Answers

Grade 9 science

يستخدم محتوى هذه الأوراق كأنشطة إضافية للتدريب ومصدره الأساسي الكتاب المدرسي ولا تغني هذه الأوراق بأي حال عن الكتاب المدرسي.

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FORCE AND MOTION, Force

1: T — A force is defined as a push or pull exerted on an object.

2: F— Field forces act without contact, meaning not all forces require physical touching.

3: T — Forces are vectors because they have both magnitude and direction.

4: T — Earth exerts a gravitational force even when it is not touching an object.

5: F— Balanced forces do not cause acceleration; only unbalanced forces do.

6: T — The system is the object being analyzed in a force problem.

7: T — Field forces include gravity and magnetism.

8: T — In a free-body diagram, the object is represented by a particle or dot.

9: T — Every force must have an agent and a system.

10: T — Motion diagrams show the position of an object at equal time intervals.

Matching

Force: 3 — A push or pull.

Contact force: 4 — A force requiring physical touching.

Field force: 5 — A force acting without contact.

System: 6 — The object being analyzed.

Agent: 2 — The cause of a force.

Free-body diagram: 1 — A representation showing forces acting on a system.

Motion diagram: 8 — A diagram showing an object's position at equal time intervals.

Magnitude: 7 — Size or amount of a quantity.

Vector: 9 — A quantity with magnitude and direction.

Unbalanced force: 10 — Causes acceleration because forces do not cancel.

Choose the Correct Answer

1: A — Force is defined as a push or pull exerted on an object.

2: B — A field force is exerted without touching the object.

3: C — A hand pushing a shopping cart is an example of a contact force.

4: C — The length of each arrow in a free-body diagram represents the magnitude of the force.

5: D — The mass of Earth is considered the agent in the force of gravity acting on a book.

6: C — Unbalanced forces cause an object to accelerate.

7: C — The system in a physics problem refers to the object being analyzed.

8: C — Vectors have the property of having both magnitude and direction.

9: D — Force vectors always point away from the particle in a free-body diagram.

10: B — The table is part of the external world when the system is a book on a table.

COMBINING FORCES & NET FORCE

11: T — When two equal forces act in opposite directions, the net force is zero.

12: F— Forces in the same direction are added, not subtracted, to find the net force.

13: F— A net force of zero means no acceleration, but the object could be moving at constant velocity or be at rest.

14: T — The net force determines the object's acceleration.

15: T — If one force is larger, the net force points toward that larger force.

16: F— Net force is the vector sum, not the scalar sum, of forces acting on an object.

17: T — When two people push a table in the same direction, the forces add.

18: T — If the net force is not zero, the object will accelerate.

19: T — A negative net force means acceleration is in the negative direction.

20: F— Opposite forces produce acceleration if they are unbalanced (not equal).

Matching

Net Force: 5 — The vector sum of all forces on an object.

Resultant Vector: 2 — The single vector representing the combined effect of two or more forces.

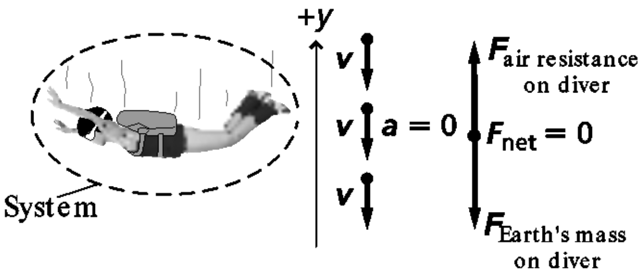
Balanced Forces: 1 — Forces that cancel out to produce zero acceleration.

Unbalanced Forces: 4 — The cause of acceleration when the vector sum is not zero.

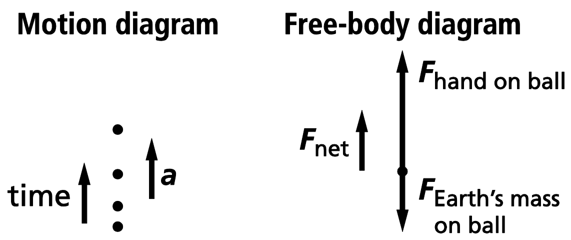
Opposite Direction Forces: 3 — Forces acting along the same line but toward opposite sides.

Practice Problems (Answers)

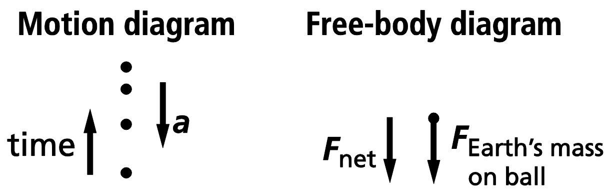
1. A skydiver falls downward through the air at constant velocity. (The air exerts an upward force on the person.)



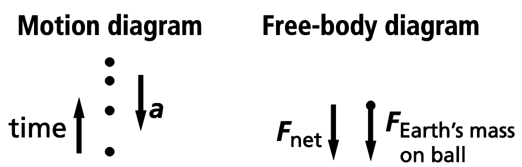
2. You hold a softball in the palm of your hand and toss it up. Draw the diagrams while the ball is still touching your hand.



