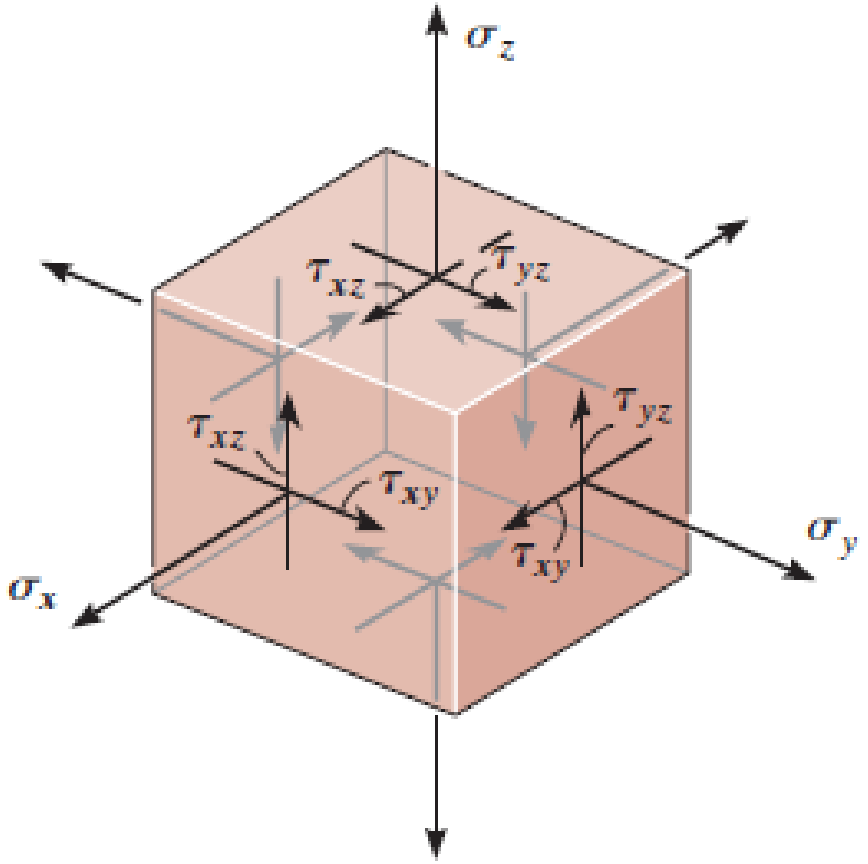
Strength of Material

Plane Stress

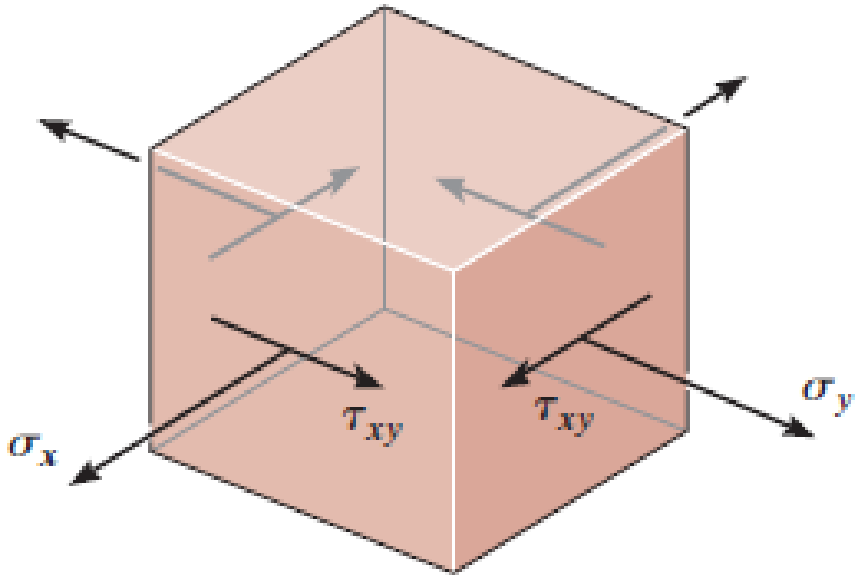
Stress

In this section, we will show how to apply the equations for plane stress transformation using a graphical solution that is often convenient to use and easy to remember. Furthermore, this approach will allow us to “visualize” how the normal and shear stress components and vary as the plane on which they act is oriented in different directions,



