SOLUTIONS MANUAL

THE
PHYSICS
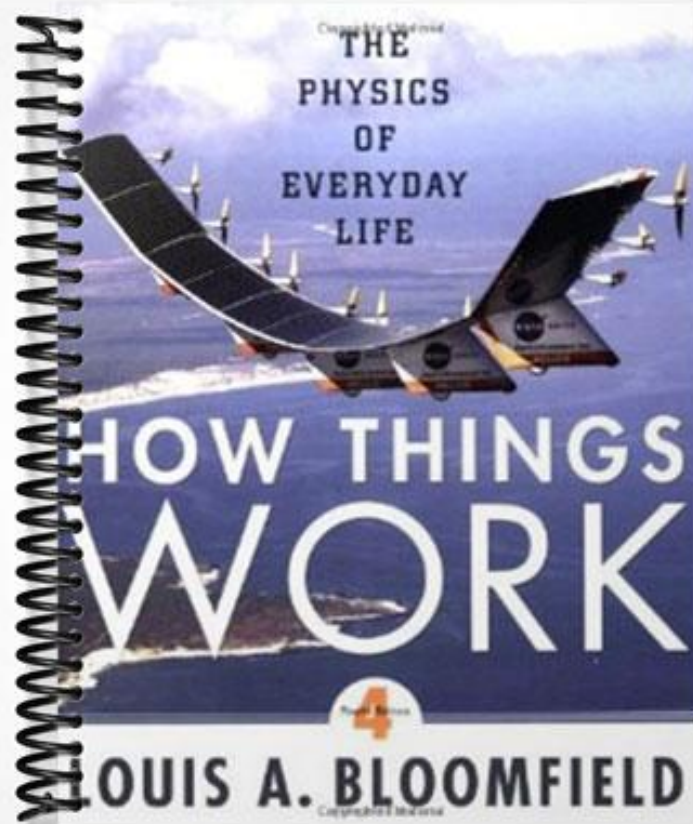OF
EVERYDAY
LIFE

HOW THINGS
WORK

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LOUIS A. BLOOMFIELD

Exercises – Chapter 1

1. A dolphin can leap several meters above the ocean's surface. Why doesn't gravity stop the dolphin from leaving the water?

    E.1   The dolphin's inertia carries it upward, even though its weight makes it accelerate downward and gradually stop rising.

2. As you jump across a small stream, does a horizontal force keep you moving forward? If so, what is that force?

    E.2   There is no force keeping you moving forward.

    E.2   Your inertia keeps you moving forward.

3. Why does stamping your feet clean the snow off them?

    E.3   Your feet accelerate upward rapidly when they hit the ground and the snow continues downward, leaving your feet behind.

4. Why does tapping your toothbrush on the sink dry it off?

    E.4   As the toothbrush stops suddenly, the water's inertia keeps it going and it flies off the toothbrush.

5. The back of your car seat has a headrest to protect your neck during a collision. What type of collision causes your head to press against the headrest?

    E.5   Any collision in which the car accelerates forward, such as when the car is hit from behind by a faster moving car.

6. An unseatbelted driver can be injured by the steering wheel during a head-on collision. Why does the driver hit the steering wheel when the car suddenly comes to a stop?

    E.6   Nothing pushes on the driver, so the driver's inertia causes the driver to coast forward and collide with the steering wheel.

    E.6   The car stops because something pushes it backward

7. Why do loose objects on the dashboard slide to the right when the car turns suddenly to the left?

    E.7   As it turns left, the car accelerates left. The loose objects remain behind and end up on the right side of the dashboard.

8. Why is your velocity continuously changing as you ride on a carousel?

    E.8   Your direction of travel changes all the time and a change in direction involves an acceleration

9. When you apply the brakes on your bicycle, which way do you accelerate?

    E.9   Backward, in the direction opposite your forward velocity.

10. One type of home coffee grinder has a small blade that rotates very rapidly and cuts the coffee beans into powder. Nothing prevents the coffee beans from moving so why don't they get out of the way when the blade begins to push on them?

