EP0605 Tutorial 3 – Kinematics

1. What is the difference between distance and displacement?

2. Average speed can mean the magnitude of the average velocity vector. Another meaning given to it is that average speed is the total length of path travelled divided by the elapsed time. Are these meanings different? If so, give an example.

3. When the velocity is constant, does the average velocity over any time interval differ from the instantaneous velocity at any instant?

4. Can a body have zero velocity and still be accelerating?

5. Can a body have constant speed and still have a varying velocity?

6. Can an object have an eastward velocity while experiencing a westward acceleration?

7. A car travels in the +*x*-direction on a straight road. For the first 4.00 s of its motion, the average velocity of the car is 6.25 m/s. How far does the car travel in 4.00 s?

8. A car is stopped at a traffic light. It then travels along a straight road so that its distance *x* from the traffic light as a function of time as $x(t) = bt^2 - ct^3$ where b = 2.40 m/s^2 and c = 0.120 m/s^3.

   (a) Calculate the average velocity of the car during t = 0.00 s to t = 10.00 s.
   (b) Calculate the instantaneous velocity of the car at t = 5.00 s and t = 10.00 s.
   (c) How long after starting from rest is the car again at rest?

9. The human body can survive an acceleration trauma accident (sudden stop) if the magnitude of the acceleration is less than 250 m/s^2. If a person is in an automobile accident with an initial speed of 105 km/h and the person is stopped by an airbag that inflates from the dashboard, over what distance must the airbag stop the person to survive the crash?

10. Falls resulting in hip fractures is a major cause of injury and death to the elderly. Typically the hip's speed at impact is about 2.0 m/s. If this speed can be reduced to 1.3 m/s or less the hip will usually not fracture. One way to do this is by wearing elastic hip pads. You can assume vertical motion during the fall.

    (a) If a typical pad is 5.0 cm and compresses by 2.0 cm during the impact of a fall, what constant acceleration does the hip undergo to reduce its speed from 2.0 m/s to 1.3 m/s?
    (b) How long does this acceleration last?

11. Two stones are thrown vertically upward from the ground, one with three times the initial speed of the other. Assume free fall.
    (a) If the faster stone takes 10 s to return to the ground, how long will it take the slower stone to return?
    (b) If the slower stone reaches a maximum height of *H*, how high (in terms of *H*) will the faster stone go?

12. A web page designer creates an animation in which a dot on a computer screen has a position of $\mathbf{r} = [4.0\text{ cm} + (2.5\text{ cm/s}^2)\,t^2]\mathbf{i} + (5.0\text{ cm/s})t\,\mathbf{j}$

    (a) Find the magnitude & direction of the dot's average velocity between $t = 0.0$ s and $t = 2.0$ s.
    (b) Find the magnitude and direction of the instantaneous velocity at $t = 0.0$ s, $t = 1.0$ s and $t = 2.0$ s.

13. Firemen are shooting a stream of water at a burning building using a high-pressure hose that shoots out the water with a speed of 25.0 m/s as it leaves the end of the hose. Once it leaves the hose the water moves in projectile motion. The firemen adjust the angle of elevation α of the hose until the water takes 3.00 s to reach the building 45.0 m away. You can ignore air resistance and assume that the end of the hose is at the ground level.

    (a) Find the angle of elevation α.
    (b) Find the speed and the acceleration of the water at the highest point in its trajectory.
    (c) How high above the ground does the water strike the building and how fast is it moving just before it hits the building?

14. A 124-kg balloon carrying a 22-kg basket is descending with a constant downward velocity of 20.0 m/s. A 1.0-kg rock is thrown from the basket with an initial velocity of 15.0 m/s perpendicular to the path of the descending balloon, as measured relative to a person at rest in the basket. The person in the basket sees the stone hit the ground 6.00 s after being thrown. Assume that the balloon continues its downward descent with the same constant speed of 20.0 m/s.

    (a) How high was the balloon when the rock was thrown out?
    (b) How high is the balloon when the rock hits the ground?
    (c) At the instant the rock hits the ground, how far is it from the basket?
    (d) Just before the rock hits the ground, find its horizontal and vertical components as measured by an observer (i) at rest in the basket and (ii) at rest on the ground.

15. A canoe has a velocity of 0.40 m/s southeast relative to the earth. The canoe is on a river that is flows at 0.50 m/s east relative to the earth. Find the magnitude and direction of the canoe relative to the river.

Answers

7. 25 m
8. a) 12.0 m/s b) 15.0 m/s, 12.0 m/s c)13.3 s
9. 1.70 m
10. a) – 58 m/s² or – 5.9*g* b) 12 ms
11. a) 3.3 s b) 9 H
12. a) 7.1 cm/s, 45° b) 5.0 cm/s, 90°, 7.1 cm/s, 45°, 11 cm/s, 27°
13. a) 53.1° b) 15.0 m/s, 9.80 m/s² c) 15.9 m, 17.7 m/s
14. a) 296 m b) 176 m c) 198 m d) (i)15.0 m/s, 58.8 m/s (ii)15.0 m/s, 78.8 m/s
15. a) 0.36 m/s, 52.5° south of west