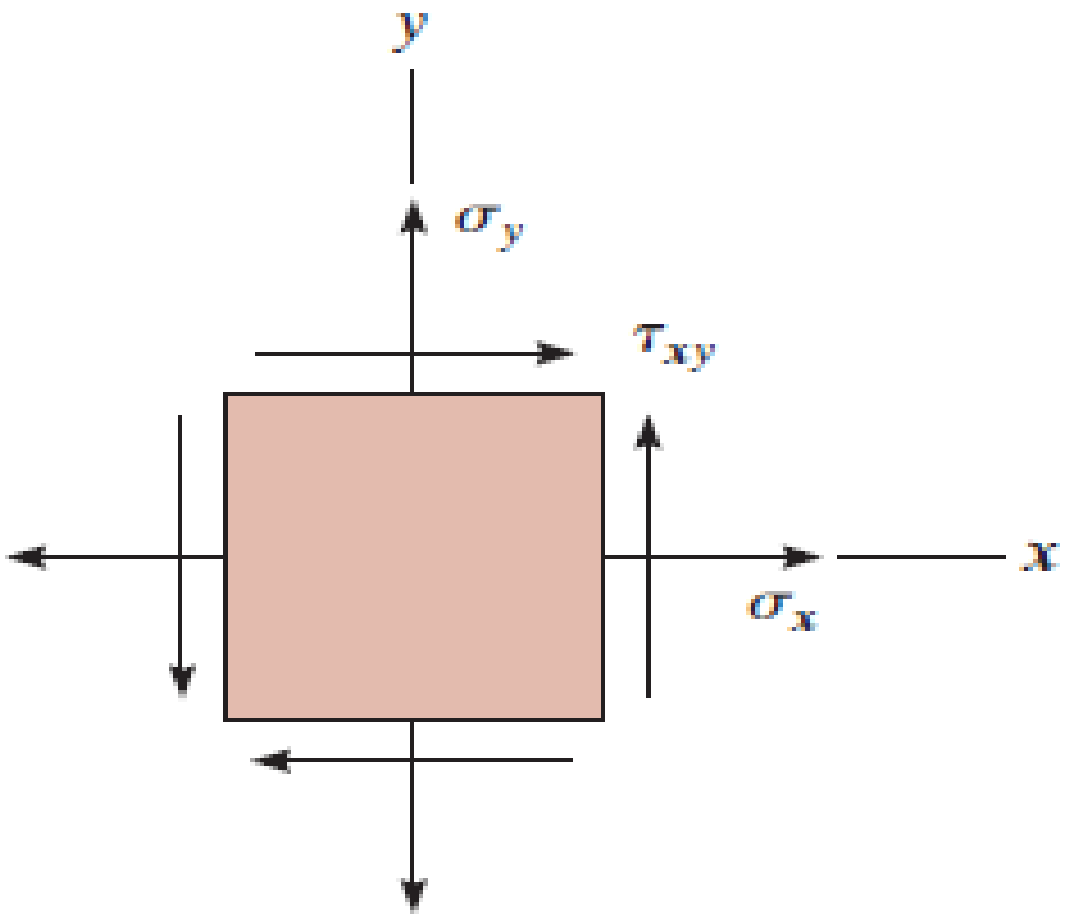
General state of stress

(a)

