Kinematics Answer Key

Problem 1: An LRT train can achieve average accelerations of 1.4 m/s^2. Suppose such a train accelerates from rest at this rate for 3.41 s. How far does it travel in this time?

Solution: Since the train starts from rest, its initial velocity and position is equal to 0. We are given with the following quantities:

$$a_x = 1.4 \text{ m/s}^2$$

$$t = 3.41 \text{ s}$$

We can then use the formula

$$x = x_0 + v_{0x}t + \tfrac{1}{2}a_x t^2$$

Since x_0 and v_{0x} is equal to 0,

$$x = \tfrac{1}{2}a_x t^2$$

Substituting the values, we will get

$$x = \tfrac{1}{2}\,(1.4 \text{ m/s}^2)\,(3.41 \text{ s})^2$$

$$x = \mathbf{8.14\ m}$$

For numbers 2 and 3: A ball is thrown vertically upward with a speed of 15 m/s from the roof of a 28-m tower. The ball did not hit the tower on its way back down and landed in the ground below. Neglecting air resistance,

Problem 2: Find the speed of the ball just before it hits the ground.

Solution: We are given with the following quantities:

$$v_{0y} = 15 \text{ m/s}$$

$$y - y_0 = -28 \text{ m (downward)}$$

$$g = -9.8 \text{ m/s}^2$$

To find the speed of the ball before it hits the ground, we must use the equation

$$v_{fy}^2 = v_{0y}^2 + 2gy$$

Substituting the values, we will get

$$v_{fy}^2 = (15 \text{ m/s})^2 + 2(-9.8 \text{ m/s}^2)(-28 \text{ m})$$

$$v_{fy}^2 = 773.8 \text{ m}^2/\text{s}^2$$

$$v_{fy} = \mathbf{27.8 \text{ m/s}}$$

Problem 3: Determine the total time elapsed from when the ball is thrown upward until it hits the ground.

Solution: To find the time t, we are going to use the equation $v_{fy} = v_{0y}+gt$. Solving for t,

$$t = (v_{fy} - v_{0y})/g$$

$$t = (-27.8 \text{ m/s} - 15 \text{ m/s})/-9.8 \text{ m/s}^2$$

$$t = \mathbf{4.37 \text{ s}}$$

For numbers 4 and 5: A football player throws the ball upward with an initial velocity of 8.0 m/s and a horizontal velocity component of 24.0 m/s. Neglecting air resistance,

Problem 4: How long does it take for the football to reach the highest point of the trajectory?

Solution: We are given with the following quantities:

$$v_{0y} = 8.0 \text{ m/s}$$

$$v_x = 24.0 \text{ m/s}$$

The time required to reach the maximum point of trajectory is given by

$$t = (v_{fy} - v_{0y})/g$$

Substituting the values, we have

$$t = (0 - 8 \text{ m/s})/-9.8 \text{ m/s}^2$$

$$t = \mathbf{0.82 \text{ s}}$$

Problem 5: What is the maximum height of the trajectory?

Solution: To find the maximum height, we are going to use the equation

$$v_{fy}^2 = v_{0y}^2 - 2gy$$

Solving for y, we have

$$y = (v_{fy}^2 - v_{0y}^2)/2g$$

$$y = (8 \text{ m/s})^2/2 (-9.8 \text{ m/s}^2)$$

$$y = \mathbf{3.27\ m}$$

Note that in this case, we are going to neglect the negative sign since we are only looking for the maximum height.