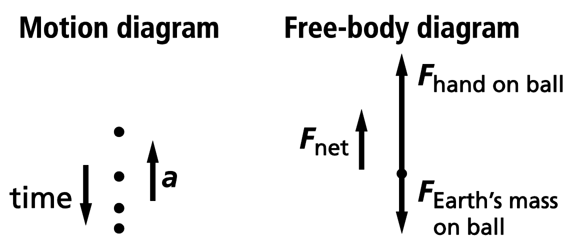
3. After the softball leaves your hand, it rises, slowing down.



4. After the softball reaches its maximum height, it falls down, speeding up.



5. **CHALLENGE** You catch the ball in your hand and bring it to rest.



Choose the Correct Answer

11: A — Adding forces in the same direction (40 N + 40 N) equals 80 N.

12: D — Subtracting opposite forces (60 N left and 40 N right) equals 20 N left.

13: B — When forces are balanced, the object must move at constant velocity or remain at rest.

14: C — Net force is defined as the vector sum of all forces acting on an object.

15: A — A 30 N force right and 50 N force left results in acceleration to the left.

16: B — Opposite direction forces subtract to find the net force.

17: C — Unbalanced forces produce acceleration in the direction of the net force.

18: C — If the net force on an object is zero, it has no acceleration.

19: D — A net force of –15 N means acceleration is in the negative direction.

20: D — Two equal forces acting in opposite directions result in a net force of zero.

21: C — A 25 N force right and 10 N force left equals 15 N right.

ACCELERATION AND FORCE

21: T — A constant unbalanced force produces a constant acceleration.

22: F— The slope of a velocity-time graph represents acceleration, not force.

23: T — Adding more identical carts increases the mass of the system.

24: T — Acceleration decreases when mass increases for the same applied force.

25: T — A spring scale can provide a constant force if the reading is kept steady.

Matching

Constant force: B — Achieved by using a spring scale.

Acceleration: A — Rate of change of velocity.

Velocity-time slope: D — Represents acceleration.

Slope of acceleration-force graph: C — Equals 1/mass in the force–acceleration graph.

Choose the Correct Answer

22: A — A constant slope on a velocity-time graph indicates constant acceleration.

23: A — A spring scale is used to exert a constant unbalanced force in investigations.

24: B — When applied force increases while mass stays constant, acceleration increases proportionally.

25: C — The slope in the force–acceleration graph represents the reciprocal of mass (1/mass).

26: D — If mass increases and force stays the same, acceleration decreases.

27: A — F = ma correctly represents the relationship among force, mass, and acceleration.

28: D — Doubling the mass while keeping force constant will reduce acceleration by half.

Adding more carts: C — Adding more carts results in a larger mass.

29: A — A force of approximately 1 Newton is closest to the force of an apple on your hand.

30: D — If three identical carts are pulled with the same force as one cart, acceleration will be one-third.

NEWTON'S SECOND LAW – FORCE, MASS, AND ACCELERATION

Practice Problems Answers

6. $\boldsymbol{F_{net} = 225\text{ N} + 165\text{ N} = 3.90\times10^{2}\text{ N}}$ **in the direction of the two forces**

7. $F_{net} = 225\text{ N} - 165\text{ N} = 6.0\times10^{1}\text{ N}$ in the direction of the larger force

8. **CHALLENGE** Identify east as positive and the sled as the system.

$$F_{net} = F_{\text{Alutia on sled}} + F_{\text{Seward on sled}} - F_{\text{Kodiak on sled}}$$

$$= 35\text{ N} + 42\text{ N} - 53\text{ N} = 24\text{ N} \qquad F_{net} = 24\text{ N east}$$

9.

$$F_{net} = ma$$
$$a = \frac{F_{net}}{m}$$
$$= \frac{2.7\text{ N}}{0.64\text{ kg}}$$
$$= 4.2\text{ m/s}^2$$

10. $F_{net} = ma = (27.2\text{ kg})(0.80\text{ m/s}^2) = 22\text{ N}$

11. **CHALLENGE**

a. Draw a force diagram for the horizontal forces acting on the crate.

b. What is the net force acting on the crate?

$$F_{net} = F_{right} - F_{left}$$
$$= 317\text{ N} - 173\text{ N}$$
$$= 144\text{ N}$$

c. First, find the average acceleration.

$$\bar{a} = \frac{\Delta v}{\Delta t}$$
$$= \frac{v_f - v_i}{t_f - t_i}$$
$$= \frac{6.5\text{ m/s} - 0\text{ m/s}}{5\text{ s} - 0\text{ s}}$$
$$= 1.3\text{ m/s}^2$$

Then use the average acceleration to find the mass.

$$F_{net} = ma$$
$$m = \frac{F_{net}}{a}$$
$$= \frac{144\text{ N}}{1.3\text{ m/s}^2}$$
$$= 111\text{ kg}$$

26: T — The net force on an object is the sum of all individual forces acting on it.

27: T — If the net force is zero, the object must be at rest or moving at constant velocity.

28: F— According to Newton's Second Law, if mass increases while force stays constant, acceleration decreases.

29: T — Two equal forces acting in opposite directions produce a net force of zero.

30: F— Acceleration always occurs in the direction of the net force, not opposite to it.