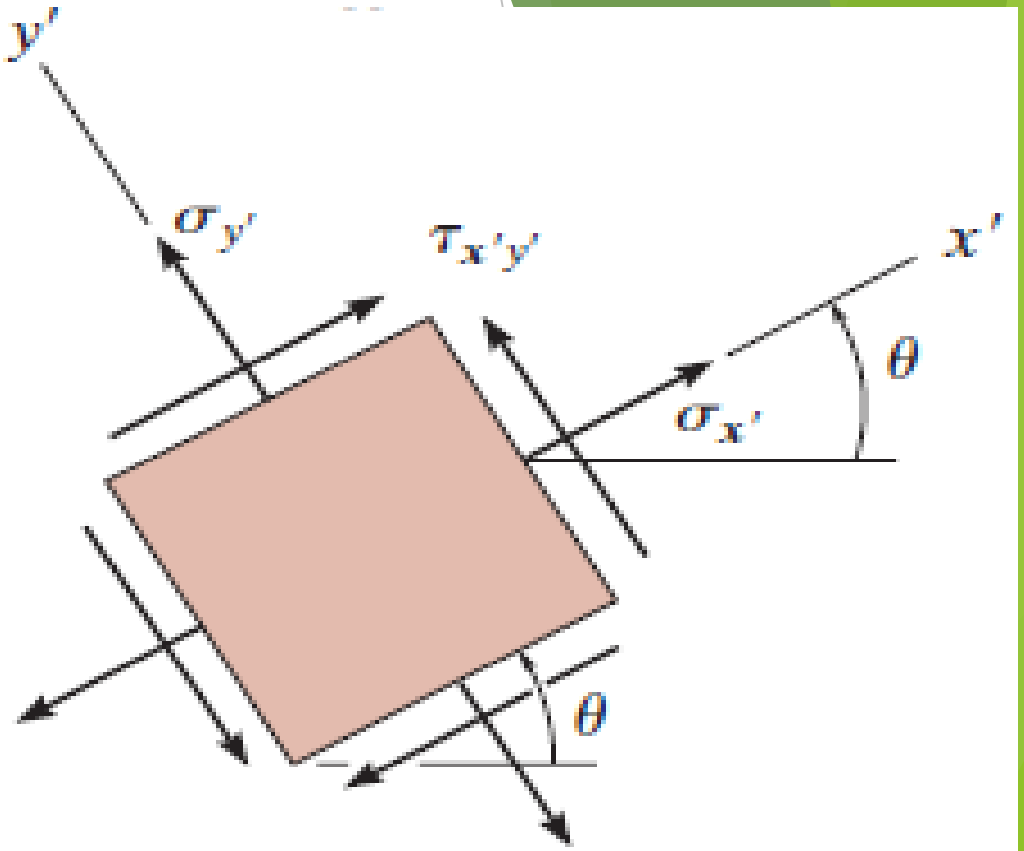


Plane stress

(b)

