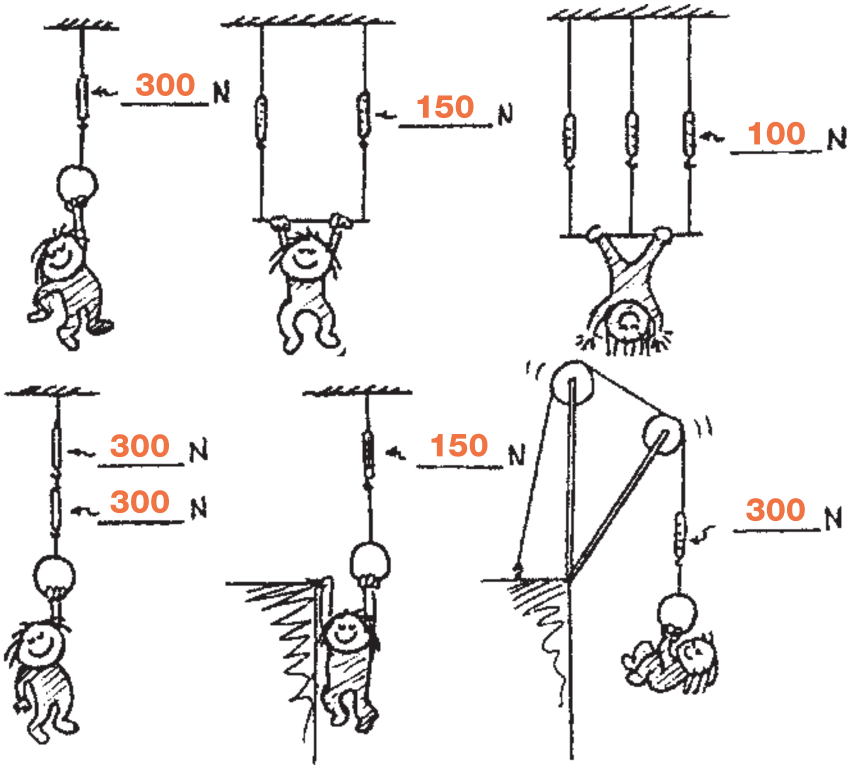
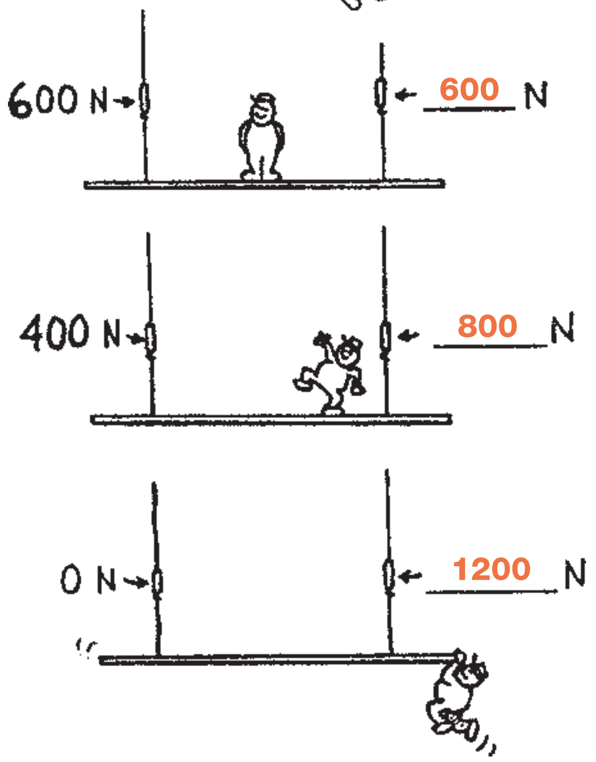
Name ______________________ Class ____________ Date ____________

Concept-Development Practice Page 2-1

Static Equilibrium

1. Little Nellie Newton wishes to be a gymnast and hangs from a variety of positions as shown. Since she is not accelerating, the net force on her is zero. That is, $\sum F = 0$. This means the upward pull of the rope(s) equals the downward pull of gravity. She weighs 300 N. Show the scale reading(s) for each case.