31: T — A free-body diagram shows all forces acting on a system.

32: T — Doubling the net force while keeping mass constant doubles the acceleration.

33: F— For the same net force, a larger mass results in a smaller acceleration.

Matching

Net force: C — Sum of all vectors acting on a system.

Free-body diagram: A — Diagram showing all forces acting on an object.

Mass: D — Inversely proportional to acceleration.

Acceleration: B — Quantity proportional to net force.

Choose the Correct Answer

31: D — Newton's Second Law states that acceleration is proportional to the net force.

32: B — If two forces act in opposite directions, the net force is the difference between them.

33: C — A large net force applied to a very small mass results in very large acceleration.

34: C — Mass resists changes in motion according to Newton's Second Law.

35: D — If the net force on a system doubles (with mass constant), the acceleration doubles.

36: A — The net force must be known first when solving Newton's Second Law problems.

37: D — A free-body diagram is used to show all forces acting on the object.

38: C — If the same force acts on two objects of different masses, the lighter object accelerates more.

39: A — If mass is doubled while force stays the same, acceleration is reduced to half.

40: D — The correct unit of force in Newton's Second Law is $kg \cdot m/s^2$.

NEWTON'S FIRST LAW, INERTIA, AND EQUILIBRIUM

Choose the Correct Answer

41: B — Newton's First Law applies when the net force acting on an object is zero.

42: C — An object in equilibrium must have zero net force acting on it.

43: B — A ball rolling on smooth ice slows down slowly because friction is very small.

44: B — Inertia is the tendency of an object to resist changes in motion.

45: C — A cup at rest on a table is a situation showing equilibrium.

46: B — A moving object with zero net force will continue to move with constant velocity.

47: C — A block moves forward when a cart suddenly stops because of inertia.

48: C — A skydiver at terminal velocity is in equilibrium because the net force is zero.

49: B — A ball rolling on carpet and stopping quickly is NOT an example of Newton's First Law applying (as friction is a net force).

50: B — An object changes its motion only when a net force acts on it.

True or False

34: F— Inertia is a property of mass, not a force that keeps objects moving.

35: T — If net force equals zero, the object's velocity stays constant.

36: T — Being at rest is a special case of equilibrium.

37: T — Real objects never stop unless friction or another net force acts on them.

38: F— A net force is NOT required to maintain constant velocity; it is required to change it.

Matching

Inertia: B — Resistance to changes in velocity.

Equilibrium: C — Net force equals zero.

Newton's First Law: A — An object continues in constant motion unless acted upon by net force.

Short Answers (Suggested Responses)

I. It experiences almost no opposing force, so net force ≈ 0 → constant velocity.
II. Their bodies keep moving forward due to inertia when the bus stops.
III. Net force = 0 because air resistance = weight → equilibrium.
IV. Any object at rest or moving at constant velocity (e.g., book on table, car on highway at constant speed).
V. Inertia is a property of mass Not an interaction between two objects.

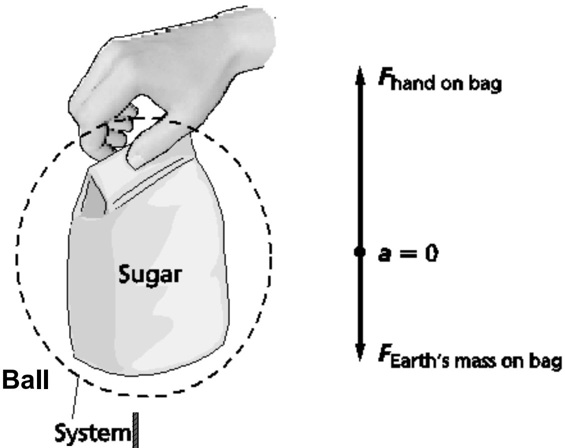
Check Your Progress – Newton's First Law

Answer Key – Check Your Progress

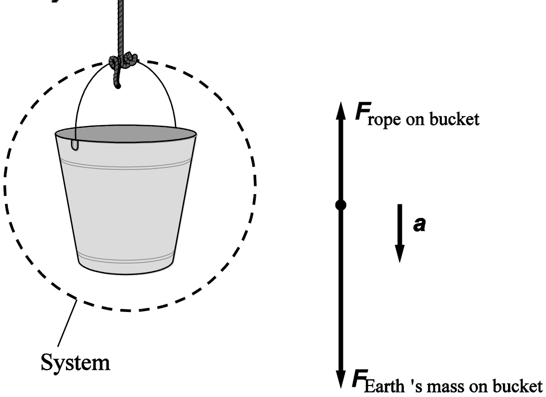
12. Forces Classification

Item	Type
Mass	c (not a force)
Inertia	c (not a force)
Push of a hand	a (contact force)
Friction	a (contact force)
Air resistance	a (contact force)
Spring force	a (contact force)
Gravity	b (field force)
Acceleration	c (not a force)

13. Free-Body Diagram – Accelerating Book



14. Free-Body Diagram – Slowing Ball



15. Critical Thinking – Mass and Acceleration

Because $m = F/a$ and the forces are the same, the mass of the second block is one-third the mass of the first.

