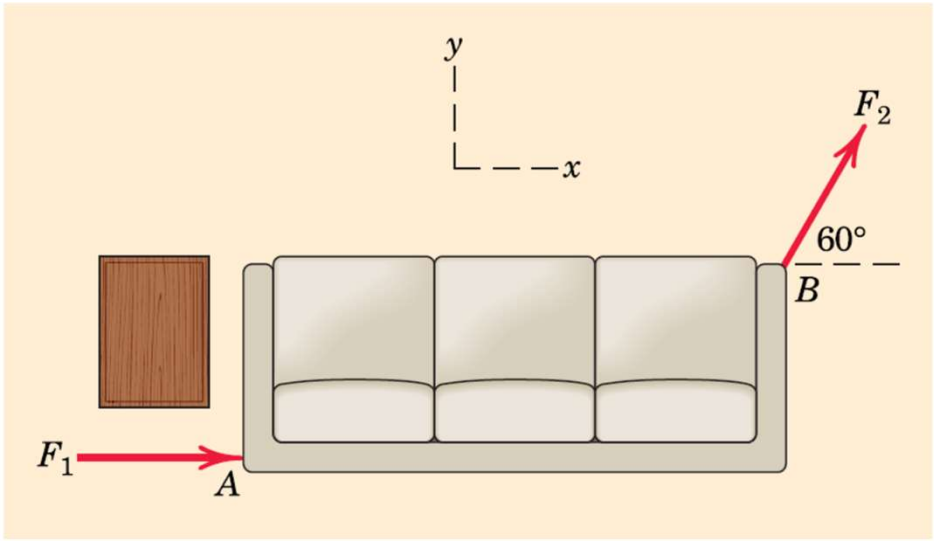
$\theta = 49.9°$

$R_y = \Sigma F_y = -800 \sin 70° - 425 \sin 49.9°$

$= -1077$ N

So $R = 1077$ N

2/7) Two individuals are attempting to relocate a sofa by applying forces in the indicated direction. If $F_1 = 500$ N and $F_2 = 350$ N, determine the vector expression for the resultant R of the two forces. Then determine the magnitude of the resultant and the angle which it makes with the positive x-axis.



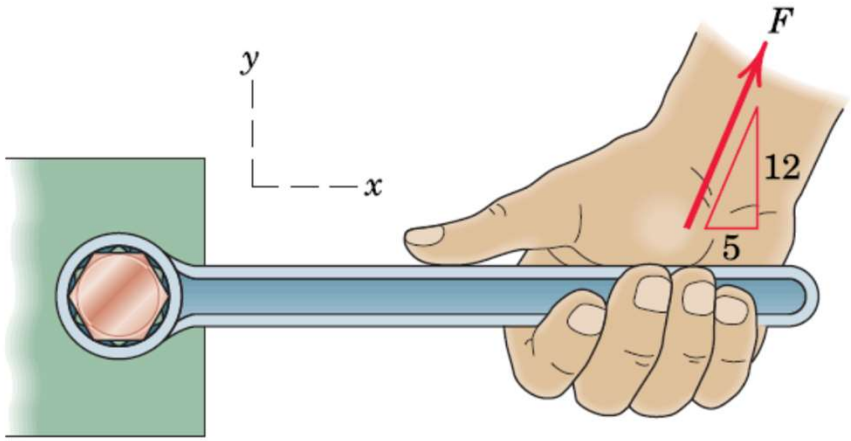
$$\underline{R} = (500 + 350\cos 60^\circ)\,\underline{i} + 350 \sin 60^\circ\,\underline{j}$$

$$\underline{R} = 675\,\underline{i} + 303\,\underline{j}\ \text{N}$$

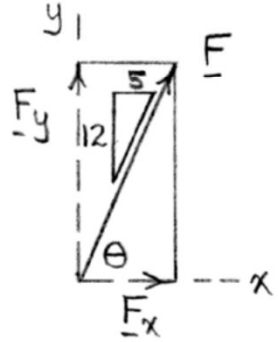
$$R = \sqrt{675^2 + 303^2} \longrightarrow R = 740\ \text{N}$$

$$\theta_x = \cos^{-1}\left(\frac{R_x}{R}\right) = \cos^{-1}\left(\frac{675}{740}\right) \longrightarrow \theta_x = 24.2^\circ \text{ ABOVE } +X \text{ AXIS}$$

2/8) The y-component of the force F which a person exerts on the handle of the box wench is known to be 320N. Determine the x-component and the magnitude of F.