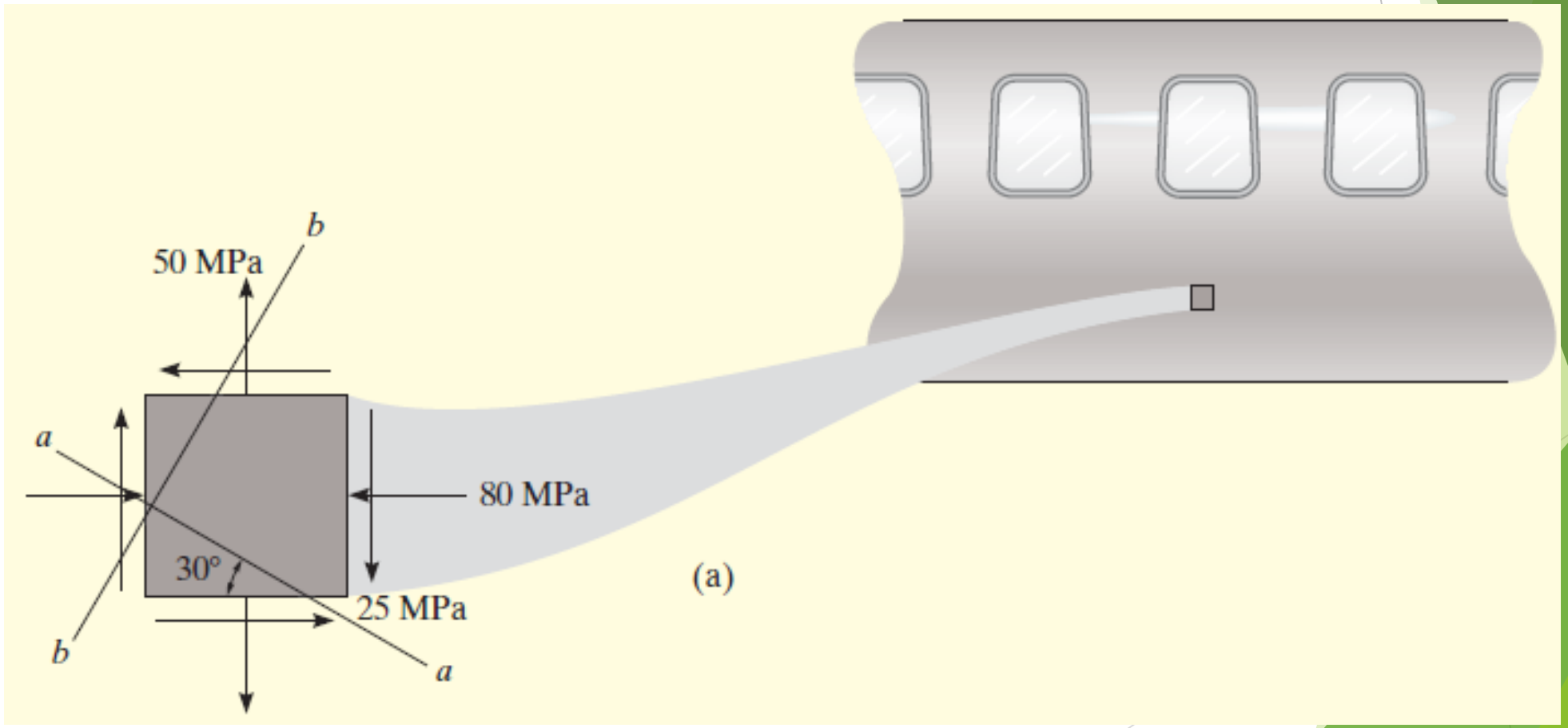


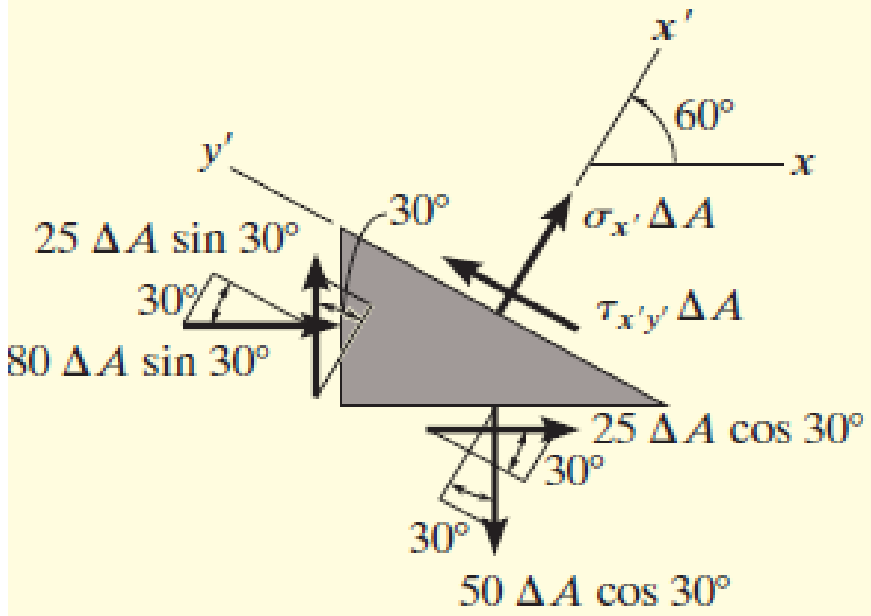
(a)



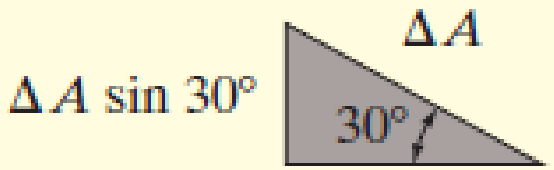
(b)

Example The state of plane stress at a point on the surface of the airplane fuselage is represented on the element oriented as shown in Fig. . Represent the state of stress at the point on an element that is oriented 30° clockwise from the position shown.





