EXERCISES

Conceptual Questions

1. If you pull a tablecloth very fast from underneath a table setting, given minimal friction, the dishes will not move from their original position. Describe this trick in terms of Newton's first law.

2. Are there any conditions you could impose on the demonstration in Question 1 to make it more difficult? Describe them in terms of Newton's second law.

3. a) Use Newton's laws to explain why you feel the same in a motionless car as you do in a car moving with a constant velocity.
   b) Explain the effect of being pressed back in your seat when accelerating forward and pushed forward when coming to a sudden stop.

4. Dingle balls, furry dice, and air fresheners hanging from the rearview mirror of your car indicate all the possible motions of the car because of their hanging position. For the following motions, indicate which way the above articles will move.
   a) Constant velocity forward
   b) Constant velocity backward
   c) Speeding up backward
   d) Slowing down forward
   e) Coming to sudden stop while going forward

5. While driving your car, you make a sharp turn. Explain what happens to you in terms of Newton's laws of motion. What happens to the dingle balls hanging from the rearview mirror? Is a turning motion an example of Newton's first law?

6. Whiplash is a consequence of many car accidents. Use Newton's laws to explain why whiplash occurs.

7. What do the propulsion system of rockets, balloons, and squids have in common?

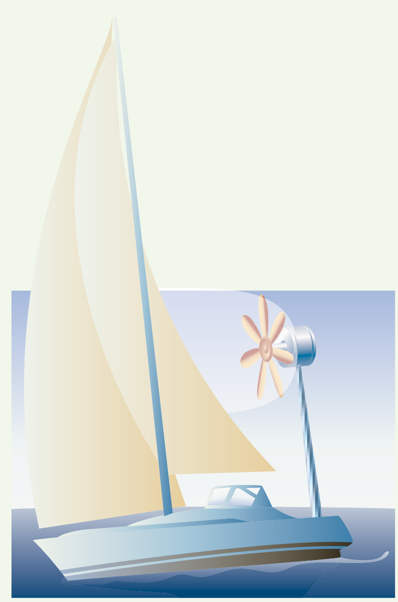
8. As a rocket accelerates upward, its thrust remains constant but its acceleration increases. Given that $\vec{F} = m\vec{a}$, what could cause an increase in acceleration? (Hint: It's a major contributor to space junk.)

9. When you are standing on the floor, you push down on the floor and the floor pushes back on you. Why doesn't the floor make you rise up?

10. A person steps onto a dock off a boat that is tied securely and close to the dock. In another case, a person steps off a boat not attached to the dock. Use Newton's laws to explain what happens in each case.

11. In Fig. 4.28, explain why this method of propelling a boat will not work. Suggest three modifications to the diagram that would allow the boat to move forward.

Fig.4.28



12. If Earth pulls you down, then, according to Newton's third law, you pull Earth up. Is this possible? (Remember that $\vec{F} = m\vec{a}$ for each object.)

13. A particle is moving with a constant speed in a corkscrew tunnel (i.e., it is moving in a circle as it moves forward). When it exits the tunnel, what path will it follow?

14. A car driving too fast hits an icy patch where the steering becomes useless. It then drives into a bale of hay. Use all of Newton's laws to explain this event.

15. A three-stage rocket is launched from Earth to travel to Pluto. After the rocket stages are jettisoned, the rocket continues on its way. For each part of the journey, state which of Newton's laws is applicable.

16. Explain how Newton's first law applies to air bags, seat belts, and head rests.

17. Riding a roller coaster is a great way to experience Newton's laws. Relate each law to an aspect of the ride. (Don't forget about the butterflies in your stomach!)

18. The back of a loaded pickup truck is open. A car rear-ends the pickup truck, causing its load to spill. Explain the event in terms of Newton's laws.

Problems

4.2 Newton's Second Law, $\vec{F}_{net} = m\vec{a}$

19. Calculate the net force acting on a 20 kg object if the acceleration is
    a) 9.8 m/s^2.
    b) 0.28 m/s^2.
    c) 5669 km/h^2.
    d) (50 km/h)/s.

20. What is the acceleration when an unbalanced force of 50 N is applied to
    a) a 40 kg person?
    b) a 3 g penny?
    c) a 1.6×10^8 kg supertanker?
    d) a 2.2×10^6 g car?

21. On the Superman roller coaster, you are able to experience an acceleration of 4.5 *g*s. If one *g* is 9.8 m/s^2, find the net force acting on a person of mass 65 kg.