2/9



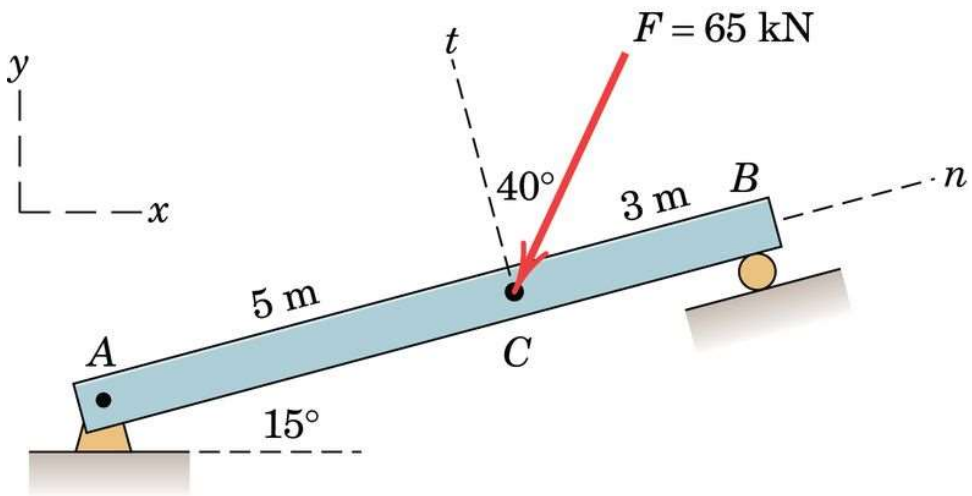
$\cos\theta = \frac{5}{13}$, $\sin\theta = \frac{12}{13}$

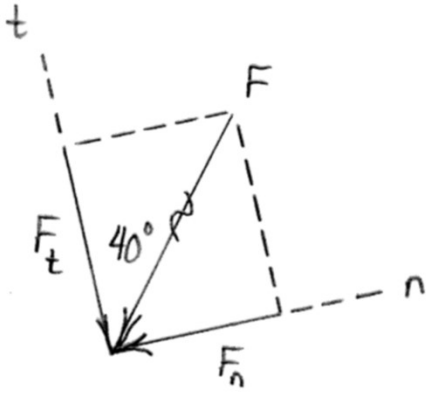
$F_y = F\sin\theta = F\frac{12}{13} = 320\ \text{N}$

$F = 347\ \text{N}$

$F_x = F\cos\theta = 347\left(\frac{5}{13}\right) = 133.3\ \text{N}$

2/10) Determine the x-y and n-t components of the 65-kN force F acting on the simply-supported beam.





