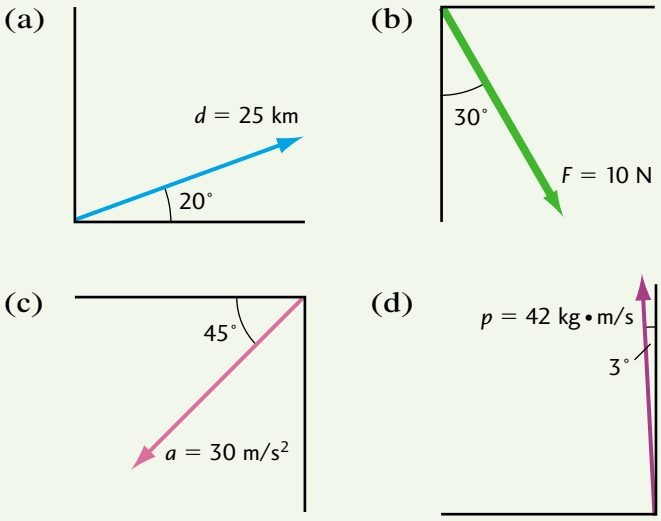
## Problems

### 2.1 Vectors in Two Dimensions

14. In your notebook, break each of the following two-dimensional vectors into perpendicular components.

Fig.2.55




15. A 10-m-long crane is inclined at an angle of 40° to the horizontal. If the Sun is directly overhead,
    a) what is the length of the crane's shadow on the ground?
    b) how high above the ground is the top of the crane?

16. A skier accelerates at a rate of 4.0 m/s$^2$ down a ski hill inclined at 35°. What are the vertical and horizontal components of her acceleration?

17. A pizza delivery truck drives 2.0 km [W], followed by 3.0 km [W20°N]. What is the total displacement of the delivery truck?

18. A projectile is launched with a horizontal velocity of 10 m/s and a vertical velocity of 20 m/s. What is the magnitude and direction of the projectile's initial velocity?

19. Add the following displacements using the component method:
    $\vec{d}_1$ = 20 cm [N], $\vec{d}_2$ = 50 cm [S35°E],
    $\vec{d}_3$ = 100 cm [W15°S]

20. A tennis ball's initial velocity is 30 m/s [S]. When struck by a tennis racquet, its velocity becomes 28 m/s [N30°W]. Determine the ball's change in velocity.

21. A billiard ball with an initial velocity of 2.0 m/s [S30°E] strikes the bumper of a billiard table and reflects off it at a velocity of 1.8 m/s [N30°E]. If the interaction with the bumper takes 0.10 s, determine the vector acceleration of the billiard ball.

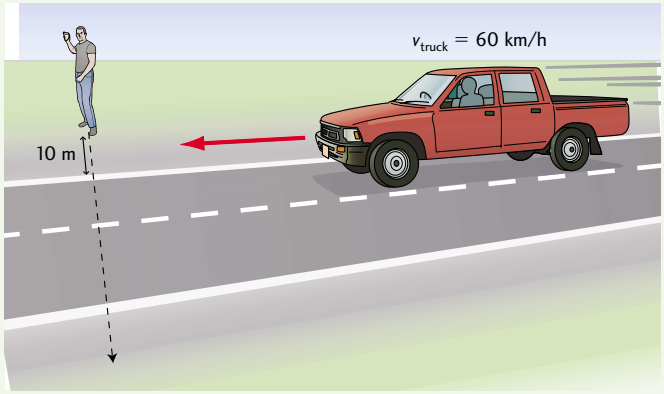
### 2.2 Relative Motion

22. A swimmer, who can swim at a maximum speed of 1.8 km/h, swims heading straight north across a river of width 0.80 km. If the river's current is 0.50 km/h [E],
    a) how long does it take the swimmer to cross the river?
    b) how far downstream will the swimmer land?
    c) what is the swimmer's ground velocity?

23. If the swimmer in problem 22 decided to change his direction so as to go straight north, determine
    a) his heading.
    b) his ground velocity.
    c) the amount of time it would take him to cross the river.

24. A concerned parent wants to throw a forgotten lunch bag into the back of his daughter's passing pickup truck. The parent is standing 10 m north of a road that runs east–west. If the parent can throw the bag at a speed of 2.0 m/s and the speed limit on the road is 60 km/h, how far east of the parent must the westbound truck be when the bag is released?