22. a) A Sikorsky freight helicopter can easily lift a 5000 kg truck. If the acceleration of the truck is 1.5 m/s^2 up, what is the net force being applied by the helicopter?
    b) Calculate the acceleration on a 2.5×10^6 kg rocket if the net thrust of the rocket is 2.8×10^7 N.

23. A person accelerating at 9.80 m/s^2 as she falls out of a plane experiences a net force of 1000 N. What is her mass?

24. A skateboarder of mass 60 000 g undergoes an acceleration of 12.6 m/s^2. What is the unbalanced force acting on him?

25. A jet reaches a takeoff speed of 95 m/s in 50 s, while a jet fighter reaches 60 m/s in 3.0 s. If each plane is 8.0×10^4 kg, find the net force applied to each.

26. A supertanker of mass 1.0×10^8 kg travels 3.5 km, reaching a speed of 4.1 km/h from rest. What was the magnitude of the unbalanced force acting on it?

27. If it takes a human cannonball 1.5 s to exit a 1.6 m long cannon, what is the average net force acting on the performer if his mass is 65 kg?

28. A net force of 200 N is applied to an object, causing its velocity to change from 30 km/h to 20 km/h in 2.3 s. What is the object's acceleration? What is its mass?

29. A car changes its velocity from 20 m/s [N] to 20 m/s [S] in 5.5 s. If the mass of the car is 1500 kg, what is the net force acting on it?

30. A bicycle of mass 14.6 kg and a rider of mass 50 kg generate a net force of 12 N. How fast are they going after 2.0 s?

31. A batter of mass 100 kg uses a bat of mass 2.0 kg to hit a 140 g ball. If the impact time is 0.010 s and the ball reaches a speed of 60 km/h from rest, what was the average force applied to the ball?

32. Repeat Problem 31, for a bat of mass 3.0 kg hitting a 140 g pitched ball moving at 60 km/h, causing it to fly off at 60 km/h along the same line as the pitch.