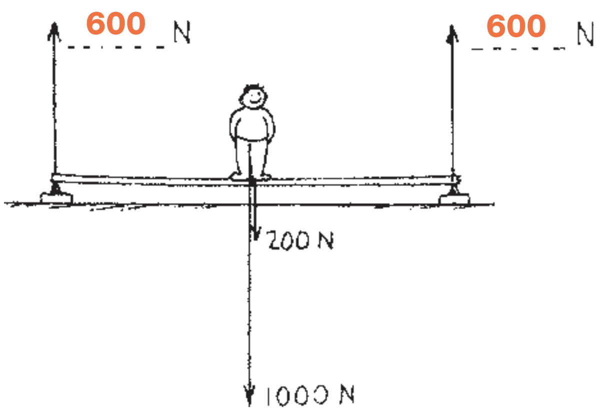
2. When Burl the painter stands in the exact middle of his staging, the left scale reads 600 N. Fill in the reading on the right scale. The total weight of Burl and staging must be 1200 N.

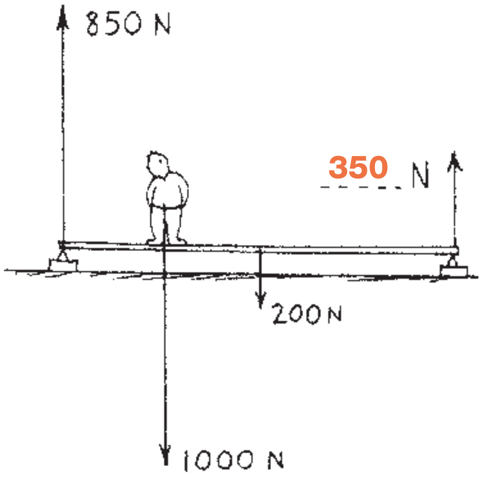
3. Burl stands farther from the left. Fill in the reading on the right scale.

4. In a silly mood, Burl dangles from the right end. Fill in the reading on the right scale.

The Equilibrium Rule: $\Sigma F = 0$

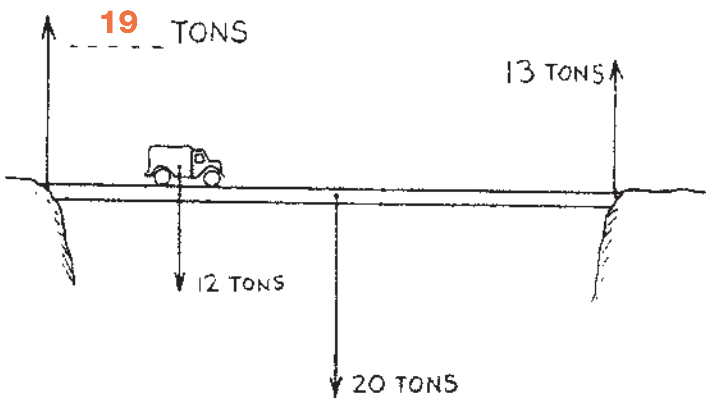
1. Manuel weighs 1000 N and stands in the middle of a board that weighs 200 N. The ends of the board rest on bathroom scales. (We can assume the weight of the board acts at its center.) Fill in the correct weight reading on each scale.



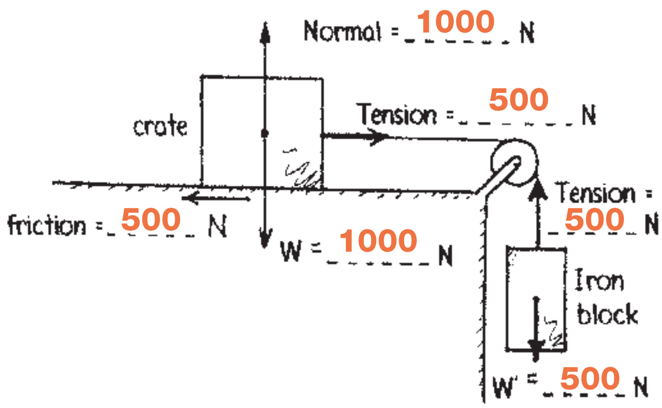


2. When Manuel moves to the left as shown, the scale closest to him reads 850 N. Fill in the weight for the far scale.

3. A 12-ton truck is one-quarter the way across a bridge that weighs 20 tons. A 13-ton force supports the right side of the bridge as shown. How much support force is on the left side?



