Answer on Question 58480, Physics, Other

Question:

An anti-aircraft shell is fired vertically upward with a muzzle velocity of $488\,ms^{-1}$. What is the maximum height it can reach? What time it takes to reach the maximum height? What is the instantaneous velocity at the end of $40\,s$, $60\,s$?

Solution:

a) Let's take the upwards as the positive direction. Then, we can find the maximum height from the kinematic equation:

$$v_f^2 = v_i^2 + 2ah,$$

here, $v_f = 0\,ms^{-1}$ is the final velocity of the shell at the maximum height, v_i is the initial velocity of the shell, $a = g = -9.8\,ms^{-2}$ is the acceleration due to gravity, h is the height.

Then, we get:

$$0 = (488\,ms^{-1})^2 + 2 \cdot (-9.8\,ms^{-2}) \cdot h,$$

$$19.6\,ms^{-2} \cdot h = 238144\,m^2s^{-2},$$

$$h = \frac{238144\,m^2s^{-2}}{19.6\,ms^{-2}} = 12.15 \cdot 10^3\,m = 12.15\,km.$$

b) We can find the time that shell takes to reach the maximum height from the kinematic equation:

$$v_f = v_i + at,$$

here, $v_f = 0\,ms^{-1}$ is the final velocity of the shell at the maximum height, v_i is the initial velocity of the shell, $a = g = -9.8\,ms^{-2}$ is the acceleration due to gravity, t is the time.

Then, we get:

$$0 = 488\,ms^{-1} + (-9.8\,ms^{-2}) \cdot t,$$

$$9.8\,ms^{-2} \cdot t = 488\,ms^{-1},$$

$$t = \frac{488\, ms^{-1}}{9.8\, ms^{-2}} = 49.8\, s.$$

c) We can find the instantaneous velocity at the end of $40\, s$ from the kinematic equation:

$$v_f = v_i + at = 488\, ms^{-1} + (-9.8\, ms^{-2}) \cdot 40\, s = 96\, ms^{-1}.$$

d) Similarly, we can find the instantaneous velocity at the end of $60\, s$:

$$v_f = v_i + at = 488\, ms^{-1} + (-9.8\, ms^{-2}) \cdot 60\, s = -100\, ms^{-1}.$$

The sign minus indicates that the velocity of the shell is directed downward (the shell is begin to fall).

Answer:

a) $h = 12.15\, km$

b) $t = 49.8\, s$

c) $v_f = 96\, ms^{-1}$

d) $v_f = -100\, ms^{-1}$