WEIGHT AND DRAG FORCE

Matching

Weight of a watermelon: b — Field force.

Spring scale push: a — Contact force.

Mass of the watermelon: c — Not a force.

Gravity: b — Field force.

Air resistance: a — Contact force.

True or False

39: F— Weight is not the same on all planets because gravitational fields differ.

40: T — The reading on a scale equals the upward force it exerts on an object.

41: T — Drag force increases when a parachute opens.

42: T — An object in equilibrium experiences no net force.

Practice problems

16. You place a 4.0-kg watermelon on a spring scale that measures in newtons. What is the scale's reading?

The scale reads the weight of the watermelon:

$F_g = mg = (4.0\text{ kg})(9.8\text{ N/kg}) = 39\text{ N}$

17. You place a 22.50-kg television on a spring scale. If the scale reads 235.2 N, what is the gravitational field?

$F_g = mg$

$$g = \frac{F_g}{m}$$

$$= \frac{235.2\text{ N}}{22.50\text{ kg}}$$

$= 10.5\text{ N/kg}$

18. A 0.50-kg guinea pig is lifted up from the ground. What is the smallest force needed to lift it? Describe the particular motion resulting from this minimum force.

$F_{lift} = F_g$

$= mg$

$= (0.50\text{ kg})(9.8\text{ N/kg})$

$= 4.9\text{ N}$

It would move at a constant speed.

19. CHALLENGE A grocery sack can withstand a maximum of 230 N before it rips. Will a bag holding 15 kg of groceries that is lifted from the checkout counter at an acceleration of 7.0 m/s2 hold?

Use Newton's second law $F_{net} = ma$.
If $F_{\text{bag on groceries}} > 230\text{ N}$, then the bag rips.

$F_{net} = F_{\text{bag on groceries}} + F_g$

$F_{\text{bag on groceries}} = F_{net} - F_g$

$= (15\text{ kg})(7.0\text{ m/s}^2) - (15\text{ kg})(-9.8\text{ N/kg})$

$= 105\text{ N} + 147\text{ N}$

$= 252\text{ N}$

The bag does not hold.

Choose the Correct Answer

51: B — The weight of an object is the gravitational force acting on it.

52: C — If a skydiver deploys a parachute, the drag force increases.

53: B — The unit used to measure weight is Newtons (N).

54: A — A scale measures the weight (upward support force) of an object.

55: C — Gravity near Earth's surface has a magnitude of 9.8 N/kg or 9.8 m/s².

56: D — An object in equilibrium has net force = 0 and is either at rest or moving at constant velocity.

57: B — The minimum upward force to lift an object equals its weight (F = mg).

58: A — When a parachute opens, the falling object's velocity decreases.

59: C — The drag force acts opposite to the direction of motion.

60: C — If a bag is lifted with acceleration, the required force is F = mg + ma.

APPARENT WEIGHT

Practice Problems Answers

20. On Earth, a scale shows that you weigh 585 N.

a. What is your mass?

The scale reads 585 N. Since there is no acceleration, your weight equals the downward force of gravity:

$F_g = mg$

so $m = \frac{F_g}{g} = \frac{585\text{ N}}{9.8\text{ N/kg}} = 60\text{ kg}$

b. What would the scale read on the Moon ($g = 1.60$ N/kg)?

On the moon, g changes:

$F_g = mg_{Moon} = (59.7\text{ kg})(1.60\text{ N/kg}) = 95.5\text{ N}$

21. **CHALLENGE** Use the results from Example Problem 3 to answer questions about a scale in an elevator on Earth. What force would be exerted by the scale on a person in the following situations?

a. The elevator moves upward at constant speed.

Constant speed, so $a = 0$ and $F_{net} = 0$.

$F_{scale} = F_g$

$= mg = (75.0\text{ kg})(9.8\text{ N/kg}) = 735\text{ N}$

b. It slows at 2.0 m/s^2 while moving downward.

$a = 2.00\text{ m/s}^2$

$F_{scale} = F_{net} + F_g = ma + mg$

$= (75.0\text{ kg})(2.00\text{ m/s}^2) + (75.0\text{ kg})(9.8\text{ N/kg})$

$= 150\text{ N} + 735\text{ N} = 885\text{ N}$

c. It speeds up at 2.00 m/s^2 while moving downward.

$a = -2.00\text{ m/s}^2$

$F_{scale} = F_{net} + F_g$

$= ma + mg$

$= (75.0\text{ kg})(-2.00\text{ m/s}^2) + (75.0\text{ kg})(9.8\text{ N/kg})$

$= -150\text{ N} + 735\text{ N} = 585\text{ N}$

d. It moves downward at constant speed.

Constant speed, so

$a = 0$ and $F_{net} = 0$

$F_{scale} = F_g = mg$

$= (75.0 \text{ kg})(9.8 \text{ N/kg}) = 735 \text{ N}$

e. In what direction is the net force as the elevator slows to a stop as it is moving down?

The acceleration is upward, so the net force is also upward.

Matching

Standing on a stationary scale: a — Actual weight.

Elevator accelerating upward: b — Apparent weight.

Astronaut in orbit: c — Weightless.

Free-falling elevator: c — Weightless.

