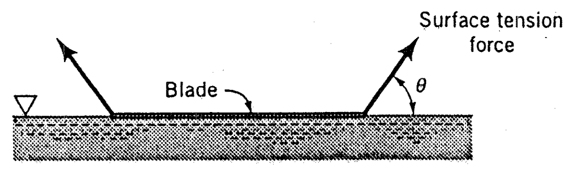
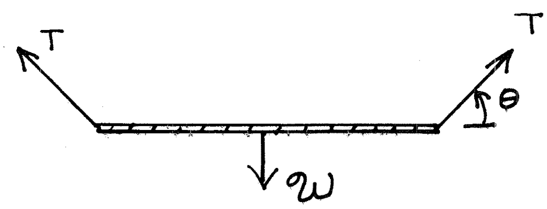
1.84

1.84 As shown in Video V1.5, surface tension forces can be strong enough to allow a double-edge steel razor blade to "float" on water, but a single-edge blade will sink. Assume that the surface tension forces act at an angle θ relative to the water surface as shown in Fig. P1.84. (a) The mass of the double-edge blade is 0.64×10^{-3} kg, and the total length of its sides is 206 mm. Determine the value of θ required to maintain equilibrium between the blade weight and the resultant surface tension force. (b) The mass of the single-edge blade is 2.61×10^{-3} kg, and the total length of its sides is 154 mm. Explain why this blade sinks. Support your answer with the necessary calculations.



■ FIGURE P1.84



(a) $\sum F_{vertical} = 0$

$$\mathcal{W} = T \sin\theta$$

where $\mathcal{W} = m_{blade} \times g$ and $T = \sigma \times$ length of sides.

$$\therefore \left(0.64 \times 10^{-3}\,kg\right)\left(9.81\,m/s^2\right) = \left(7.34 \times 10^{-2}\,\frac{N}{m}\right)\left(0.206\,m\right)\sin\theta$$

$$\sin\theta = 0.415$$

$$\underline{\underline{\theta = 24.5^\circ}}$$

(b) For single-edge blade

$$\mathcal{W} = m_{blade} \times g = \left(2.61 \times 10^{-3}\,kg\right)\left(9.81\,m/s^2\right)$$
$$= 0.0256\,N$$

and

$$T \sin\theta = \left(\sigma \times \text{length of blade}\right)\sin\theta$$
$$= \left(7.34 \times 10^{-2}\,N/m\right)\left(0.154\,m\right)\sin\theta$$
$$= 0.0113 \sin\theta$$

In order for blade to "float" $\mathcal{W} < T\sin\theta$. Since maximum value for $\sin\theta$ is 1, it follows that $\mathcal{W} > T\sin\theta$ and single-edge blade will sink.