    E.10 The beans' inertias keep them from moving out of the way.

    E.10 Because the beans have mass, a force must push on them to cause them to accelerate and move out of the way.

11. A blacksmith usually hammers hot metal on the surface of a massive steel anvil. Why is this more effective than hammering the hot metal on the surface of a thin steel plate?

    E.11 The anvil's large mass slows its acceleration, so the hot metal is squeezed between the moving hammer and the stationary anvil.

12. A sprinter who is running a 200-m race travels the second 100 m in much less time than the first 100 m. Why?

    E.12 The sprinter must overcome inertia and accelerate during the first 100 m. During the second 100 m, the sprinter must simply maintain full speed.

    E.12 Part of the first 100 m is traveled at less than full speed as the sprinter struggles to accelerate from rest.

13. If you pull slowly on the top sheet of a pad of paper, the whole pad will move. But if you yank suddenly on that sheet, it will tear away from the pad. What causes these different behaviors?

    E.13 The pad's inertia tends to keep it in place. If you pull the paper away too quickly, the pad won't be able to accelerate with the paper.

14. A ball falls from rest for 5 seconds. Neglecting air resistance, during which of the 5 seconds does the ball's speed increase most?

E.14 The ball's speed increases steadily, so there is no second during which its speed increases most.

15. If you drop a ball from a height of 4.9 m, it will hit the ground 1 s later. If you fire a bullet exactly horizontally from a height of 4.9 m, it will also hit the ground 1 s later. Explain.

E.15 Regardless of their horizontal components of velocity, all objects fall at the same rate. The ball and bullet descend together.

16. An acorn falls from a branch located 9.8 m above the ground. After 1 second of falling, the acorn's velocity will be 9.8 m/s downward. Why hasn't the acorn hit the ground?

E.16 The acorn's average velocity during this second is less than 9.8 m/s.

E.16 The acorn started from rest, so it isn't traveling 9.8 m/s at first.

17. A diver leaps from a 50-m cliff into the water below. The cliff is not perfectly vertical so the diver must travel forward several meters in order to avoid the rocks beneath him. In fact, he leaps directly forward rather than upward. Explain why a forward leap allows him to miss the rocks.

E.17 The forward component of his velocity remains constant as he falls, and he follows an arc that carries him forward over the rocks.

18. The kicker in a sporting event isn't always concerned with how far downfield the ball travels. Sometimes the ball's flight time is more important. If he wants to keep the ball in the air as long as possible, which way should he kick it?

E.18 He should kick the ball straight up.

E.18 Although the ball will eventually land right where it started, that ball will stay in the air a long time.

19. The heads of different golf clubs are angled to give the golf ball different initial velocities. The golf ball's speed remains almost constant, but the angle changes with the different clubs. Neglecting any air effects, how does changing the initial angle of the ball affect the distance the ball travels?

E.19 In the absence of air effects, a ball hit at 45° above horizontal will travel farthest. A ball hit higher or lower won't travel as far.

20. A speedboat is pulling a water-skier with a rope, exerting a large forward force on her. The skier is traveling forward in a straight line at constant speed. What is the net force she experiences?

E.20 She experiences zero net force.

E.20 Since she isn't accelerating, she must be experiencing a net force of zero.

21. Your suitcase weighs 50 N. As you ride up an escalator toward the second floor, carrying that suitcase, you are traveling at a constant velocity. How much upward force must you exert on the suitcase to keep it moving with you?

E.21 Its magnitude must equal the suitcase's weight.

22. What is the net force on (a) the first car, (b) the middle car, and (c) the last car of a metro train traveling at constant velocity?

E.22 All three cars experience zero net force.

E.22 Since they aren't accelerating, the cars must be experience net forces of zero.

23. Two teams are having a tug-of-war with a sturdy rope. It has been an even match so far, with neither team moving. What is the net force on the left team?

E.23 Zero net force.

24. When you kick a soccer ball, which pushes on the other harder: your foot or the soccer ball?

E.24 The two push equally hard on one another (but in opposite directions).

