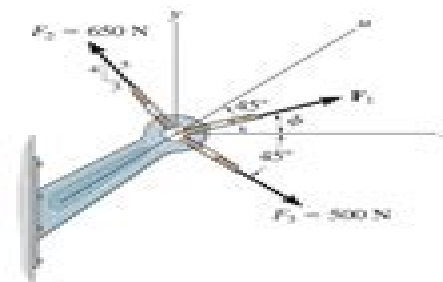


2-45.

If the resultant force acting on the bracket is to be directed along the positive  $x$  axis, and the magnitude of  $F_1$  is required to be minimum, determine the magnitudes of the resultant force and  $F_1$ .



## SOLUTION

**Rectangular Components:** By referring to Figs.  $a$  and  $b$ , the  $x$  and  $y$  components of  $F_1$ ,  $F_2$ ,  $F_3$ , and  $F_R$  can be written as

$$\begin{aligned}(F_1)_x &= F_1 \cos \phi & (F_1)_y &= F_1 \sin \phi \\(F_2)_x &= 650 \left( \frac{3}{5} \right) = 390 \text{ N} & (F_2)_y &= 650 \left( \frac{4}{5} \right) = 520 \text{ N} \\(F_3)_x &= 500 \cos 45^\circ = 353.55 \text{ N} & (F_3)_y &= 500 \sin 45^\circ = 353.55 \text{ N} \\(F_R)_x &= F_R \cos 45^\circ = 0.7071 F_R & (F_R)_y &= F_R \sin 45^\circ = 0.7071 F_R\end{aligned}$$

**Resultant Force:** Summing the force components algebraically along the  $x$  and  $y$  axes, we have

$$\begin{aligned}\rightarrow \sum (F_R)_x &= \sum F_{x_i} & 0.7071 F_R &= F_1 \cos \phi - 390 + 353.55 & (1)\end{aligned}$$

$$+\uparrow \sum (F_R)_y = \sum F_{y_i} & 0.7071 F_R &= F_1 \sin \phi + 520 - 353.55 & (2)$$

Eliminating  $F_R$  from Eqs. (1) and (2), yields

$$F_1 = \frac{202.89}{\cos \phi - \sin \phi} \quad (3)$$

The first derivative of Eq. (3) is

$$\frac{dF_1}{d\phi} = \frac{\sin \phi + \cos \phi}{(\cos \phi - \sin \phi)^2} \quad (4)$$

The second derivative of Eq. (3) is

$$\frac{d^2 F_1}{d\phi^2} = \frac{2(\sin \phi + \cos \phi)^2}{(\cos \phi - \sin \phi)^3} + \frac{1}{\cos \phi - \sin \phi} \quad (5)$$

For  $F_1$  to be minimum,  $\frac{dF_1}{d\phi} = 0$ . Thus, from Eq. (4)

$$\sin \phi + \cos \phi = 0$$

$$\tan \phi = -1$$

$$\phi = -45^\circ$$

Substituting  $\phi = -45^\circ$  into Eq. (5), yields

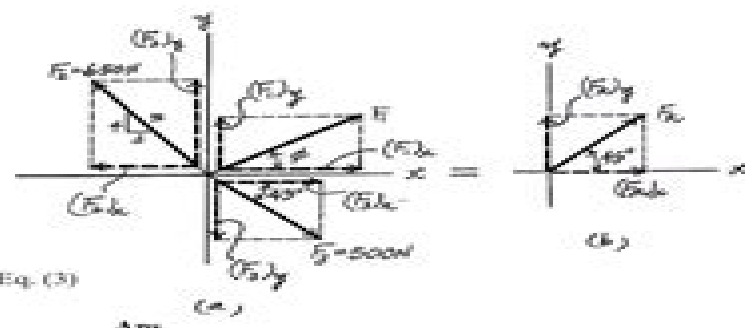
$$\frac{d^2 F_1}{d\phi^2} = 0.7071 > 0$$

This shows that  $\phi = -45^\circ$  indeed produces minimum  $F_1$ . Thus, from Eq. (3)

$$F_1 = \frac{202.89}{\cos(-45^\circ) - \sin(-45^\circ)} = 143.47 \text{ N} \approx 143 \text{ N}$$

Substituting  $\phi = -45^\circ$  and  $F_1 = 143.47 \text{ N}$  into either Eq. (1) or Eq. (2), yields

$$F_R = 91.9 \text{ N}$$



Ans.

Ans.

# Mechanics Statics Solutions Chapter 4

**JL Elias**



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