

59. (a) The half angle θ of the Mach cone is given by $\sin \theta = v/v_S$, where v is the speed of sound and v_S is the speed of the plane. Since $v_S = 1.5v$, $\sin \theta = v/1.5v = 1/1.5$. This means $\theta = 42^\circ$.
- (b) Let h be the altitude of the plane and suppose the Mach cone intersects Earth's surface a distance d behind the plane. The situation is shown on the diagram below, with P indicating the plane and O indicating the observer. The cone angle is related to h and d by $\tan \theta = h/d$, so $d = h/\tan \theta$. The shock wave reaches O in the time the plane takes to fly the distance d : $t = d/v = h/v \tan \theta = (5000 \text{ m})/1.5(331 \text{ m/s}) \tan 42^\circ = 11 \text{ s}$.