Elevator moving downward at constant speed: a — Actual weight.

True or False

43: T — Apparent weight equals actual weight when there is no acceleration.

44: F— An upward acceleration increases the scale reading, while downward acceleration decreases it.

45: F— Weightlessness means there is no contact/support force, not zero mass.

46: T — The net force always points in the direction of acceleration.

Choose the Correct Answer

61: A — When an elevator accelerates upward, the apparent weight increases.

62: B — If an elevator accelerates downward, the scale reading decreases.

63: D — Weightlessness occurs when no contact/support force exists.

64: A — Apparent weight is the support force measured by a scale.

65: C — If an elevator moves at constant speed upward, the scale reads equal to weight.

66: D — A scale in free fall reads zero.

67: C — A person feels heavier when accelerating upward.

68: B — The net force on a person in an elevator accelerating downward is downward.

69: A — If a 70 kg person accelerates upward at 2 m/s², the apparent weight is 826 N.

70: D — Apparent weight differs from actual weight because acceleration changes the support force.

DRAG FORCE AND TERMINAL VELOCITY

Physics Challenge Answers

A 415-kg container of food and water is dropped from an airplane at an altitude of 300 m. First, consider the situation ignoring air resistance. Then calculate the more realistic situation involving a drag force provided by a parachute.

1. If you ignore air resistance, how long will it take the container to fall 300 m to the ground?

Define the ground as 0 m and up as the positive direction.

$$x_f = x_i + v_i t_f + \frac{1}{2}\bar{a}t_f^2$$

$$0 \text{ m} = 300 \text{ m} + (0 \text{ m/s})t_f + \frac{1}{2}(-9.8 \text{ m/s}^2)$$

$$-300 \text{ m} = \frac{1}{2}(-9.8 \text{ m/s}^2)t_f^2$$

Solve for t_f:

$$t_f = \sqrt{\frac{2(-300 \text{ m})}{(-9.8 \text{ m/s}^2)}}$$

$$t_f = 7.8 \text{ s}$$

2. Again, ignoring air resistance, what is the speed of the container just before it hits the ground?

$$\begin{aligned} v_f &= v_i + \bar{a}\Delta t \\ &= \mathbf{0\ m/s} + (\mathbf{-9.8\ m/s^2})(\mathbf{7.8\ s}) \\ &= \mathbf{-76\ m/s} \end{aligned}$$

3. The container is attached to a parachute designed to produce a drag force that allows the container to reach a constant downward velocity of 6 m/s. What is the magnitude of the drag force when the container is falling at a constant 6 m/s down?

Since the container is falling at a constant speed, the acceleration is zero. The net force on the container is zero. The drag force must equal the opposite of the container's weight:

$$\begin{aligned} F_{net} &= F_{drag} + F_{weight} \\ 0 &= F_{drag} + F_{weight} \\ F_{drag} &= -F_{weight} \\ &= mg \\ &= -(\mathbf{415\ kg})(\mathbf{-9.8\ N/kg}) \\ &= \mathbf{4100\ N} \end{aligned}$$

Matching

Increasing speed: a — Increases drag.

Streamlining the shape: b — Decreases drag.

Increasing surface area: a — Increases drag.

Denser fluid: a — Increases drag.

True or False

47: F— Drag force acts opposite to the direction of motion, not in the same direction.

48: T — Terminal velocity occurs when net force = 0.

49: F— Larger surface area increases drag; it does not reduce it.

50: T — Skydivers can change terminal velocity by changing their body orientation.

Choose the Correct Answer

71: C — Drag force acts opposite to the direction of motion.

72: A — Terminal velocity occurs when drag equals weight.

73: D — A heavier object with a small surface area accelerates downward faster initially before drag builds up.

74: B — Increasing the fluid's density increases drag.

75: A — A skydiver in the spread-eagle position has a slower terminal velocity.

76: B — A parachute opening increases drag and reduces terminal velocity.

77: D — Drag force is affected by both the object's speed and its shape.

78: A — The net force during falling before reaching terminal velocity is downward.

79: C — The terminal velocity of a baseball is higher than that of a table-tennis ball.

80: D — A skydiver can reduce terminal velocity by both opening a parachute and lying flat horizontal.

Lesson 2 Check Your Progress Answers

22. The skydiver in **Figure** falls at a constant speed in the spread-eagle position. Immediately after opening the parachute, is the skydiver accelerating? If so, in which direction? Explain your answer.

Yes; for a while the diver is accelerating upward because there is an additional upward force due to air resistance on the parachute. The upward acceleration causes the diver's downward velocity to decrease. Newton's second law says that a net force in a certain direction will result in an acceleration in that direction ($F_{net} = ma$).

23. Lunar Gravity Compare the force holding a 10.0-kg rock on Earth and on the Moon. The gravitational field on the Moon is 1.6 N/kg.

To hold the rock on Earth:

$F_{net} = F_{Earth\ on\ rock} - F_{hold\ on\ rock} = 0$

$F_{hold\ on\ rock} = F_{Earth\ on\ rock} = mg_{Earth}$

$= (10.0\ kg)(9.8\ N/kg) \quad = 98\ N$

To hold the rock on the Moon:

$F_{net} = F_{Moon\ on\ rock} - F_{hold\ on\ rock} = 0$

$F_{hold\ on\ rock} = F_{Moon\ on\ rock} = mg_{Moon}$

$= (10.0\ kg)(1.6\ N/kg) \quad = 16\ N$

The force on the Moon is one-fifth the force on Earth.