4. A 1000-N crate resting on a surface is connected to a 500-N block through a frictionless pulley as shown. Friction between the crate and surface is enough to keep the system at rest. The arrows show the forces that act on the crate and the block. Fill in the magnitude of each force.



5. If the crate and block in the preceding question move at constant speed, the tension in the rope (is the same) (increases) (decreases).
The sliding system is then in (static equilibrium) (dynamic equilibrium).

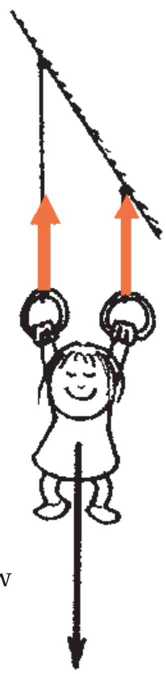
Name ____________________ Class ____________ Date ____________

Concept-Development Practice Page 2-2

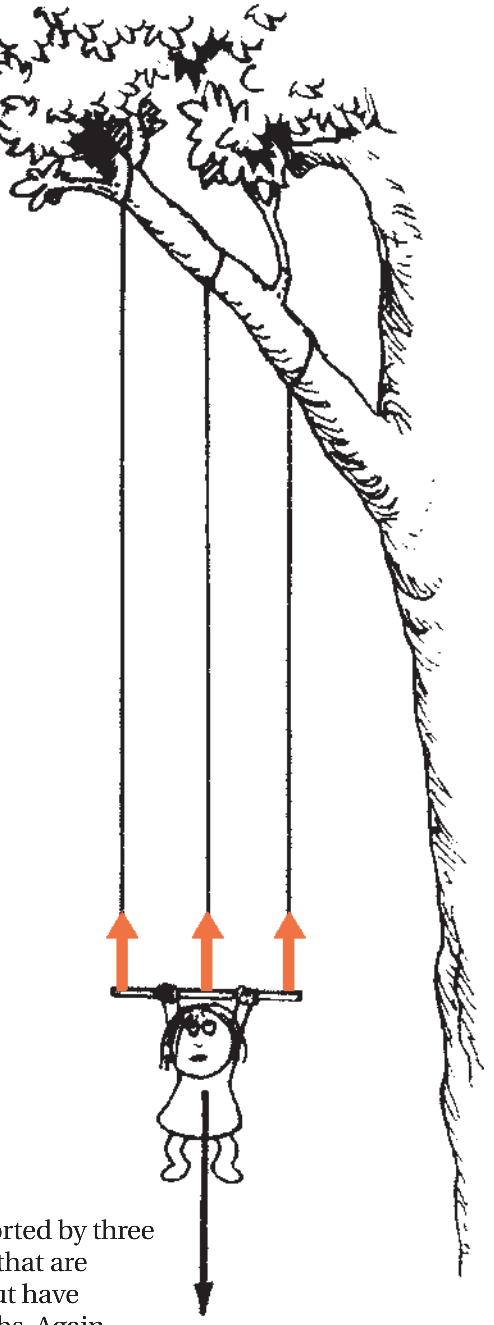
Vectors and Equilibrium

1. Nellie Newton dangles from a vertical rope in equilibrium: $\sum F = 0$. The tension in the rope (upward vector) has the same magnitude as the downward pull of gravity (downward vector).

2. Nellie is supported by two vertical ropes. Draw tension vectors to scale along the direction of each rope.



3. This time the vertical ropes have different lengths. Draw tension vectors to scale for each of the two ropes.



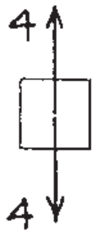
4. Nellie is supported by three vertical ropes that are equally taut but have different lengths. Again, draw tension vectors to scale for each of the three ropes.

Circle the correct answers.

5. We see that tension in a rope is (dependent on) (independent of) the length of the rope. So the length of a vector representing rope tension is (dependent on) (independent of) the length of the rope.

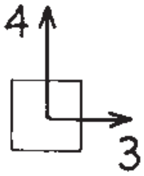
Net Force

Fill in the magnitudes of net force for each case.