E.24 In accordance with Newton's third law, the foot and ball must push equally hard on one another; they are a Newton's third law pair.

25. The earth exerts a downward force of 850 N on a veteran astronaut as he works outside the space shuttle. What force (if any) does the astronaut exert on the earth?

E.25 The astronaut exerts an upward force of 850 N on the earth.

26. A car passes by, heading to your left, and you reach out and push it toward the left with a force of 50 N. Does this moving car push on you and, if so, with what force?

E.26 The car pushes you to the right with a force of 50 N.

E.26 In accordance with Newton's third law, you and the car must push equally hard on one another; you are a Newton's third law pair.

27. Which is larger: the force the earth exerts on you or the force you exert on the earth?

E.27 Both forces have exactly the same magnitude.

28. Comic book superheroes often catch a falling person only a hairsbreadth from the ground. Why would this rescue actually be just as fatal for the victim as hitting the ground itself?

E.28 The upward acceleration needed to stop the falling person is enough to injure them severely, whether the ground or a superhero exerts that force.

29. You accidentally miss the doorway and run into the wall. You suddenly experience a backward force that is several times larger than your weight. What's the origin of this force?

E.29 The wall exerts a support force to accelerate you backward.

30. When you fly a kite, there is a time when you must do (positive) work on the kite. Is that time when you let the kite out or when you pull it in?

E.30 You do positive work when you pull the kite in.

E.30 When you pull the kite in you pull toward you and the kite moves toward you, so you do work on the kite.

31. Which does more work in lifting a grain of rice over its head: an ant or a person? Use this result to explain how insects can perform seemingly incredible feats of lifting and jumping.

E.31 A person does more work. Movements that appear large compared to the ant's height still involve small distances and little work.

32. Are you doing work while kneading bread? If so, when?

E.32 Yes, you are doing work whenever you push on the bread and it moves in the direction of that push.

33. While hanging a picture, you accidentally dent the wall with a hammer. Did the hammer do work on the wall?

E.33 Yes, it pushed the wall inward and the wall dented inward.

34. You're cutting wood with a handsaw. You have to push the saw away from you as it moves away from you and pull the saw toward you as it moves toward you. When are you doing work on the saw?

E.34 In both cases, you do work on the saw: when you push it away from you as it moves away from you and as you pull it toward you as it moves toward you.

E.34 Whenever you push something in the direction it moves, you do work on it.

35. The steel ball in a pinball game rolls around a flat, tilted surface. If you flick the ball straight uphill, it gradually slows to a stop and then begins to roll downhill. Which way is the ball accelerating as it rolls uphill? downhill?

E.35 As it rolls on the surface, it always accelerates downhill.

36. Why do less snow and other debris accumulate on a steep roof than on a flatter roof?

E.36 The steeper the roof, the larger the downhill force on the snow and debris and the more likely they are to slide off the roof.

37. You roll a marble down a playground slide that starts level, then curves downward, and finally curves very gradually upward so that it's level again at the end. Where along its travel does the marble experience its greatest acceleration? its greatest speed?

E.37 Its greatest acceleration is at the steepest point; its greatest speed is at the bottom of the slide.

38. When you're roller skating on level pavement, you can maintain your speed for a long time. But as soon as you start up a gradual hill, you begin to slow down. What slows you?

E.38 The downhill force pushes you in the direction opposite your motion and do negative work on you.

E.38 As you roll up a hill, the downhill force acting on you pushes you in the direction opposite your motion. Gravity is doing negative work on you and you slow down.

39. When the brakes on his truck fail, the driver steers it up a runaway truck ramp. As the truck rolls up the ramp, it slows to a stop. What happens to the truck's kinetic energy, its energy of motion?

E.39 The kinetic energy becomes gravitational potential energy.

Problems – Chapter 1

1. If your car has a mass of 800 kg, how much force is required to accelerate it forward at 4 m/s^2?

P.1   3200 N.