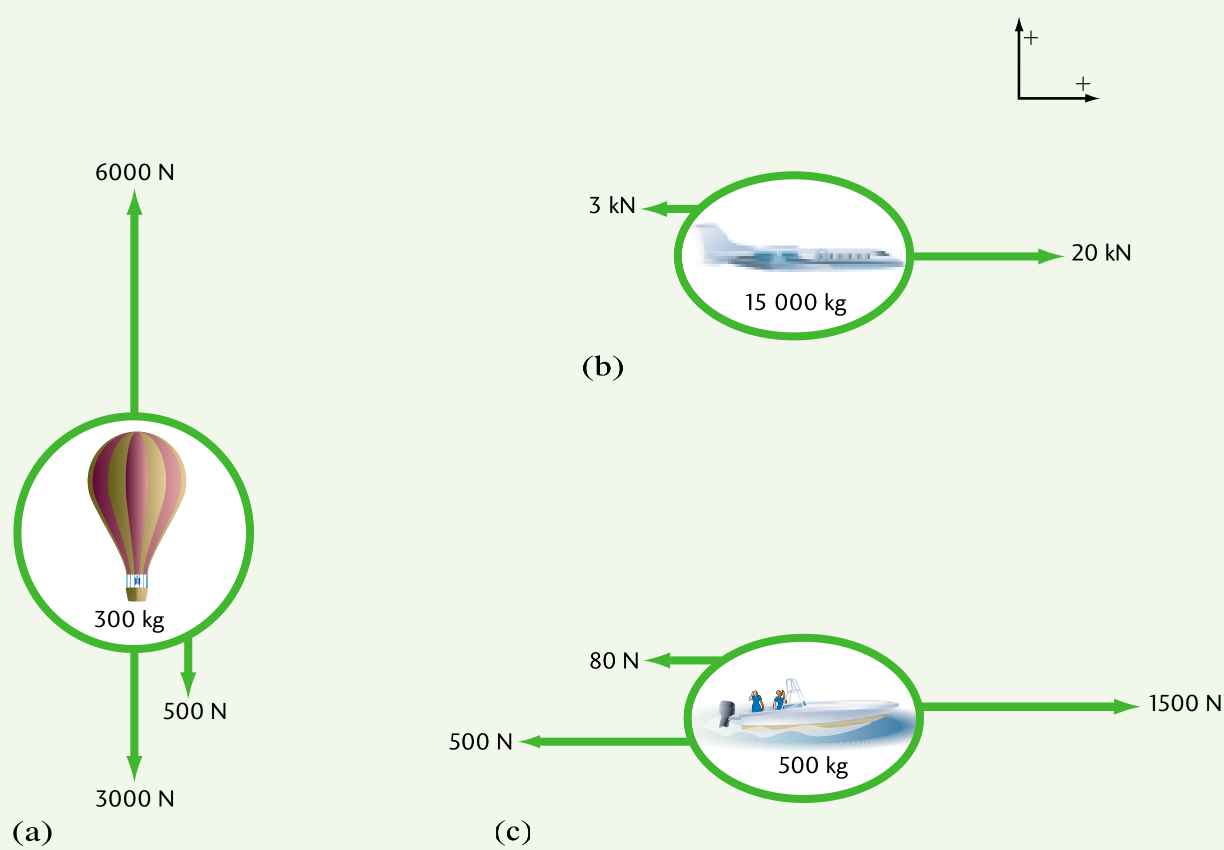
4.3 Free-body Diagrams

33. For the following situations, draw a properly labelled FBD and include an $\vec{F}_{net}$ statement.
    a) A fishing lure descends slowly into the water.
    b) A parachute slows the shuttle after touch-down.
    c) A gorilla holds barbells equivalent to the mass of two cars above its head (no steroids).
    d) An apple is hanging on a tree branch.
    e) A car is moving with a constant velocity on a level road.

34. Draw all possible FBD combinations for three people on sleds attached by ropes, being pulled in a straight line along the ice. (Draw FBDs for all the people individually, then in combinations.)

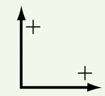
35. Find the acceleration in the following FBDs (Fig. 4.29):