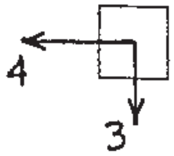


F_{net} = 0

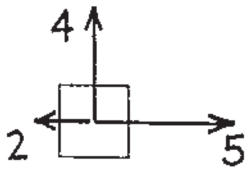
F_{net} = 1



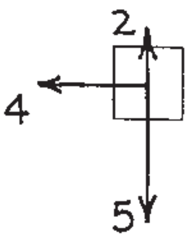
F_{net} = 5



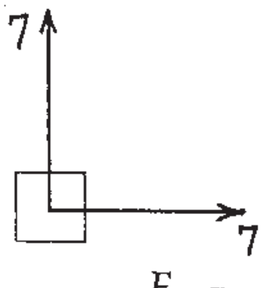
F_{net} = 5



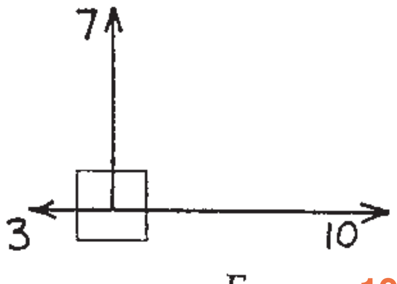
F_{net} = 5



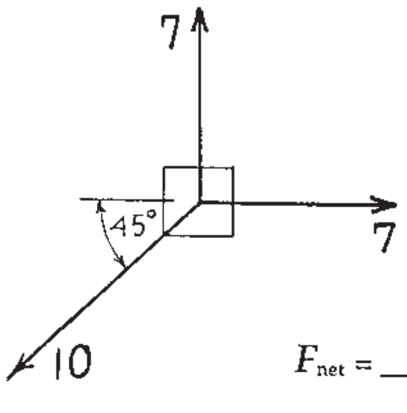
F_{net} = 5



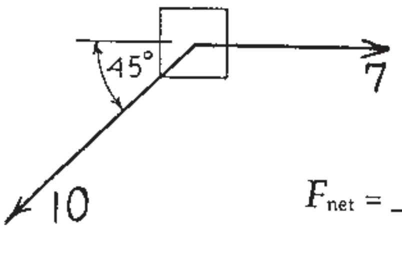
F_{net} = ≈10



F_{net} = ≈10



F_{net} = ≈0

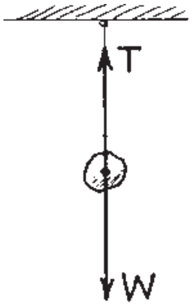


F_{net} = 7

CONCEPTUAL PHYSICS

Name ______________________ Class ______________ Date ______________

Vectors and Equilibrium



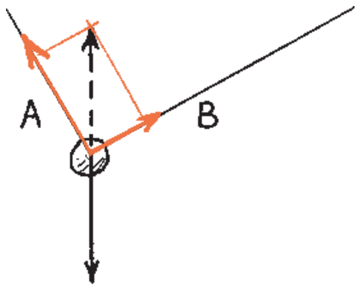
The rock hangs at rest from a single string. Only two forces act on it, the upward tension **T** of the string, and the downward pull of gravity **W**. The forces are equal in magnitude and opposite in direction.

Net force on the rock is (zero) (greater than zero).

Here the rock is suspended by 2 strings. Tension in each string acts in a direction along the string. We'll show tension of the left string by vector **A**, and tension of the right string by vector **B**. The resultant of **A** and **B** is found by the **parallelogram rule**, and is shown by the dashed vector. Note it has the same magnitude as **W**, so the net force on the rock is

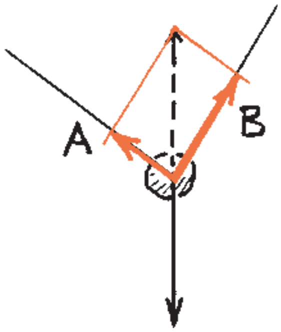
(zero) (greater than zero).

Consider strings at unequal angles. The resultant **A + B** is still equal and opposite to **W**, and is shown by the dashed vector. Construct the appropriate parallelogram to produce this resultant. Show the relative magnitudes of **A** and **B**.

