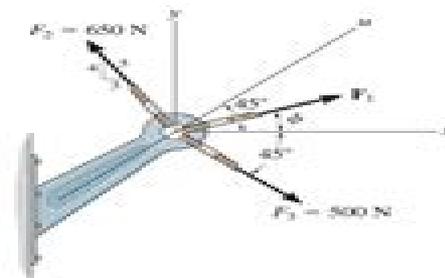**2–45.**

If the resultant force acting on the bracket is to be directed along the positive u axis, and the magnitude of $\mathbf{F}_1$ is required to be *minimum*, determine the magnitudes of the resultant force and $\mathbf{F}_1$.

SOLUTION

Rectangular Components: By referring to Figs. a and b, the x and y components of $\mathbf{F}_1$, $\mathbf{F}_2$, $\mathbf{F}_3$, and $\mathbf{F}_R$ can be written as

$$(F_1)_x = F_1 \cos\phi \qquad\qquad (F_1)_y = F_1 \sin\phi$$

$$(F_2)_x = 650\left(\frac{3}{5}\right) = 390\ \text{N} \qquad\qquad (F_2)_y = 650\left(\frac{4}{5}\right) = 520\ \text{N}$$

$$(F_3)_x = 500\cos 45° = 353.55\ \text{N} \qquad (F_3)_y = 500 \sin 45° = 353.55\ \text{N}$$

$$(F_R)_x = F_R \cos 45° = 0.7071 F_R \qquad (F_R)_y = F_R \sin 45° = 0.7071 F_R$$

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

$$\xrightarrow{+} \Sigma(F_R)_x = \Sigma F_x; \qquad 0.7071 F_R = F_1\cos\phi - 390 + 353.55 \qquad \textbf{(1)}$$

$$+\uparrow \Sigma(F_R)_y = \Sigma F_y; \qquad 0.7071 F_R = F_1\sin\phi + 520 - 353.55 \qquad \textbf{(2)}$$

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

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

The first derivative of Eq. (3) is

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

The second derivative of Eq. (3) is

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

For $\mathbf{F}_1$ to be minimum, $\dfrac{dF_1}{d\phi} = 0$. Thus, from Eq. (4)

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

$$\tan\phi = -1$$

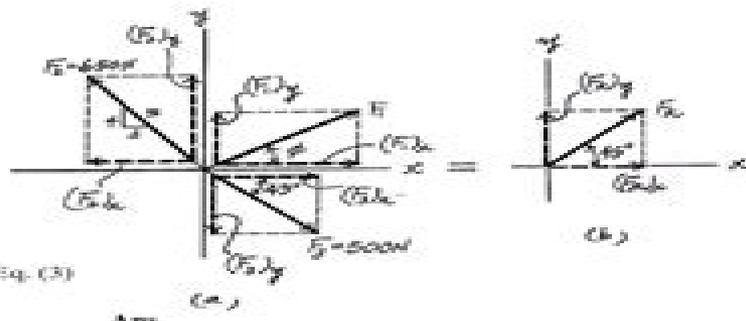$$\phi = -45°$$

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

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

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

$$F_1 = \frac{202.89}{\cos(-45°) - \sin(-45°)} = 143.47\ \text{N} = 143\ \text{N} \qquad \textbf{Ans.}$$

Substituting $\phi = -45°$ and $F_1 = 143.47$ N into either Eq. (1) or Eq. (2), yields

$$F_R = 91.9\ \text{N} \qquad \textbf{Ans.}$$

Statics And Mechanics Of Materials Solutions

SJ Ball

Statics And Mechanics Of Materials Solutions :

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