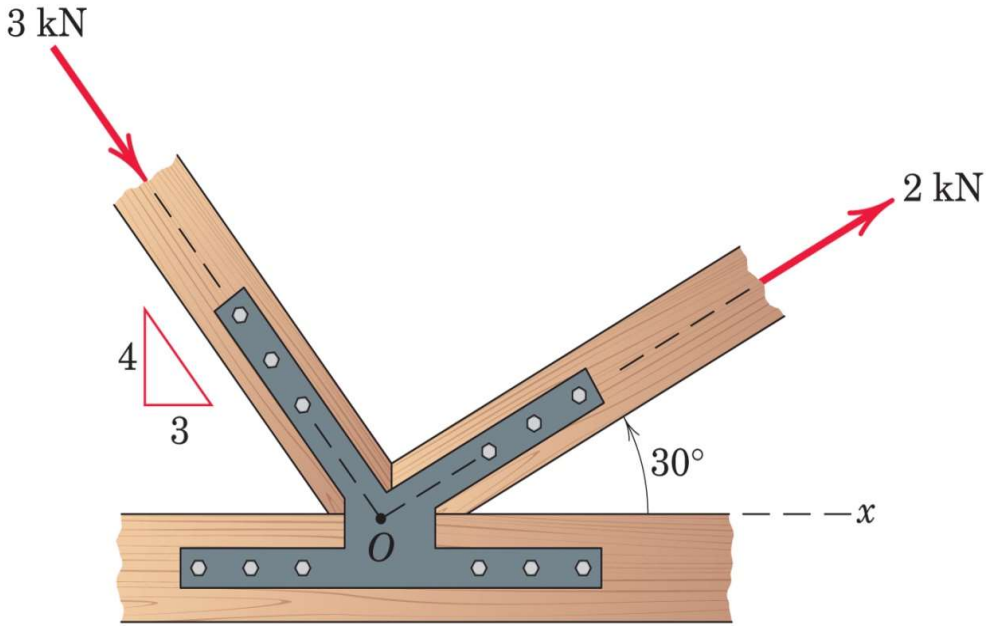
$$F_n = -F \sin 40^\circ = -65 \sin 40^\circ$$

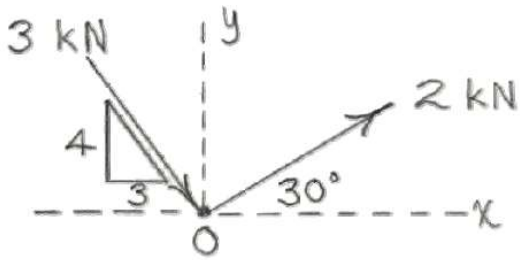
$$F_n = -41.8 \text{ kN}$$

$$F_t = -F \cos 40^\circ = -65 \cos 40^\circ$$

$$F_t = -49.8 \text{ kN}$$

2/11) The two structural members, one of which is in tension and the other in compression, exert the indicated forces on joint O. Determine the magnitude of the resultant R of the two forces and the angle ɵ which R makes with the positive x-axis.





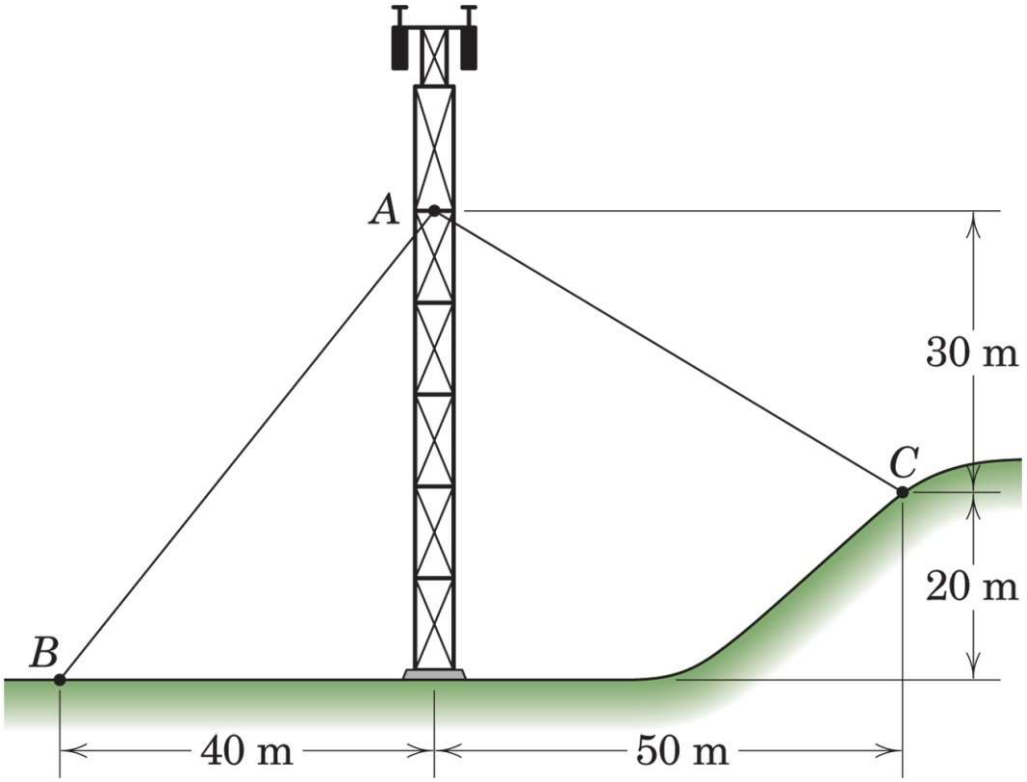
$$R_x = \Sigma F_x = +3\left(\frac{3}{5}\right) + 2\cos 30^\circ = 3.53 \text{ kN}$$