24. Motion of an Elevator You are riding in an elevator holding a spring scale with a 1-kg mass suspended from it. You look at the scale and see that it reads 9.3 N. What does this tell you about the elevator's motion?

If the elevator is stationary or moving at a constant velocity, the scale should read 9.8 N. Because the scale reads a lighter weight, the elevator must be accelerating downward. To find the exact acceleration: identify up as positive and the 1-kg mass as the system.

$F_{net} = F_{scale\ on\ 1\ kg} - F_{Earth's\ mass\ on\ 1\ kg} = ma$

$$a = \frac{F_{scale\ on\ 1\,kg} - F_{Earth's\ mass\ on\ 1\,kg}}{m}$$

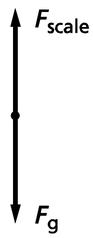
$$= \frac{9.3\ N - 9.8\ N}{1\ kg} = -0.5\ m/s^2$$

The acceleration is 0.5 m/s^2 downward.

25. Apparent Weight You take a ride in a fast elevator to the top of a tall building and ride back down. Compare your apparent and real weights at each part of the journey. Sketch free-body diagrams to support your answers.

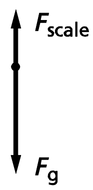
Apparent weight and real weight are the same when you are traveling either up or down at a constant velocity. Apparent weight is less than real weight when the elevator is slowing while rising or speeding up while descending. Apparent weight is greater when speeding up while rising or slowing while going down.

Constant Velocity



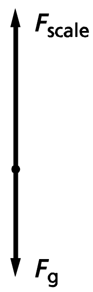
apparent weight = real weight

Slowing While Rising/ Speeding Up While Descending



apparent weight < real weight

Speeding Up While Rising/ Slowing While Descending



apparent weight > real weight

26. **Acceleration** Tecle, with a mass of 65.0 kg, is standing on an ice-skating rink. His friend applies a force of 9.0 N to him. What is Tecle's resulting acceleration?

Identify Tecle as the system and the direction away from the boards as positive. The ice can be treated as a resistance-free surface.

$F_{net} = F_{friend\ on\ Tecle} = ma$

$$a = \frac{F_{friend\ on\ Tecle}}{m}$$

$$= \frac{9.0\ N}{65.0\ kg} = 0.14\ m/s^2 \text{ in the direction of the force applied by his friend}$$

27. **Critical Thinking** You have a job loading inventory onto trucks at a meat warehouse. Each truck has a weight limit of 10,000 N of cargo. You push each crate of meat along a low-resistance roller belt to a scale and weigh it before moving it onto the truck. One night, right after you weigh a 1000-N crate, the scale breaks. Describe a way in which you could apply Newton's laws to approximate the masses of the remaining crates.

Sample Answer: You can neglect resistance if you do all your maneuvering on the roller belt. Because you know the weight of the 1000 N crate, you can use it as your standard. Pull on the 1000 N crate with a particular force for 1 s, estimate its velocity, and calculate the acceleration that your force gave to it. Next, pull on a crate of unknown mass with as close to the same force as you can for 1 s. Estimate the crate's velocity and calculate the acceleration your force gave to it. The force you pulled with on each crate will be the net force in each case.

$F_{net\ 1000\text{-}N\ crate} = F_{net\ unknown\ crate}$

$(1000\ N)(a_{1000\text{-}N\ crate}) = (m_{unk})(a_{unknown})$

$$m_{unknown} = \frac{(1000\ N)(a_{1000-N\ crate})}{a_{unknown}}$$

NEWTON'S THIRD LAW, INTERACTION PAIRS

Practice Problems Answers

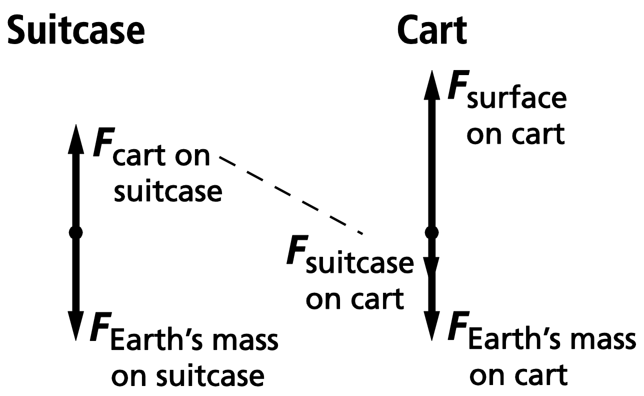
28. You lift a relatively light bowling ball with your hand, accelerating it upward. What are the forces on the ball? What forces does the ball exert? What objects are these forces exerted on?

The forces on the ball are the force of your hand and the gravitational force of Earth's mass. The ball exerts a force on your hand and a gravitational force on Earth. All these forces are exerted on your hand, on the ball, or on Earth.