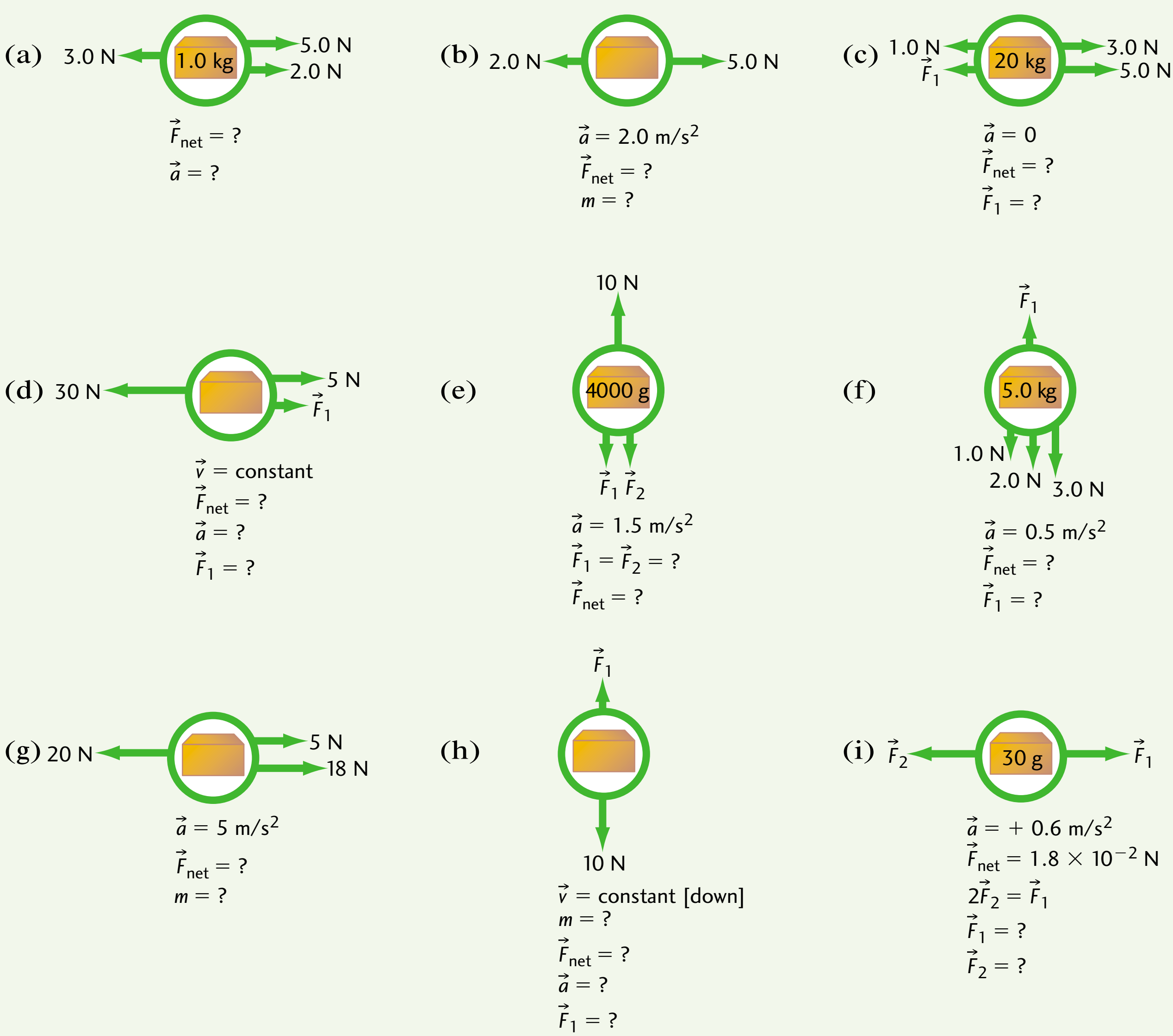
Fig.4.29



36. Fill in the missing quantity for the following:

Fig.4.30





37. A car of mass 2000 kg has a driving force of 4500 N and experiences an air resistance of 1500 N. What is the car's acceleration?

38. Being the good daughter you are, you are cutting the estate lawn with a push mower of mass 12.6 kg. You exert a force of 117 N horizontally, and you experience a frictional force of 45 N due to the mechanism of the machine as well as a resistive force of 58 N due to the grass itself.

a) What is your acceleration?

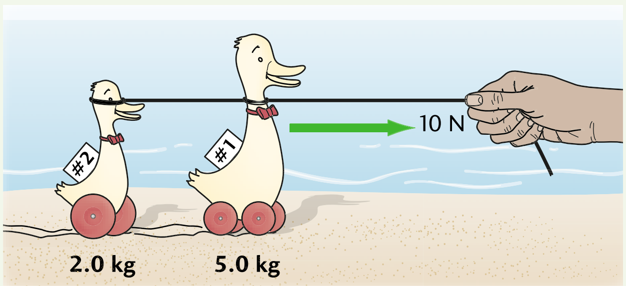
b) What speed do you reach after 7.0 s of pushing from rest?

39. Two toy ducks, attached to each other by a string, are being pulled by a very happy guy who just got them as a graduation present (Fig. 4.31). The front duck is 5.0 kg and the back duck is 2.0 kg. If the happy guy pulls them with a force of 10 N and there is no friction, calculate

a) the acceleration of both ducks.

b) the tension in the string connecting duck 1 and duck 2.

Fig.4.31



40. If the student in Problem 39 receives another duck of mass 1.0 kg from his grandma (he now has three ducks), and he puts the new duck at the front of the row, find

a) the acceleration of the three ducks.

b) the tension in the string connecting ducks 1 and 2.

c) The tension in the string connecting ducks 2 and 3.

d) Repeat b) and c) with different FBDs.

41. A puck of mass 30 g slides across rough ice, experiencing a frictional force of 0.2 N. If it was moving at 10 km/h when it hit the ice patch,

a) how long did it take to stop?

b) how long was the ice patch?

42. A dragster reaches 350 km/h from rest in 6.2 s. If the car is 800 kg and generates a driving force of 1600 N, find the force of friction acting on the car.

43. A parachutist of mass 70 kg, in free fall at 136 km/h, opens a parachute. If the chute creates a 895 N air resistive force and the parachutist is being pulled down by a force of gravity of 686 N,

a) find the acceleration of the parachutist.