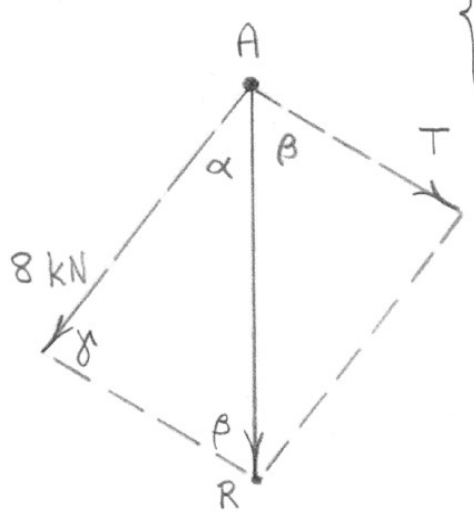
$$R_y = \Sigma F_y = -3\left(\frac{4}{5}\right) + 2\sin 30^\circ = -1.4 \text{ kN}$$

$$R = \sqrt{R_x^2 + R_y^2} = 3.80 \text{ kN}$$

$$\theta = \tan^{-1}\left(\frac{R_y}{R_x}\right) = \tan^{-1}\left(\frac{-1.4}{3.53}\right) = 338^\circ \quad (\text{or } -21.6^\circ)$$

2/12) The guy cables AB and AC are attached to the top of the transmission tower. The tension in cable AB is 8 kN. Determine the required tension T in cable AC such that the net effect of the two cable tensions is a downward force at point A. Determine the magnitude R of this downward force.





$$\alpha = \tan^{-1}\frac{40}{50} = 38.7^\circ$$

$$\beta = \tan^{-1}\frac{50}{30} = 59.0^\circ$$

$$\gamma = 180^\circ - \alpha - \beta$$

$$= 82.3^\circ$$

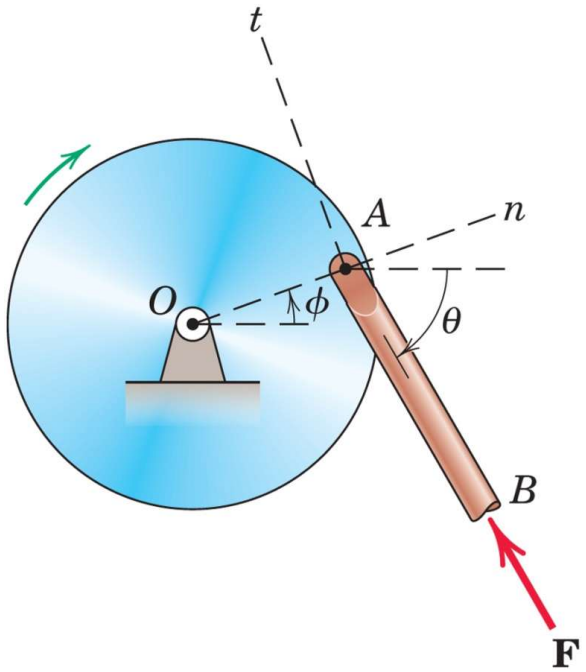
$$\frac{\sin\beta}{8} = \frac{\sin\alpha}{T}$$