2. If your car accelerates from rest at a steady rate of 4 m/s^2, how soon will it reach 88.5 km/h (55.0 mph or 24.6 m/s)?

P.2   It will take 6.15 seconds to reach 88.5 km/h.

3. On Mars, the acceleration due to gravity is 3.71 m/s^2. What would a rock's velocity be 3 s after you dropped it on Mars?

P.3   11.13 m/s.

4. How far would a rock fall in 3 s if you dropped it on Mars? (See Problem 3.)

P.4   The rock will fall 16.7 meters during those 3 seconds.

5. How would your Mars weight compare to your earth weight? (See Problem 3.)

P.5   Your Mars weight would be about 38% of your earth weight.

6. A basketball player can leap upward 0.5 m. What is his initial velocity at the start of the leap?

P.6   The basketball player's initial upward velocity is 3.1 m/s.

7. How long does the basketball player in Problem 6 remain in the air?

P.7   About 0.64 s (0.32 s on the way up and 0.32 s on the way down).

8. A sprinter can reach a speed of 10 m/s in 1 s. If the sprinter's acceleration is constant during that time, what is the sprinter's acceleration?

P.8   The sprinter's acceleration is 10 m/s2

9. If a sprinter's mass is 60 kg, how much forward force must be exerted on the sprinter to make the sprinter accelerate at 0.8 m/s^2?

P.9   48 N.

10. How much does a 60-kg person weigh on earth?

P.10   The 60-kg person weighs about 588 newtons.

11. If you jump upward with a speed of 2 m/s, how long will it take before you stop rising?

P.11   About 0.20 s.

12. How high will you be when you stop rising in Problem 11?

P.12   You will rise to a height of 0.20 meters.

13. How much force must a locomotive exert on a 12,000-kg boxcar to make it accelerate forward at 0.4 m/s^2?

P.13   4800 N

14. How long will it take the boxcar in Problem 13 to reach its cruising speed of 100 km/h (62 mph or 28 m/s)?

P.14   The boxcar will have to accelerate for 70 seconds to reach cruising speed.

15. The builders of the pyramids used a long ramp to lift 20,000-kg (22-ton) blocks. If a block rose 1 m in height while traveling 20 m along the ramp's surface, how much uphill force was needed to push it up the ramp at constant velocity?

P.15   9800 N.

16. How much work was done in raising one of the blocks in Problem 15 to a height of 50 m?

P.16   It takes 9.8 million joules of work to raise a 20,000-kg block 50 meters upward.

17. What is the gravitational potential energy of one of the blocks in Problem 15 if it's now 75 m above the ground?

P.17   14,700,000 J.

18. As water descends from the top of a tall hydroelectric dam, its gravitational potential energy is converted to electric energy. How much gravitational potential energy is released when 1000 kg of water descends 200 m to the generators?

P.18   1000 kg of water releases 1.96 million joules of gravitational potential energy in descending 200 meters.

19. The tire of your bicycle needs air so you attach a bicycle pump to it and begin to push down on the pump's handle. If you exert a downward force of 25 N on the handle and the handle moves downward 0.5 m, how much work do you do?

P.19   12.5 J.

20. You're using a wedge to split a log. You are hitting the wedge with a large hammer to drive it into the log. It takes a force of 2000 N to push the wedge into the wood. If the wedge moves 0.2 m into the log, how much work have you done on the wedge?

P.20   You have done 400 joules of work on the wedge.

21. The wedge in Problem 20 acts like a ramp, slowly splitting the wood apart as it enters the log. The work you do on the wedge, pushing it into the log, is the work it does on the wood, separating its two halves. If the two halves of the log only separate by a distance of 0.05 m while the wedge travels 0.2 m into the log, how much force is the wedge exerting on the two halves of the log to rip them apart?

P.21   8000 N.

22. You're sanding a table. You must exert a force of 30 N on the sandpaper to keep it moving steadily across the table's surface. You slide the paper back and forth for 20 minutes, during which time you move it 1000 m. How much work have you done?

P.22   You have done 30,000 joules of work.