Fig.2.56



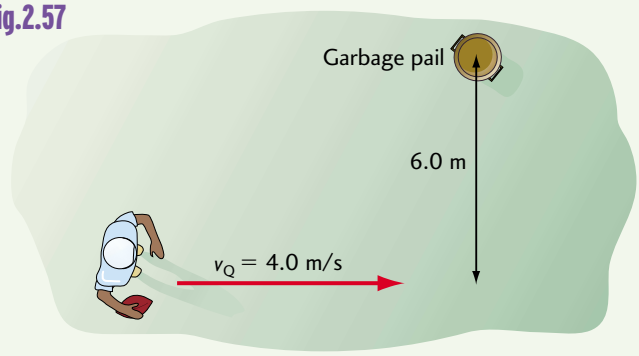

25. A helicopter pilot wishes to fly east. There's a wind from the north at 20 km/h. If the helicopter can fly at a speed of 150 km/h in still air, in which direction must the pilot point the helicopter in order to fly east (i.e., what is the pilot's heading)?

26. A ship's captain wishes to sail his ship northeast. A current is moving his ship with a velocity of 5.0 km/h [S]. If the ship has a maximum speed of 30 km/h, what is the ship's required heading?

27. A cruise ship is sailing north at a speed of 10 km/h. A passenger walks along the deck with a velocity of 0.5 m/s toward the stern of the ship. She then turns toward port and walks to the railing at the same speed. Determine the passenger's velocity for both motions
a) relative to the ship.
b) relative to the water.

28. A high-school football quarterback is practising by throwing a football into a garbage pail. The quarterback runs along a line 6.0 m away from the garbage pail at a speed of 4.0 m/s. If the quarterback can throw the football at a speed of 5.0 m/s,

Fig.2.57




a) how far in advance of the garbage pail must the quarterback release the ball if the ball is thrown perpendicular to the direction in which he's running?
b) how long will it take the football to reach the garbage pail?
c) what is the football's ground velocity?

29. The quarterback in the problem 28 decides to practise in a different way. This time, he runs along the same path, 10 m away from the garbage pail, and releases the football just as he passes the garbage pail.
a) In which direction must he throw the football so that it lands in the garbage pail?
b) How long does it take the football to reach the garbage pail this time?
c) What is the football's ground velocity?

## 2.3 Projectile Motion

30. Blarney, the orange dinosaur, throws a Nerf™ ball horizontally out of an open window with a velocity of 3.0 m/s. If the window is 10 m above the ground, how far away from the building must Blarney's friend stand to catch the ball at ground level?

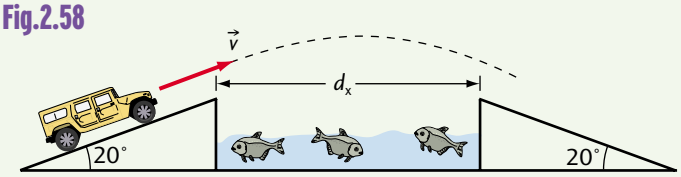
31. A rock thrown horizontally from the top of a water tower lands 20.0 m from the base of the tower. If the rock was initially thrown at a velocity of 10.0 m/s,
a) how high is the water tower?
b) What is the final velocity of the rock?

32. A bag of mail is catapulted from the top of a building 200 m above the ground with a velocity of 20 m/s at an angle of 15° above the horizontal. If the mail is to land on the roof of another building 100 m away, how tall is the second building?

33. A tourist taking the train from Toronto, Ontario to Montreal, Quebec accidentally drops a cup of coffee from a height of 1.3 m. The train is travelling at 180 km/h.
    a) How long does it take the cup of coffee to hit the floor?
    b) Where does the cup land relative to the tourist?
    c) How much closer to Montreal is the cup when it strikes the floor compared to when it was dropped?

34. Bounder of Adventure is trying to cross a piranha-infested pool of water in his Humvee. He races up a ramp inclined at 20° to the horizontal at a speed of 30 m/s. There is an identical ramp on the other side of the pool. What is the maximum width of the pool that Bounder of Adventure can successfully cross?

Fig.2.58




35. A soccer ball is kicked from the ground at an angle θ above the horizontal. Show that the equation $h = 0.25R \tan \theta$ represents the maximum height of the ball, where $h$ is the height and $R$ is the range.

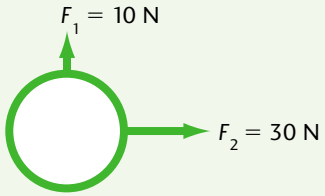
36. A baseball player makes perfect contact with the ball, striking it 45° above the horizontal at a point 1.3 m above the ground. His home-run hit just clears the 3.0-m wall 130 m from home plate. With what velocity did the baseball player strike the ball?

## 2.4 Newton's Laws in Two Dimensions

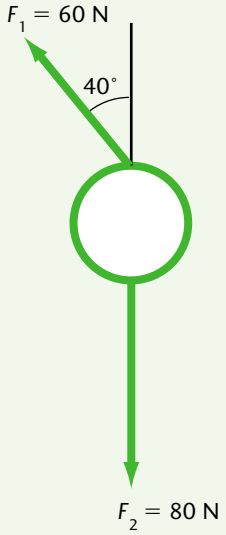
37. Determine the net force for each of the following situations:

Fig.2.59

(a)




(b)




(c)