

## Kinematics in 1-D/Straight Line Motion

1. A crazy dog runs 300 meters east, changes his mind and then runs 200 meters west. He then changes his mind again and runs 500 meters east. This entire trip takes 2 minutes.

- a) What is the total distance traveled?
- b) What is the total displacement?
- c) What was the dog's average speed?
- d) What was the dog's average velocity?

2. A long distance runner is running the 10000 m race. He runs the first 2000 m in 5 minutes, the next 5000 m in 14 minutes and the final 3000 meters in 7 minutes. What was the runner's average speed?

3. Mary Lou is running errands for her mother. She leaves her house and goes 1 mile north to the bakery. She then goes 2.5 miles south to get her hair cut. She continues south for 1.5 miles to check out a book from the library. She then goes 0.75 miles north to meet a friend. This entire voyage lasts 3 hours.

- a) What is the total distance traveled?
- b) What is the total displacement?
- c) What was her average speed?
- d) What was her average velocity?

4. Bill travels 400 m east in 20 seconds and then travels 300 m north in 20 seconds.

- a) What is the total distance traveled?
- b) What is the total displacement?
- c) What was his average speed?
- d) What was his average velocity?

5. A river has a current of 4 m/s south with respect to the shore. A swimmer is swimming in the river (which is redundant).

- a) If the swimmer is swimming 2 m/s north with respect to the water, what is his velocity relative to the shore?
- b) If the swimmer is swimming 3 m/s south with respect to the water, what is his velocity relative to the shore?

6. A child boards a bus for summer camp. His mom is waiting next to the bus. The bus begins moving 3 m/s east with respect to the ground. The child is walking 0.5 m/s west towards the back of the bus with respect to the bus. The mother begins running 1 m/s east with respect to the ground, chasing after the bus and thoroughly humiliating her child. What is the child's velocity

- a) relative to the ground?
- b) relative to the mother?

7. A bullet is accelerated in the muzzle of a gun from rest to 150 m/s in 0.50 sec. What is the acceleration?
8. A car starts at rest and accelerates at a constant rate for 12 seconds to a speed of 30 m/s.
- What is the acceleration?
  - What is the total distance traveled in these 12 seconds?
9. A motorcycle has a constant acceleration of  $2.5 \text{ m/s}^2$ . How much time is required for the motorcycle to change its speed from
- 20 m/s to 30 m/s?
  - 50 m/s to 60 m/s?
  - How far does it travel in each case?
10. A runner is initially going 5 m/s to the right when she slows down at to 2 m/s over 10 seconds.
- What is her acceleration?
  - How far does she travel in these 10 seconds?
11. A sport car speeds up from 40 m/s to 60 m/s. The car travels 350 meters during this acceleration.
- What is the acceleration of the car?
  - What is the time required to make this change?
12. A roller coaster car is traveling at a constant 3 m/s when it reaches a downward slope. On the slope, the car accelerates at a constant rate of  $4.5 \text{ m/s}^2$ . The length of the slope is 45 meters.
- Find the velocity of the car at the bottom of the hill.
  - Find the time of travel.
13. A ball is rolling at 2 m/s east when it encounters a steady breeze that causes it to change its velocity at a constant rate until it is finally going 4 m/s west. This takes 0.75 seconds.
- What is the acceleration?
  - At what time does the ball stop?
  - What is the total displacement?
  - What is the total distance traveled?
  - What is the average velocity?
  - What is the average speed?
14. An airplane starts at rest on a runway. It takes the airplane 50 seconds until it takes off. If the airplane had a constant acceleration and an average velocity of 60 m/s during the takeoff find
- the final velocity
  - the acceleration
  - the minimum length the runway needs to be
  - at what time the plane is halfway down the runway

15. A woman and her dog are out for a morning run to the river which is located 4.0 km away. The woman runs at a constant 2.5 m/s. The dog is unleashed and runs back and forth between his owner and the river at 4.5 m/s until she reaches the river. What is the total distance that the dog runs?

16. An elevator is initially moving upward at a speed of 12.00 m/s. The elevator experiences a constant downward acceleration of magnitude  $4.00 \text{ m/s}^2$  for 3.00 s.