29. A brick falls from a construction scaffold. Identify any forces acting on the brick. Also identify any forces the brick exerts and the objects on which these forces are exerted. (Air resistance may be ignored.)

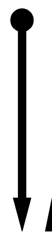
The only force acting on the brick is the gravitational attraction of Earth's mass. The brick exerts an equal and opposite force on Earth.

30. A suitcase sits on a stationary airport luggage cart, as in **Figure 16.** Draw a free-body diagram for each object and specifically indicate any interaction pairs between the two.



The only force interaction pair in these diagrams is $F_{cart\ on\ suitcase}$ and $F_{suitcase\ on\ cart}$.

31. **CHALLENGE** You toss a ball up in the air. Draw a free-body diagram for the ball after it has lost contact with your hand but while it is still moving upward. Identify any forces acting on the ball. Also identify any forces that the ball exerts and the objects on which these forces are exerted. Assume that air resistance is negligible.



The only force acting on the ball is the force of Earth's mass on the ball, when ignoring air resistance. The ball exerts an equal and oppo site force on Earth.

True or False

51: F— Interaction pairs always act on different objects, never the same one.

52: F— Newton's third law implies forces occur simultaneously; one does not "cause" the other in a sequence.

53: T — Forces of gravity between Earth and a falling ball are an interaction pair.

54: T — If you push a wall, the wall exerts an equal and opposite force on you.

55: F— A ball's weight and the table's upward force act on the same object (the ball) and are not an interaction pair.

Matching

Hand → Book: B — Book.

Book → Hand: A — Hand.

Ball → Table: C — Table.

Table → Ball: D — Ball.

Choose the Correct Answer

81: A — Newton's third law states that forces occur in equal and opposite pairs acting on different objects.

82: C — If a book rests on a table, the interaction pair is the table pushing up on the book and the book pushing down on the table.

83: B — Forces on the same object in opposite directions are NOT interaction pairs.

84: A — When you push on a wall, the wall exerts a force equal in magnitude and opposite in direction.

85: B — Earth's acceleration in response to a softball is very small due to Earth's large mass.

86: A — Interaction pairs exist because forces always come in pairs.

87: C — The ball's weight and the table's upward force are not an interaction pair.

88: B — Forces exerted by a falling brick on Earth are part of an interaction pair with Earth.

89: A — A bowling ball lifted upward interacts with your hand.

90: C — After tossing a ball upward, the interaction pair is the gravity on the ball and the gravity on Earth.

TENSION

Practice Problems Answers

32. Diego and Mika are trying to fix a tire from Diego's car. When they pull together in the same direction, Mika with a force of 23 N and Diego with a force of 31 N, they just barely get the tire to move off the wheel. What is the magnitude of the force between the tire and the wheel?

Identify the tire as the system and the direction of pulling as positive.

$$F_{\text{net}} = F_{\text{wheel on tire}} - F_{\text{Mika on tire}} - F_{\text{Diego on tire}}$$

$$= ma = 0$$

$$F_{\text{wheel on tire}} = F_{\text{Mika on tire}} + F_{\text{Diego on tire}}$$

$$= 23\text{ N} + 31\text{ N}$$

$$= 54\text{ N}$$

33. **CHALLENGE** You are loading equipment into a bucket that roofers will hoist to a rooftop. If the rope will not break as long as the tension does not exceed 450 N and you fill the bucket until it has a mass of 42 kg, what is the greatest acceleration the workers can give the bucket as they hoist it?

Identify the bucket as the system and up as positive.

$$F_{net} = F_{rope\ on\ bucket} - F_{Earth's\ mass\ on\ bucket}$$

$$= ma$$

$$a = \frac{F_{rope\ on\ bucket} - F_{Earth's\ mass\ on\ bucket}}{m}$$

$$= \frac{F_{rope\ on\ bucket} - mg}{m}$$

$$= \frac{450\ N - (42\ kg)(9.8\ N/kg)}{42\ kg}$$

$$= 0.91\ m/s^2$$

True or False

56: T — Tension always acts along the direction of the rope.

57: F— Tension is a pull force; ropes cannot push objects.

58: T — Tension at any point in a massless rope is the same.

59: F— Upward tension force equals weight only in equilibrium; it differs during acceleration.

60: T — A rope pulling up on a bucket is part of an interaction pair.

Matching

Rope → Bucket: B — Bucket.

Bucket → Rope: A — Rope above bucket.

Rope → Ceiling: D — Ceiling.

Rope → Worker: C — Worker.

Choose the Correct Answer

91: B — Tension is a force exerted by a rope on an object.

92: A — In a stationary rope holding a bucket, tension equals the weight of the bucket.

93: B — If a rope does not accelerate in tug-of-war, tension is equal to one team's force.

94: A — If a rope exerts a force on an object, the interaction pair is the object pulling on the rope.

95: A — If a rope breaks at 500 N with a 20 kg mass, the max upward acceleration is approximately 15 m/s².

96: D — If a rope is massless, the tension is the same at all points.

97: A — If a bucket moves upward with acceleration, the tension must be greater than the weight.

98: B — If the rope pulls the ceiling with 100 N, the rope pulls the bucket with 100 N.

99: D — The interaction pair for tension is the rope pulling the bucket and the bucket pulling the rope.

