

**Kinematics (Lessons 1 to 9)**

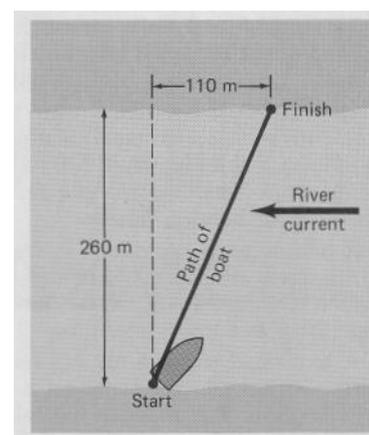
1. A truck is transporting new cars to a car dealer-ship. There are 8 cars on the truck's trailer. Describe a frame of reference in which a car is: (a) moving. (b) at rest.
2. Draw a graphical diagram to illustrate the motion of a car travelling from one traffic light to the next. When the traffic light turns green the car's speed increases, it then travels at a constant speed, and then brakes to slow down to a stop at the next traffic light.
3. A girl is taking her dog for a walk. They walk 5.0 km [N] and then turn around and walk 12 km [S].
  - (a) What is the total distance that they travelled? (17 km)
  - (b) What is their displacement? (7.0 km south)
  - (c) What displacement would they have to walk to get back to their starting point? (7.0 km north)
4. A cyclist is travelling with an average velocity of 5.90 m/s [W]. What will be his displacement after 1.20 h? (25.5 km west)
5. A canoeist paddles 1.6 km downstream and then turns around and paddles back upstream for 1.2 km. The entire trip takes 45 minutes.
  - (a) What is the displacement of the canoeist? (0.40 km downstream)
  - (b) Calculate the average speed of the canoeist. (3.73 km/h)
6. The closest star to our solar system is Alpha Centauri, which is  $4.12 \times 10^{16}$  m away. How long would it take light from Alpha Centauri to reach our solar system if the speed of light is  $3.00 \times 10^8$  m/s? (4.35 years)
7. A car is travelling at 14 m/s when the traffic light ahead turns red. The car brakes and comes to a stop in 5.0 s. Calculate the acceleration of the car. ( $-2.8 \text{ m/s}^2$ )
8. At the very end of their race, a runner accelerates at  $0.30 \text{ m/s}^2$  for 12 s to attain a speed of 6.4 m/s. Determine the initial speed of the runner. (2.8 m/s)
9. The acceleration due to gravity on the moon is  $1.6 \text{ m/s}^2$ . If a baseball was thrown up with an initial speed of 4.5 m/s, what would its velocity be after 4.0 s? ( $-1.9 \text{ m/s}$ )
10. When the traffic light turns green a car's speed increases, it then travels at a constant speed, and then brakes to slow down to a stop at the next traffic light.
  - (a) Sketch a position-time graph to represent the car's motion.
  - (b) Sketch a velocity-time graph to represent the car's motion.
11. A car that starts from rest can travel a distance of 50 m in a time of 6.0 s.
  - (a) What is the final velocity of the car at this time? (16.7 m/s)
  - (b) What is the acceleration of the car? ( $2.8 \text{ m/s}^2$ )
12. A cyclist is travelling at 5.6 m/s when she starts to accelerate at  $0.60 \text{ m/s}^2$  for a time interval of 4.0 s.
  - (a) How far did she travel during this time interval? (27 m)
  - (b) What velocity did she attain? (8.0 m/s)

13. A truck is travelling at 22 m/s when the driver notices a speed limit sign for the town ahead. He slows down to a speed of 14 m/s. He travels a distance of 125 m while he is slowing down.
- Calculate the acceleration of the truck. ( $-1.2 \text{ m/s}^2$ )
  - How long did it take the truck driver to change his speed? (6.9 s)
14. A skydiver falling towards the ground accelerates at  $3.2 \text{ m/s}^2$ . Calculate his displacement for the first 8.0 s of his fall. ( $1.0 \times 10^2 \text{ m}$  down)