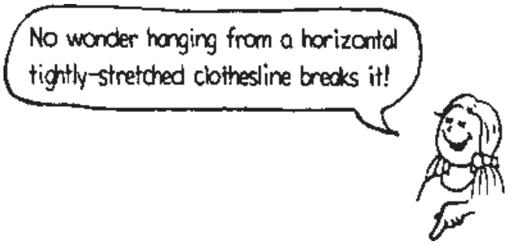


Tension in **A** is (less than) (equal to) (greater than) tension in **B**.

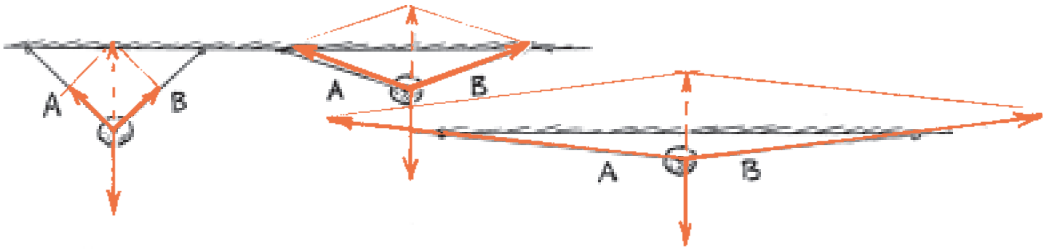
Repeat the procedure for the arrangement below.



Here tension is greater in B.



Construct vectors **A** and **B** for the cases below. First draw a vector **W**, then the parallelogram that has equal and opposite vector **A + B** as the diagonal. Then find approximate magnitudes of **A** and **B**.



CONCEPTUAL PHYSICS

Name ______________________ Class ______________ Date ______________

Concept-Development Practice Page **3-1**

Mass and Weight

Learning physics is learning the connections among concepts in nature, and also learning to distinguish between closely related concepts. Velocity and acceleration, which are treated in the next chapter, are often confused. Similarly in this chapter, we find that mass and weight are often confused. They aren't the same! Please review the distinction between mass and weight in your textbook. To reinforce your understanding of this distinction, circle the correct answers below.

Comparing the concepts of mass and weight, one is basic—fundamental—depending only on the internal makeup of an object and the number and kind of atoms that compose it. The concept that is fundamental is (mass) (weight).

The concept that additionally depends on location in a gravitational field is (mass) (weight).

(Mass) (Weight) is a measure of the amount of matter in an object and only depends on the number and kind of atoms that compose it.

It can correctly be said that (mass) (weight) is a measure of "laziness" of an object.

(Mass) (Weight) is related to the gravitational force acting on the object.

(Mass) (Weight) depends on an object's location, whereas (mass) (weight) does not.

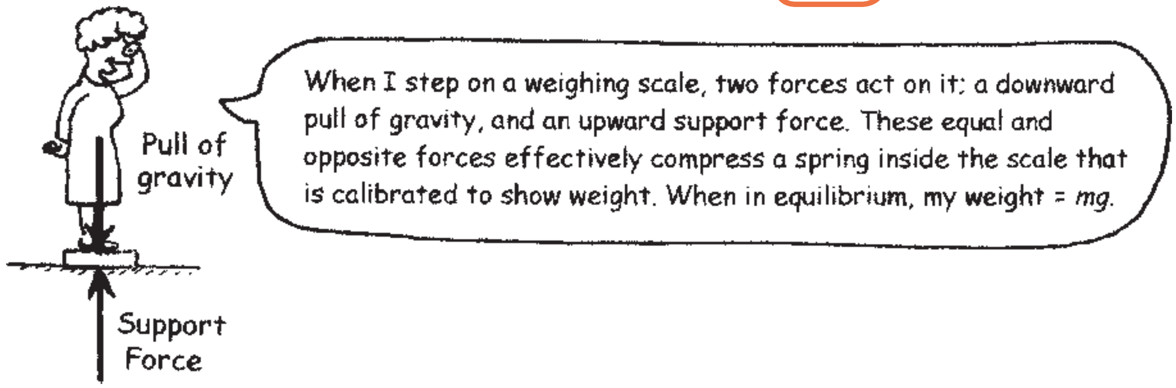
In other words, a stone would have the same (mass) (weight) whether it is on the surface of Earth or on the surface of the moon. However, its (mass) (weight) depends on its location.