100: C — Interaction pair forces in a rope are equal and opposite.

THE NORMAL FORCE

True or False

61: F— The normal force is not always equal to the object's weight.

62: T — The normal force always acts perpendicular to the surface.

63: T — Pulling an object upward slightly decreases the normal force.

64: T — Pushing down on an object increases the normal force.

65: T — The normal force can act along an inclined surface (perpendicular to it).

Matching

Box on flat table, stationary:

Pull upward with string:

Push downward:

Problem-Solving Questions Answers

1. A 50-kg box rests on a horizontal floor. You pull upward with 100 N. Find (F_N).

   $W = mg = 50 \times 9.8 = 490$ N

   $FN = W - F_{up} = 490 - 100 = 390$ N

2. You push down on the same 50-kg box with 50 N. Find (F_N).

   $FN = W + F_{down} = 490 + 50 = 540$ N

3. A 20-kg object hangs from a rope on a table. Rope pulls upward 50 N. Normal force?

   $W = 20 \times 9.8 = 196$ N,

$\mathbf{F_N = W - F_{up} = 196 - 50 = 146}$ **N**

Choose the Correct Answer

101: B — The normal force always acts perpendicular to the surface.

102: B — If a box sits on the floor with no other vertical forces,

103: A — Pulling upward on a box decreases the normal force.

104: A — Pushing down on a box increases the normal force.

105: D — If a box weighs 100 N and you pull up with 30 N,

106: C —

107: D — The normal force is important because it is a factor in determining friction.

108: C — The formula for normal force when a string pulls upward is

109: B — For a box on a table with an additional downward force,

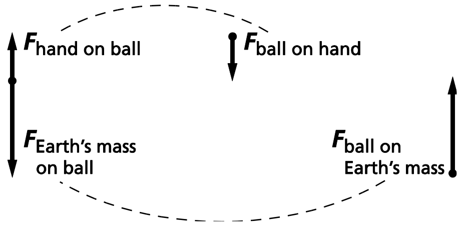
110: A — The normal force is not always equal to weight because other vertical forces may be present.

Lesson 3 Check Your Progress Answers

34. **Interaction Pair** Identify each force acting on the ball and its interaction pair in **Figure.**

The forces on the ball are the downward force of gravity due to the mass of Earth and the upward force of the hand. The force of the ball on Earth and the force of the ball on the hand are the other halves of the interaction pairs.

35. **Force** Imagine lowering the ball in **Figure** at increasing speed. Draw separate free-body diagrams for the forces acting on the ball and for each set of interaction pairs.



Yes; the force of the hand on the ball becomes smaller so there is a downward acceleration. The force of the ball on the hand also becomes smaller; you can feel that. The interaction pair partners remain the same.

36. **Tension** A block hangs from the ceiling by a massless rope. A second block is attached to the first block and hangs below it on another piece of massless rope. If each of the two blocks has a mass of 5.0 kg, what is the tension in each rope?

For the bottom rope with the positive direction upward:

$F_{\text{net}} = F_{\text{bottom rope on bottom block}} - F_{\text{Earth's mass on bottom block}} = ma = 0$

$F_{\text{bottom rope on bottom block}} = F_{\text{Earth's mass on bottom block}}$

$= mg = (5.0\text{ kg})(9.8\text{ N/kg}) = 49\text{ N}$

For the top rope, with the positive direction upward:

$F_{\text{net}} = F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}} - F_{\text{Earth's mass on top block}} = ma = 0$

$F_{\text{top rope on top block}} = F_{\text{Earth's mass on top block}} + F_{\text{bottom rope on top block}}$

$= mg + F_{\text{bottom rope on top block}}$

$= (5.0\text{ kg})(9.8\text{ N/kg}) + 49\text{ N} = 98\text{ N}$

37. **Tension** A block hangs from the ceiling by a massless rope. A 3.0-kg block is attached to the first block and hangs below it on another piece of massless rope. The tension in the top rope is 63.0 N. Find the tension in the bottom rope and the mass of the top block.

For the bottom rope with the positive direction upward:

$F_{\text{net}} = F_{\text{bottom rope on bottom block}} - F_{\text{Earth's mass on bottom block}} = ma = 0$

$F_{\text{bottom rope on bottom block}} = F_{\text{Earth's mass on bottom block}}$

$= (3.0\text{ kg})(9.8\text{ N/kg}) = 29\text{ N}$

For the top mass with the positive direction upward:

$F_{\text{net}} = F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}} - F_{\text{Earth's mass on top block}} = ma = 0$

$F_{\text{Earth's mass on top block}} = mg$

$= F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}}$

$$m = \frac{F_{\text{top rope on top block}} - F_{\text{bottom rope on top block}}}{g}$$

$$= \frac{63.0\text{ N} - 29\text{ N}}{9.8\text{ N/kg}} = 3.5\text{ kg}$$

38. **Critical Thinking** A curtain prevents two tug-of-war teams from seeing each other. One team ties its end of the rope to a tree. If the other team pulls with a 500-N force, what is the tension in the rope? Explain

The tension would be 500 N. The rope is in equilibrium, so the net force on it is zero. The team and the tree exert equal forces in opposite directions.