(c)



(b)

$$\sigma_{x'}\,\Delta A - (50\,\Delta A\cos 30^\circ)\cos 30^\circ + (25\,\Delta A\cos 30^\circ)\sin 30^\circ + (80\,\Delta A\sin 30^\circ)\sin 30^\circ + (25\,\Delta A\sin 30^\circ)\cos 30^\circ = 0$$

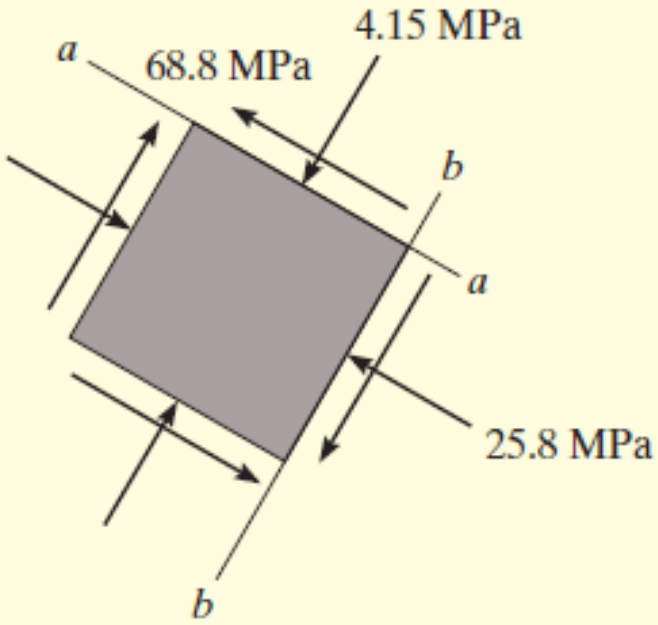
$$\sigma_{x'} = -4.15\ \text{MPa} \qquad \textit{Ans.}$$

$$\tau_{x'y'}\,\Delta A - (50\,\Delta A\cos 30^\circ)\sin 30^\circ - (25\,\Delta A\cos 30^\circ)\cos 30^\circ - (80\,\Delta A\sin 30^\circ)\cos 30^\circ + (25\,\Delta A\sin 30^\circ)\sin 30^\circ = 0$$

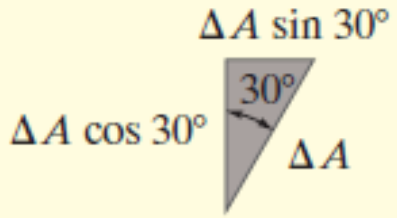
$$\tau_{x'y'} = 68.8\ \text{MPa} \qquad \textit{Ans.}$$

$$+\searrow \Sigma F_{x'} = 0; \quad \sigma_{x'}\,\Delta A - (25\,\Delta A \cos 30°) \sin 30°$$
$$+ (80\,\Delta A \cos 30°) \cos 30° - (25\,\Delta A \sin 30°) \cos 30°$$
$$- (50\,\Delta A \sin 30°) \sin 30° = 0$$
$$\sigma_{x'} = -25.8 \text{ MPa} \qquad \textit{Ans.}$$