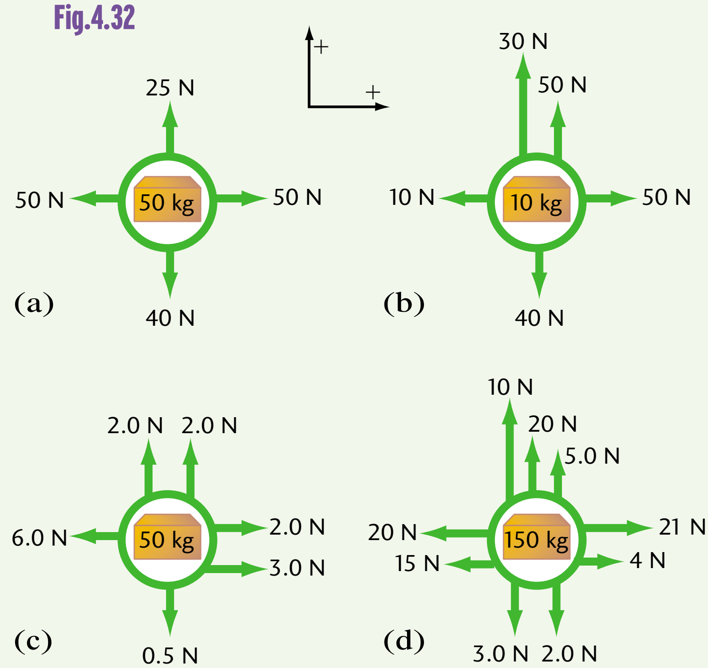
b) In which direction is the parachutist travelling just after the chute opens?

c) How far does she fall in 5.0 s?

4.4 FBDs in Two Dimensions

44. For the following FBDs, create two separate $\vec{F}_{net}$ statements, one for each direction.

Fig.4.32



45. Calculate the net force of the objects in Problem 44. Use Pythagoras' theorem and the $\tan^{-1}$ function, or use Pythagoras' theorem and state the quadrant where the total net force is acting.

46. Two people are pushing a car of mass 2000 kg. If they each push with a force of 320 N at an angle of 15° to each side of the car, calculate the acceleration of the car, assuming no resistance. Use the component and trigonometric methods.

47. Repeat Problem 46, adding a resistive force of 425 N due to friction acting on the car. Use the component method only.

48. A canoe of mass 70 kg with a paddler of mass 55 kg are in a river. If the river's current exerts a force of 15 N [E] while the paddler is paddling with an average force of 22 N [N38°W], find the acceleration of the canoe and paddler. Use both the component and trigonometric methods.

49. a) Two people are lifting a small motor using ropes attached to the top of the motor. The motor hangs straight down and has a force of gravity of 1600 N acting on it. If one person lifts at 800 N [L80°U] and the other person on the other side of the motor lifts at 830 N [R85°U], find the acceleration of the motor if its mass is 163 kg. Use the component method.
b) How far have the people moved the motor if they lift for 1.2 s?

50. a) A person is sitting on a sled. The sled and person have a mass of 110 kg. If they are being pulled with a force of 40 N [U20°R] and pushed from behind with a force 44 N [D75°R], calculate the acceleration of the person in the horizontal direction.
b) If the person and sled experience a force of gravity of 1078 N, how much more lifting force is required by the person pulling at the front to balance the weight of the sled and person?

51. a) Two tugboats are towing a tanker of mass 3.30 x 10^7 kg. If one tug is pulling at 2.40×10^4 N [E16°N] and the other is pulling at 2.40×10^4 N [E9°S], calculate the acceleration of the tanker, assuming no resistance. Use both vector methods to solve this part of the problem.
b) If the tanker has a resistive force on it of 5.60×10^3 N, find its acceleration using the component method.
c) Calculate the speed reached in each of the two cases after 2.0 minutes. Convert it to km/h.
d) Calculate the distance required in each case to reach a speed of 5.0 km/h.

52. a) A balloon with person A in it has a force of gravity of 3000 N acting on it. The balloon has an upward force of 3800 N due to the hot air in it. Two people are keeping the balloon hovering just above their heads by holding onto ropes attached to each side of the balloon. If person B exerts a force of 540 N [L40°D] and person C can exert a force of 700 N, what is the minimum angle, measured from the horizontal, at which person C should hold the rope in order for the balloon to not fly away?
b) What happens in the horizontal direction for this case?
c) If person C exerts the 700 N force straight down, how long will it take to bring the balloon to the ground if the rope held by person B is 30 m long? Remember, he is pulling at an angle of [L40°D].

4.5 Newton's Third Law and FBDs

53. Two hockey players are standing on the ice. One is a Maple Leaf (mass 100 kg) and the other is a Canuck (mass 112 kg). If the Canuck drives the Leaf with a force of 50 N,
a) what are the action–reaction forces involved in this situation?
b) calculate the acceleration of each player.

54. Would your answer to Problem 53 change if the players drive each other with 50 N forces?

55. Repeat Problem 54, adding a 5.0 N force of friction acting on each player.