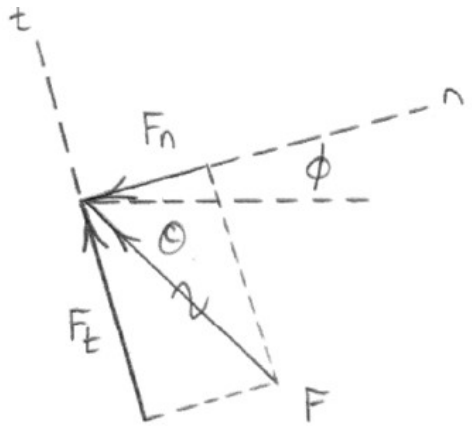
$$T = 5.83 \text{ kN}$$

$$\frac{\sin\beta}{8} = \frac{\sin\gamma}{R},$$

$$R = 9.25 \text{ kN}$$

2/15) A compressive force F is transmitted via the coupler arm AB to disk OA. Develop the general expression for the n-and t-components of F as they act on the disk. Evaluate your expression for (a) F= 500 N, $\theta = 60^0$ and $\phi = 20^0$ (b) F= 800 N, $\theta = 45^0$ and $\phi = 150^0$





$$F_n = -F\cos(\theta+\phi)$$

$$F_t = F\sin(\theta+\phi)$$

a) F = 500 N, $\theta = 60^\circ$, $\phi = 20^\circ$

$F_n = -86.8$ N

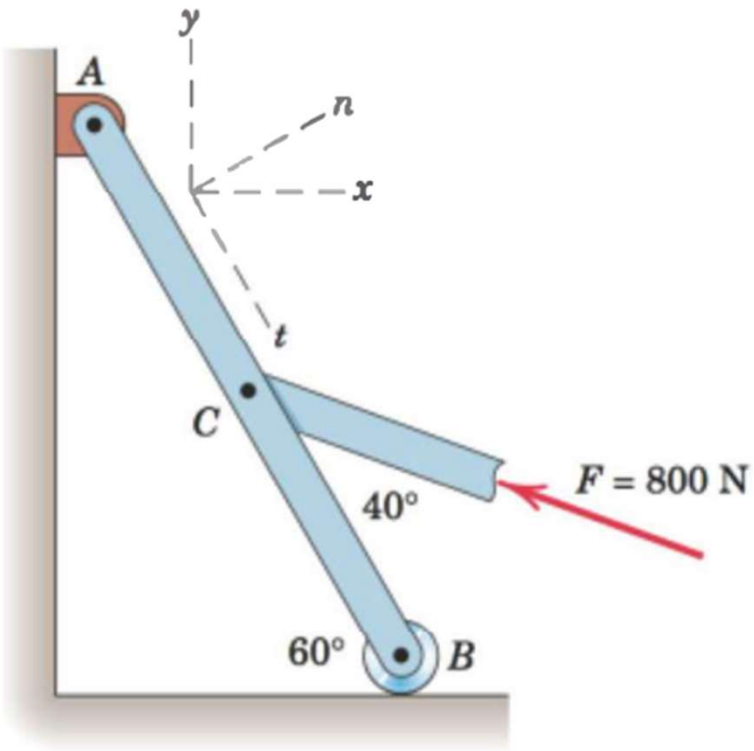
$F_t = 492$ N

b) F = 800 N, $\theta = 45^\circ$, $\phi = 150^\circ$

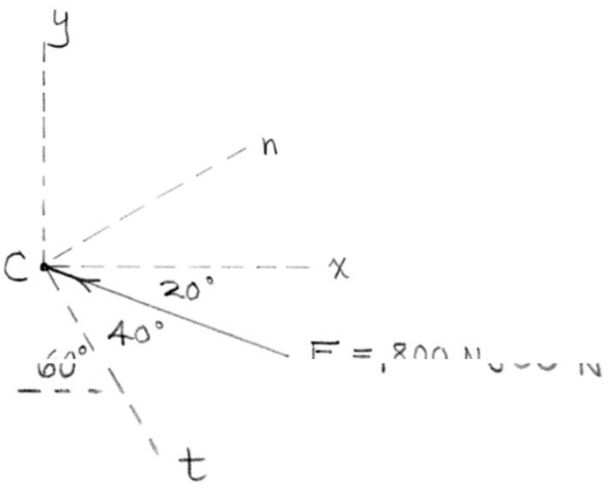
$F_n = 773$ N

$F_t = -207$ N

2/16) A force of magnitude 800 N is applied to point C of the bar AB as shown. Determine both the x-y and n-t components of F.



