An anti-aircraft shell is fired from a gun vertically and the shell explodes at the apex of its trajectory. Whilst stood next to the gun you hear the explosion 8.0 seconds after the shell was fired. At what altitude did the shell explode?

Assume that the speed of sound is 340 ms^{-1} and that air resistance can be neglected.

$$v^2 = u^2 + 2as \Rightarrow s = \frac{v^2 - u^2}{2a}$$

At greatest height $v = 0 \Rightarrow s = \frac{u^2}{2g}$

The time taken to reach this height can be found using $s = vt - \frac{1}{2}at^2$

$$\frac{u^2}{2g} = \frac{g}{2}t^2$$

$$t = \frac{u}{g}$$

Time to reach greatest height + time required for sound to travel down =

$$\frac{u}{g} + \frac{\left(\frac{u^2}{2g}\right)}{340} = 8$$

$$\frac{u^2}{680g} + \frac{u}{g} - 8 = 0$$

Solving the quadratic equation gives $u = 70.989\ ms^{-1}$

The altitude at which the shell exploded = $\frac{u^2}{2g} = \frac{70.989^2}{2 \times 9.8} = 257\ m$

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