Answer on Question #42194, Physics, Mechanics | Kinematics | Dynamics

3. A rock is dropped (from rest) from the top of a 60 m tall building. How far above the ground is the rock 1.2 s before it reaches the ground?

4. A mother racing her son has half the kinetic energy of the son, who has half the mass as the mother. Mother speeds up by 1.0 m/s and then has the same kinetic energy as that of the son. What are the original speeds of the mother and the son?

Solution:

3.

Given:

$y_0 = 60$ m,

$t = 1.2$ s,

y_1 = ?

An object in free fall experiences an acceleration g of -9.81 m/s^2. (The - sign indicates a downward acceleration.) Whether explicitly stated or not, the value of the acceleration in the kinematic equations is -9.81 m/s^2 for any freely falling object.

The equation of moving to the top point is

$$y = y_0 + v_o t + \frac{1}{2}at^2$$

where

$y_0 = 60\ m$ is initial position

$v_0 = 0$ is initial speed

$a = g = -9.81\ m/s^2$ is acceleration

At time t = 1.2 s, the position of a rock is

$$y_1 = 60 + 0 + \frac{1}{2}(-9.81)1.2^2 = 52.94 \text{ m}$$

Answer. $y_1 = 52.94$ m.

4. A mother racing her son has half the kinetic energy of the son, who has half the mass as the mother. Mother speeds up by 1.0 m/s and then has the same kinetic energy as that of the son. What are the original speeds of the mother and the son?

Solution:

Given:

$m_2 = m_1/2,$

$KE_1 = KE_2/2$

$v_1 = ?,$

$v_2 = ?$

The kinetic energy is

$$KE_1 = \frac{KE_2}{2}$$

$$\frac{m_1 v_1^2}{2} = \frac{m_2 v_2^2}{4}$$

So,

$$2m_1 v_1^2 = m_2 v_2^2$$

$$m_2 = m_1/2$$

Thus,

$$2m_1 v_1^2 = \frac{m_1}{2} v_2^2$$

$$4v_1^2 = v_2^2 \qquad (1)$$

From given we also have

$$\frac{m_1 (v_1 + 1)^2}{2} = \frac{m_2 v_2^2}{2}$$

$$\frac{m_1 (v_1 + 1)^2}{2} = \frac{m_1 v_2^2}{4}$$

Thus, the second equation is

$$2(v_1 + 1)^2 = v_2^2 \qquad (2)$$

$$2(v_1 + 1)^2 = 4v_1^2$$

$$2(v_1^2 + 2v_1 + 1) = 4v_1^2$$

We obtain quadratic equation

$$2v_1^2 - 2v_1 - 1 = 0$$

Solution is

$$v_1 = \frac{2 + \sqrt{4 + 4 \cdot 2}}{4} = 1.366 \text{ m/s}$$

$$v_2 = 2v_1 = 2 \cdot 1.366 = 2.732 \text{ m/s}$$

Answer. The mother speed is $v_1 = 1.366$ m/s,

the son speed is $v_2 = 2.732$ m/s