### Vectors (Lessons 10 to 13)

- A man walks 400 m NORTH, 275 m WEST, 150 m SOUTH and then 650 m EAST. The trip required 15 minutes.
  - What was the total distance travelled by the man? (1475 m)
  - What was the displacement of the man? ( 451 m at  $56.3^\circ \text{ E of N}$  )
  - What was the average speed of the man? ( 98.33 m/min )
- A motorcyclist travels SOUTH at 35 m/s for 2 minutes and then he travels WEST at 27 m/s for 5 minutes.
  - What was the average speed of the motorcyclist? ( 1757 m/min )
  - What was the displacement of the motorcyclist? (9.1 km at  $62.6^\circ \text{ W of S}$ )
- A soccer player runs 75 m at  $30^\circ$  North of East. Then she runs 75 m straight West. Finally she ran 65 m at  $60^\circ$  South of East. The whole activity required 3.0 minutes.
  - What was the final displacement of the girl? ( 29.3 m at  $39.9^\circ \text{ S of E}$  )
  - What was the average speed of the girl? ( 71.7 m/min )
- A young woman swims at 2 m/s at  $45^\circ$  SOUTH of WEST for 5 minutes. Then she swims at 1.5 m/s at  $80^\circ$  EAST of NORTH for 4 minutes.
  - What is the total distance travelled by the young woman? ( 960 m )
  - What is the displacement of the young woman? ( 368 m at  $79^\circ \text{ S of W}$  )
- A pilot heads her plane with a velocity of 255 km/h North. If there is a strong wind of 112 km/h blowing East, what is the actual velocity of the plane? ( 279 km/h at  $23.7^\circ \text{ E of N}$  )
- A boat travels directly NORTH across a river at a velocity of 1.0 m/s if the river flows at a velocity of 0.50 m/s EAST, in what direction is boat actually headed? ( $27^\circ \text{ W of N}$ )
- A boat that can travel on still water at a speed of 3.0 m/s WANTS to travel NORTH perpendicular to the river current. If the river current is 1.2 m/s EAST, in what direction must the boat head? ( $24^\circ \text{ W of N}$  )
- A pilot WANTS to fly WEST. If the plane has an airspeed of 95 m/s and there is a 25 m/s wind blowing NORTH, in what direction must she head the plane? (  $15^\circ \text{ S of W}$  )
- A boat that can travel 4.0 m/s on still water heads directly NORTH across a river that is 125 m wide. The river current is 2.1 m/s EAST.
  - What is the velocity of the boat with respect to the shore? ( 4.5 m/s at  $28^\circ \text{ E of N}$  )
  - How long does it take the boat to reach the opposite shore? ( 31 s )
  - How far downstream is the boat when it reaches the opposite shore? ( 66 m )

10. A dog walks at a speed of 1.8 m/s along the deck toward the front of a boat which is traveling at 7.6 m/s with respect to the water. What is the velocity of the dog with respect to the water? What if the dog were walking toward the back of the boat? (+9.4 m/s, +5.8 m/s)
11. An airplane is traveling 1000 km/h in a direction  $37^\circ$  east of north. (a) Find the components of the velocity vector in the northerly and easterly directions. (b) How far north and how far east has the plane traveled after 2.0 h? (800 km/h, 600 km/h: 1600 km, 1200 km)
12. A vacationer walks 4.0 km/h directly across a cruise ship whose speed relative to the earth is 11.2 km/h. What is the speed of the vacationer with respect to the earth? (11.9 km/h)
13. A boat can travel 2.60 m/s in still water. (a) If the boat heads directly across a stream whose current is 0.90 m/s, what is the velocity of the boat relative to the shore? (b) What will be the position of the boat, relative to its point of origin, after 4.0 s? (2.75 m/s @  $19.1^\circ$  with respect to a line perpendicular to the shore, 11.0 m @  $19.1^\circ$  with respect to a line perpendicular to the shore)
14. Two trains approach each other on parallel tracks. Each has a speed of 80 km/h with respect to the earth. If they are initially 10 km apart, how long will it be before they pass each other? (3.8 min)
15. An airplane is heading due north at a speed of 300 km/h. If a wind begins blowing from the southwest at a speed of 50 km/h (average), calculate: (a) the velocity of the plane relative to the ground, and (b) how far off course it will be after 30 min if the pilot takes no corrective action. (337 km/h @  $6.0^\circ$  E of N, 17.7 km)
16. A motorboat whose speed in still water is 8.25 km/h must aim upstream at an angle of  $25.5^\circ$  (with respect to a line perpendicular to the shore) in order to travel directly across the stream. (a) What is the speed of the current? (b) What is the resultant speed of the boat with respect to the shore? (3.55 km/h, 7.45 km/h)
17. A ferryboat, whose speed in still water is 2.85 m/s, must cross a 260 m wide river and arrive at a point 110 m upstream from where it starts. To do so, the pilot must head the boat at a  $45^\circ$  upstream angle. What is the speed of the river's current? (1.16 m/s)
18. A helicopter heads due south with an air speed of 50 km/h. The pilot observes, however, that they have covered 30 km in the previous 45 min in a southwesterly ( $45^\circ$  S of W) direction. What is the wind speed and direction? (35.6 km/h @  $52.5^\circ$  W of N)
19. A swimmer is capable of swimming 1.80 m/s in still water. (a) If she aims her body directly across a 200-m wide river whose current is 0.80 m/s, how far downstream (from a point opposite her starting point) will she land? (h) How long will it take her to reach the other side? (c) At what upstream angle must the swimmer aim if she is to arrive at a point directly across the stream? (89 m, 111 s,  $26^\circ$ )
20. An airplane, whose air speed is 380 km/h, is supposed to fly in a straight path  $23.0^\circ$  N of E. But a steady 100 km/h wind is blowing from the north. In what direction should the plane head? ( $37.0^\circ$  N of E)