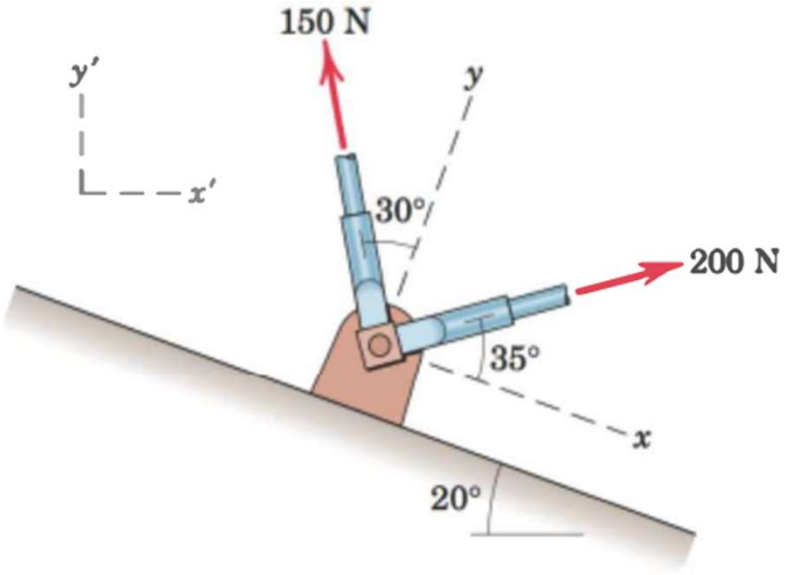
2/16



$$\begin{cases} F_x = -800\cos 20^\circ = -752\ \text{N} \\ F_y = 800\sin 20^\circ = 274\ \text{N} \end{cases}$$

$$\begin{cases} F_n = -800\sin 40^\circ = -514\ \text{N} \\ F_t = -800\cos 40^\circ = -613\ \text{N} \end{cases}$$

2/21) Determine the resultant R of the two forces applied to the bracket. Write R in terms of unit vectors along the x- and y-axes shown.



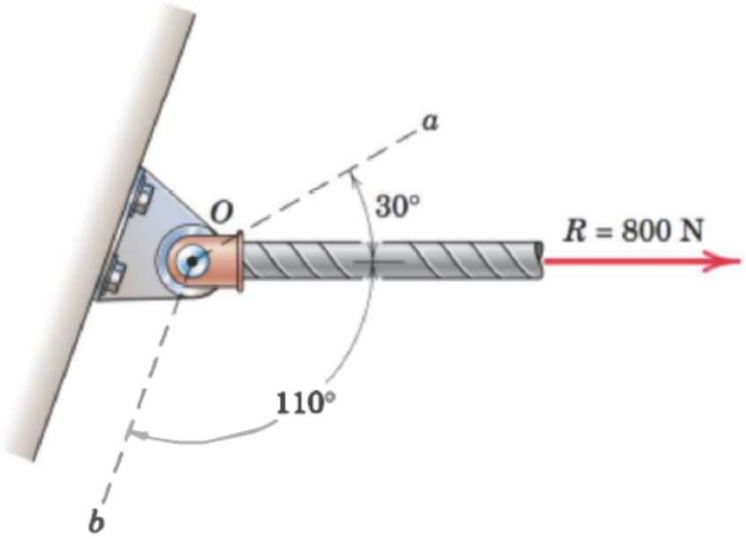
2/21 Using the coordinates of the problem figure :

