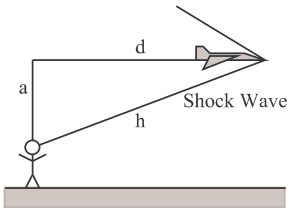
Chapter 14 Problem 71 †



Given
$v = 340\ m/s$
$u = 2.2v$
$\Delta t = 19\ s$

Solution
Find the altitude of the plane.

Since the plane is travelling at super-sonic speeds the angle of the shock wave is given by

$$\theta = \sin^{-1}\left(\frac{v}{u}\right)$$

Substituting in the value for u gives

$$\theta = \sin^{-1}\left(\frac{v}{2.2v}\right) = \sin^{-1}\left(\frac{1}{2.2}\right) = 27.0^\circ$$

From the diagram the altitude can be calculated from the angle of the shock wave and the distance the plane travels before the shock wave hits you.

$$\tan\theta = \frac{a}{d} \tag{1}$$

The distance the plane travels is velocity times time

$$d = u \cdot t$$

Substituting this into equation 1 and solving for altitude gives

$$a = d\tan\theta = u \cdot t\tan\theta$$

Substituting in the appropriate values gives

$$a = 2.2v \cdot t\tan\theta = 2.2(340\ m/s)(19\ s)\tan 27.0^\circ$$

$$a = 7240\ m = 7.24\ km$$

†Problem from Essential University Physics, Wolfson