21. An automobile traveling 90.0 km/h overtakes a 1.00 km long train traveling in the same direction on a track parallel to the road. If the train's speed is 66.0 km/h, how long does it take the car to pass it and how far will the car have traveled in this time? What are the results if the car and train are traveling in opposite directions? (150s, 3750 m; 23.1 s, 577 m)
22. A motorcycle traveling 90.0 km/h approaches a car traveling in the same direction at 80.0 km/h. When the motorcycle is 50 m behind the car, the rider accelerates and passes the car 10.0 s later. What was the acceleration of the motorcycle? ( $0.44 \text{ m/s}^2$ )
23. An unmarked police car traveling a constant 80 km/h is passed by a speeder traveling 100 km/h. Precisely 1.0 s after the speeder passes, the policeman steps on the accelerator; if the police car's acceleration is  $2.0 \text{ m/s}^2$ , how much time passes before the police car overtakes the speeder (assumed moving at constant speed)? (total time is 7.4 s)
24. Assume in the previous problem that the speeder's speed is not known. If the police car accelerates uniformly as given above for 6.0 s, what was the speeder's speed? (98.5 km/h)
25. A diver running 3.6 m/s dives out horizontally from the edge of a vertical cliff and reaches the water below 2.0 s later. How high was the cliff and how far from its base did the diver hit the water? (19.6 m, 7.2 m)
26. A tiger leaps horizontally from a 15 m high rock with a speed of 7.0 m/s. How far from the base of the rock will it land? (12 m)
27. A ball thrown horizontally at 18 m/s from the roof of a building lands 24 m from the base of the building. How high is the building? (8.7 m)
28. An airplane traveling a constant 150 km/h is to drop supplies to flood victims isolated on a patch of land 200 m below. The supplies should be dropped how many seconds before the plane is directly overhead? (6.39 s)
29. A football is kicked with a speed of 21.0 m/s at an angle of  $37^\circ$  to the horizontal. How much later does it hit the ground? Ignore air resistance. (2.6 s)
30. A hunter aims directly at a target (on the same level) 220 m away. If the bullet leaves the gun at a speed of 550 m/s, by how much will it miss the target? (0.785 m)
31. An athlete throws the shotput (mass = 7.3 kg) with an initial speed of 14 m/s at a  $40^\circ$  angle to the horizontal. Calculate the distance traveled. The shot leaves the shotputter's hand at a height of 2.2 m above the ground. (22 m)
32. An Olympic long jumper is capable of jumping 8.0 m. Assuming his horizontal speed is 9.0 m/s (top sprinting speed is slightly over 10 m/s) as he leaves the ground, how long was he in the air and how high did he go? Assume that he lands standing upright, that is, the same way he left the ground. (0.89 s, 0.97 m)
33. An athlete executing a long jump leaves the ground at a  $30^\circ$  angle and travels 8.90 m. What was the takeoff speed? (10.0 m/s)
34. Determine how much further a person can jump on the moon as compared to the earth if the takeoff speed and angle are the same. The acceleration due to gravity on the moon is one-sixth what it is on earth. (6 times)