$$R_x = \Sigma F_x = 200 \cos 35° - 150 \sin 30°$$
$$= 88.8 \text{ N}$$

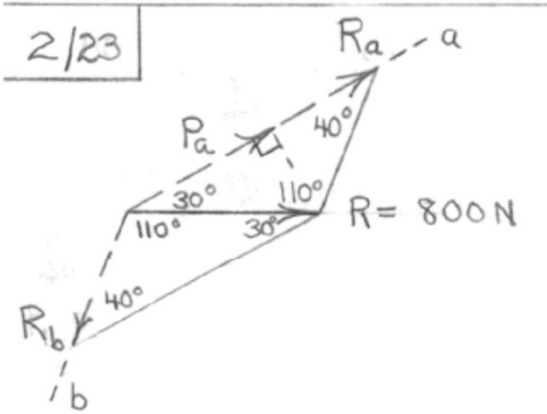
$$R_y = \Sigma F_y = 200 \sin 35° + 150 \cos 30°$$
$$= 245 \text{ N}$$

$$\therefore \underline{R} = 88.8\,\underline{i} + 245\,\underline{j} \text{ N}$$

2/23) Determine the scalar components R_a and R_b of the force R along the nonrectangular axes a and b. Also determine the orthogonal projection P_a of R onto axis a.



2/23



Law of sines :

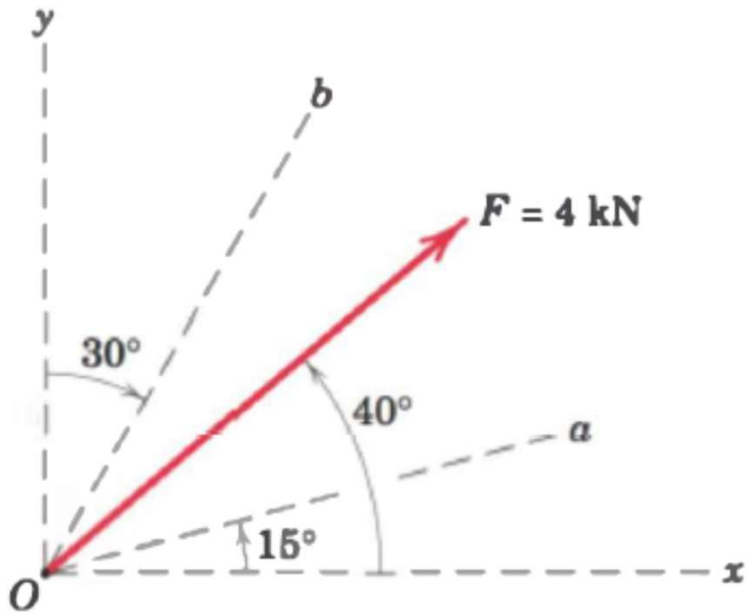
$$\frac{800}{\sin 40^\circ} = \frac{R_a}{\sin 110^\circ} = \frac{R_b}{\sin 30^\circ}$$