On the moon's surface, where gravity is only about one sixth of Earth gravity (mass) (weight) (both the mass and the weight) of the stone would be the same as on Earth.

While mass and weight are not the same, they are (directly proportional) (inversely proportional) to each other. In the same location, twice the mass has (twice) (half) the weight.

The International System of Units (SI) unit of mass is the (kilogram) (newton), and the SI unit of force is the (kilogram) (newton).

In the United States, it is common to measure the mass of something by measuring its gravitational pull to Earth, its weight. The common unit of weight in the U.S. is the (pound) (kilogram) (newton).



CONCEPTUAL PHYSICS

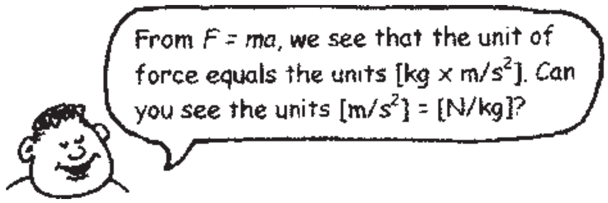
Converting Mass to Weight

Objects with mass also have weight (although they can be weightless under special conditions). If you know the mass of something in **kilograms** and want its weight in **newtons**, at Earth's surface, you can take advantage of the formula that relates weight and mass.

Weight = mass × acceleration due to gravity
$W = mg$

This is in accord with Newton's second law, written as $F = ma$. When the force of gravity is the only force, the acceleration of any object of mass m will be g, the acceleration of free fall. Importantly, g acts as a proportionality constant, 10 N/kg, which is equivalent to 10 m/s^2.

Sample Question:
How much does a 1-kg bag of nails weigh on Earth?



$W = mg = (1\text{ kg})(10\text{ m/s}^2) = 10\text{ m/s}^2 = 10\text{ N}$,
or simply, $W = mg = (1\text{ kg})(10\text{ N/kg}) = 10\text{ N}$.

Answer the following questions.
Felicia the ballet dancer has a mass of 45.0 kg.

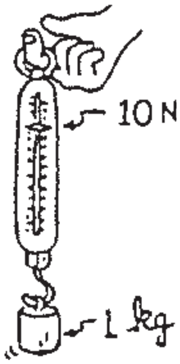
1. What is Felicia's weight in newtons at Earth's surface? **450 N**

2. Given that 1 kilogram of mass corresponds to 2.2 pounds at Earth's surface, what is Felicia's weight in pounds on Earth? **99 lb**

3. What would be Felicia's mass on the surface of Jupiter? **45.0 kg**

4. What would be Felicia's weight on Jupiter's surface, where the acceleration due to gravity is 25.0 m/s^2? **1125 N**

   Different masses are hung on a spring scale calibrated in newtons.
   The force exerted by gravity on 1 kg = 10 N.



5. The force exerted by gravity on 5 kg = **50** N.

6. The force exerted by gravity on **10** kg = 100 N.

   Make up your own mass and show the corresponding weight:
   The force exerted by gravity on ***** kg = ***** N.

   * Any value for kg as long as the same value is multiplied by 10 for N.

By whatever means (spring scales, measuring balances, etc.), find the mass of your physics book. Then complete the table.

OBJECT	MASS	WEIGHT
MELON	1 kg	**10 N**
APPLE	**0.1 kg**	1 N
BOOK		
A FRIEND	60 kg	**600 N**

CONCEPTUAL PHYSICS

Name ____________________ Class ____________ Date ____________

Concept-Development Practice Page **3-2**

Inertia

Circle the correct answers.

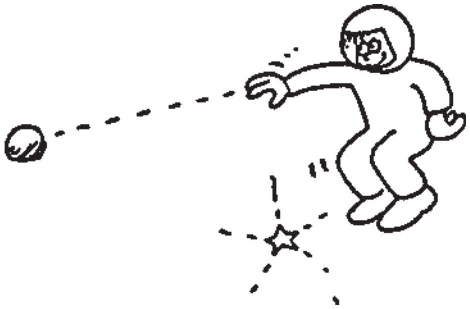
1. An astronaut in outer space away from gravitational or frictional forces throws a rock. The rock will

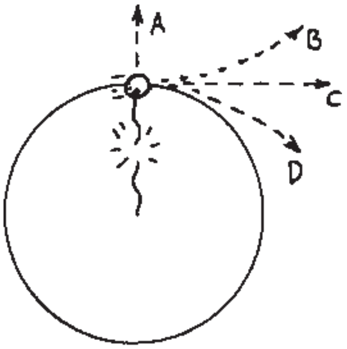
   (gradually slow to a stop)

   (continue moving in a straight line at constant speed).