- (a) Find the magnitude and direction of the elevator's final velocity.
- (b) How far did it move during the 3.00 s interval?

17. A paratrooper is initially falling downward at a speed of 30.0 m/s before her parachute opens. When it opens, she experiences an upward instantaneous acceleration of  $75.0 \text{ m/s}^2$ .

- (a) If this acceleration remained constant, how much time would be required to reduce the paratrooper's speed to a safe 5.00 m/s? (In real life, the acceleration is not constant in this case, but the equations of constant acceleration provide an easy estimate.)
- (b) How far does the paratrooper fall during this time interval?

18. The brakes are applied to a car traveling on a dry, level highway. A typical value for the magnitude of the car's acceleration is  $5.00 \text{ m/s}^2$ .

- a) If the car's initial speed is 30.0 m/s, how long does it take to stop and how far does it travel, starting from the moment the brakes are applied?
- b) How do these quantities change if we double the initial speed?

19. A nickel is dropped from the top of a very tall building. It takes 5.4 seconds for the nickel to hit the ground.

- a) Find the speed at which the nickel hits.
- b) Find the height of the building.
- c) Find the displacement during the interval 2 sec through 3 sec.

20. A ball is tossed upwards such that it is going 40 m/s upward once it leaves the person's hand. It is caught at the same height from which it is tossed.

- a) What is the velocity and acceleration at the apex? (facts, not calculation)
- b) How much time does it take the ball to reach the apex?
- c) How far is the apex off the ground?
- d) What is the velocity of the ball just before it hits the ground?
- e) What is the total displacement?
- f) What is the total time for the motion?

21. A rock is dropped from rest from the top of a 50 meter cliff.

- a) How fast is the rock going after 3 seconds?
- b) How long does it take the rock to reach the ground?
- c) How fast is it going the instant before it hits the ground?
- d) What is the object's acceleration the instant before it hits the ground?

22. A little boy spits straight downward from the top of a 75 meter tall building. When the gob of spit leaves his mouth, it is traveling 15 m/s downward.

- a) How long does it take to reach the ground?
- b) How fast is it moving upon impact?

23. An arrow is fired directly upwards at 15 m/s from ground level (don't ask why).

- a) How long is the arrow in the air?
- b) How high does the arrow go?
- c) How fast is it going just before it strikes the ground?

24. Accidentally, a cement block falls from rest from the ledge of a 53.0 meter tall building. When the block is 15.0 m above the ground, a man (who is 2.0 m tall) looks up to see his impending doom. Assuming the man has back problems and cannot squat down or bend over, how long does he have to get out of the way?

25. Maria is standing at the edge of a cliff that is 10 m high over a canyon. She throws a rock upward off the side of the cliff. Right before the rock reaches the canyon floor, it has a speed of 25 m/s.

- a) What was the rock's total displacement?
- b) What was the initial velocity of the rock?
- c) What was the total trip time?
- d) What was the maximum height above the canyon floor reached by the rock?

26. A diver springs upward with an initial speed of 5.0 m/s from a diving board that is 3.0 meters above the surface of the water.

- a) What is the velocity at the top of the dive?
- b) What is the highest point that he reaches above the water?
- c) How long does he take to get to the top of the dive?
- d) What is the total time of travel?
- e) What is the velocity when the diver hits the water?

27. A ball thrown vertically upwards is caught by the thrower after 3.5 seconds at the same height from which it was thrown.

- a) Find the initial velocity of the ball.
- b) Find the maximum height reached by the ball.

28. Little Johnny is hiding in his tree house that is 5.0 meters above the ground. He is waiting in ambush for his brother, Tommy. Tommy, not knowing of his brother's location or devious plans, is napping below the tree house.

- a) If Johnny drops the balloon from rest, how long does it take to hit Tommy?
- b) How fast is the balloon going when it hits Tommy?
- c) If Johnny throws the balloon downwards at 5 m/s, how long does it take to hit Tommy?
- d) Now, how fast is the balloon going when it hits Tommy?