$R_a = 1170$ N

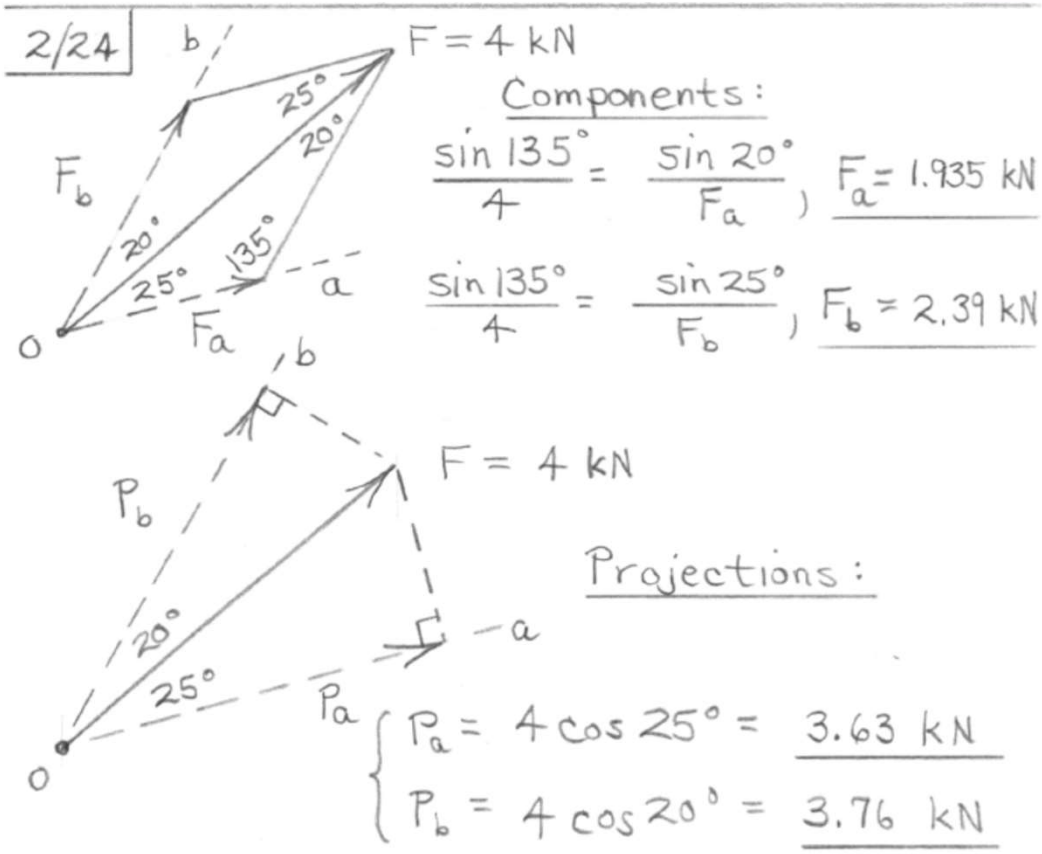
$R_b = 622$ N

Projection $P_a = R\cos 30^\circ = 800 \cos 30^\circ = 693$ N

2/24) Determine the components F_a and F_b of the 4 kN force along the oblique axes a and b. Determine the projections P_a and P_b of F onto the a and b axes.



2/24



Components:

$\frac{\sin 135^\circ}{4} = \frac{\sin 20^\circ}{F_a}$, $F_a = 1.935$ kN

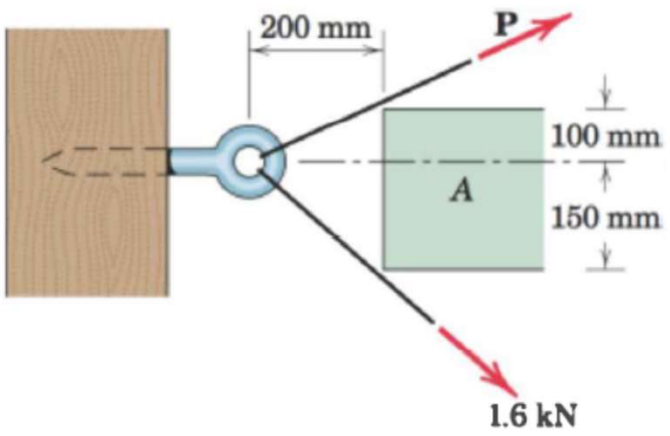
$\frac{\sin 135^\circ}{4} = \frac{\sin 25^\circ}{F_b}$, $F_b = 2.39$ kN

Projections:

$P_a = 4 \cos 25^\circ = 3.63$ kN

$P_b = 4 \cos 20^\circ = 3.76$ kN

2/26) It is desired to remove the spike from the timber by applying force along its horizontal axis. An obstruction A prevents direct access, so that two forces, one 1.6 kN and the other P, are applied by cables as shown. Compute the magnitude of P necessary to ensure a resultant T directed along the spike. Also find T.



2/26

$\alpha = \tan^{-1}\frac{100}{200} = 26.57^\circ$

$\theta = \tan^{-1}\frac{150}{200} = 36.87^\circ$

$\beta = 180 - (\alpha + \theta) = 116.57^\circ$

$\frac{P}{\sin 36.87^\circ} = \frac{1.6}{\sin 26.57}$

$P = 1.6\,\frac{0.6}{0.4472} = \underline{2.15\ kN}$

$\frac{T}{\sin 116.57^\circ} = \frac{1.6}{\sin 26.57^\circ}$) $T = 1.6\,\frac{0.8944}{0.4472} = \underline{3.20\ kN}$

THANK YOU

VINAY PAPANNA
Department of Mechanical Engineering
vinayp@pes.edu