Answer on Question #54123, Physics / Mechanics | Kinematics | Dynamics

A simple model rocket starts at rest, burns fuel to provide an acceleration of 2.5 m/s^2. Once it reaches an altitude of 460 m the rocket runs out of fuel, its engine shuts off and it enters free-fall. Throughout we are neglecting air resistance and assume acceleration due to gravity is 9.8 m/s^2.

(a) How long after being launched does the rocket run out of fuel?

(b) What is the velocity of the rocket when it runs out of fuel?

(c) What is the maximum height above the ground that the rocket reaches?

(d) What is the velocity of the rocket just before it crashes into the ground?

Solution:

(a) Kinematics equation

$$h_1 = v_0 t + \frac{at^2}{2}$$

where a is acceleration, h_1 is distance, v_0 is initial velocity.

$$v_0 = 0.$$

Thus, time is

$$t = \sqrt{\frac{2h_1}{a}} = \sqrt{\frac{2 * 460}{2.5}} = \mathbf{19.2\ s}$$

(b) Kinematics equation

$$2ah_1 = v^2 - v_0^2$$

where a is acceleration, h_1 is distance, v_0 is initial velocity and v is final velocity.

$$v_0 = 0.$$

$$v = \sqrt{2ah_1} = \sqrt{2 * 2.5 * 460} = 47.96 \approx \mathbf{48\ m/s}$$

(c) Kinematics equation

$$2ah_2 = v^2 - v_0^2$$

where a=-g is acceleration, h is distance, v_0=47.96 m/s is initial velocity and v=0 is final velocity.

Thus,

$$h_2 = \frac{v_0^2}{2g} = \frac{47.96^2}{2 * 9.8} = 117.36\ \text{m}$$

Therefore maximum height from ground

$$h = h_1 + h_2 = 460 + 117.36 = 577.36\ \text{m} \approx \mathbf{577.4\ m}$$

(d)

$$v = \sqrt{2gh} = \sqrt{2 * 9.8 * 577.36} = 106.38\ m/s \approx \mathbf{106.4\ m/s}$$