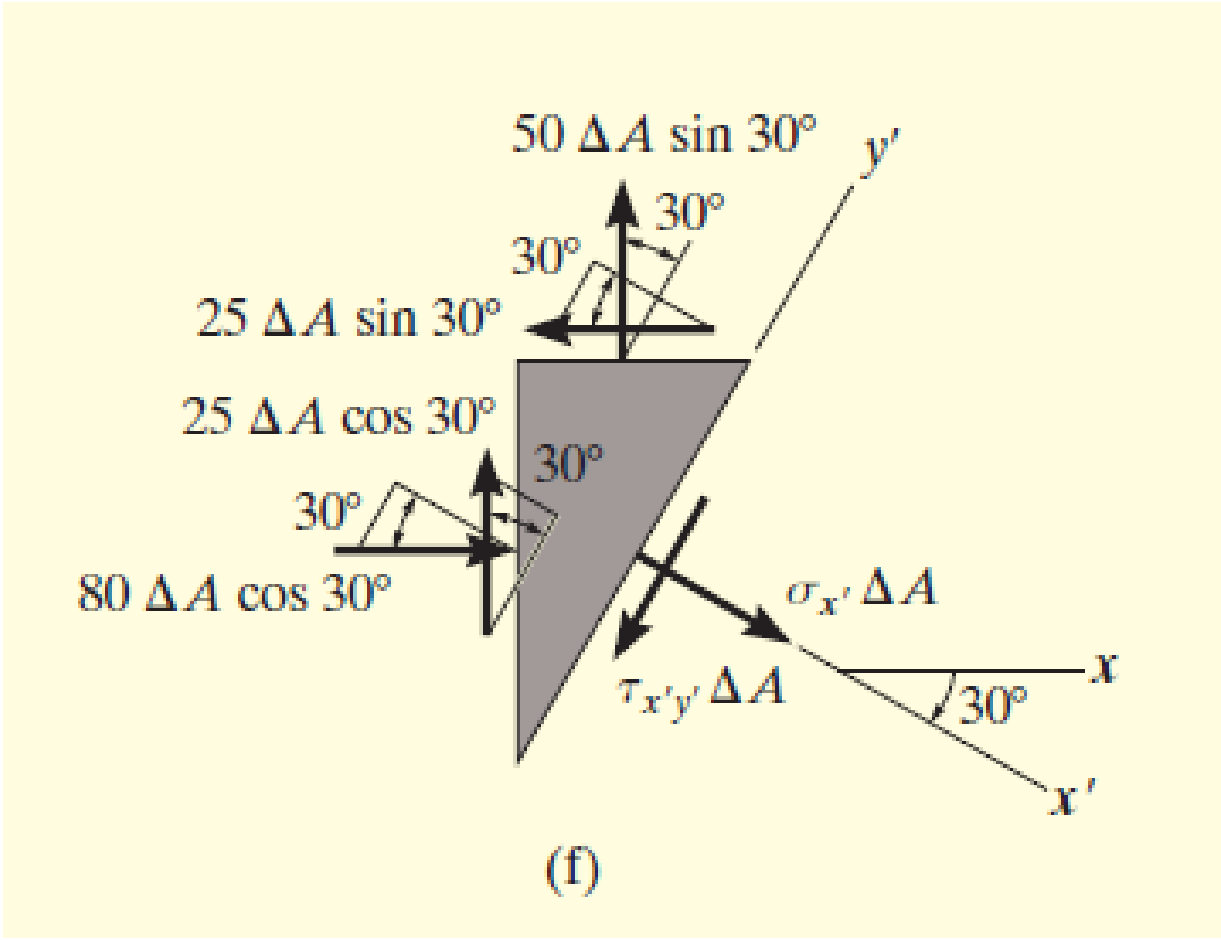
$$+\nearrow \Sigma F_{y'} = 0; \quad -\tau_{x'y'}\,\Delta A + (25\,\Delta A \cos 30°) \cos 30°$$
$$+ (80\,\Delta A \cos 30°) \sin 30° - (25\,\Delta A \sin 30°) \sin 30°$$
$$+ (50\,\Delta A \sin 30°) \cos 30° = 0$$
$$\tau_{x'y'} = 68.8 \text{ MPa} \qquad \textit{Ans.}$$



(d)



(e)


50 ΔA sin 30°
y′
30°
30°
25 ΔA sin 30°
25 ΔA cos 30°
30°
30°
80 ΔA cos 30°
σx′ ΔA
τx′y′ ΔA
x
30°
x′

(f)