   The rock's tendency to do this is called

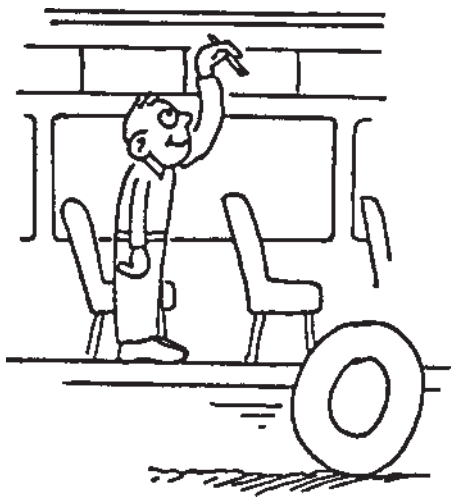
   (inertia) (weight) (acceleration).



2. 

   The sketch shows a top view of a rock being whirled at the end of a string (clockwise). If the string breaks, the path of the rock is

   (A) (B) (C) (D).



3. Suppose you are standing in the aisle of a bus that travels along a straight road at 100 km/h, and you hold a pencil still above your head. Then relative to the bus, the velocity of the pencil is 0 km/h, and relative to the road, the pencil has a horizontal velocity of

   (less than 100 km/h) (100 km/h) (more than 100 km/h).

   Suppose you release the pencil. While it is dropping, and relative to the road, the pencil still has a horizontal velocity of

   (less than 100 km/h) (100 km/h) (more than 100 km/h).

   This means that the pencil will strike the floor at a place directly

   (behind you) (at your feet below your hand) (in front of you).

   Relative to you, the way the pencil drops

   (is the same as if the bus were at rest)

   (depends on the velocity of the bus).

   How does this example illustrate the law of inertia?

   A body in motion tends to remain in motion as long as no net force is exerted on the body in the direction of motion. Since there is no horizontal force on the pencil, its horizontal motion doesn't change.

CONCEPTUAL PHYSICS

Exercises

1.1 The Basic Science—Physics (page 1)

1. The study of science today branches into the study of the
_____life_____ sciences and the _____physical_____ sciences.

2. Write *L* or *P* beside each of the following to classify it as a branch of life science or physical science.

__L__ zoology

__P__ physics

__P__ chemistry

__L__ biology

__P__ astronomy

__L__ botany

__P__ geology

3. Complete the following table by identifying each type of science described.

Type of Science	Description
Physics	The study of the nature of things such as motion, forces, energy, matter, heat, sound, light, and the composition of atoms
Chemistry	The study of how matter is put together, how atoms combine to form molecules, and how the molecules combine to make up matter
Biology	The study of matter that is alive

1.2 Mathematics—The Language of Science (page 1)

4. When the ideas of science are expressed in mathematical terms, they are
_____unambiguous_____.

5. Explain why equations are often used in science.
Equations provide compact expressions of relationships between concepts.

6. Is the following sentence true or false? Scientific findings are harder to verify or to disprove when they are expressed mathematically.
_____false_____

1.3 Scientific Methods (page 2)

7. Which two scientists are usually credited as the principal founders of the scientific method? _____Galileo Galilei_____ and _____Francis Bacon_____

8. Name five steps that are generally included in scientific methods.

a. Recognize a problem.

b. Make an educated guess—a hypothesis—about the answer.

c. Predict the consequences of the hypothesis.

d. Perform experiments to test predictions.

e. Formulate the simplest general rule that organizes the main ingredients: hypothesis, prediction, and experimental outcome.

9. Is the following statement true or false? Following the steps of the scientific method exactly is an important part of the success of science. false

1.4 The Scientific Attitude (pages 2–3)

Match each term to its definition.

	Term	Definition
b	10. law or principle	a. a close agreement by competent observers who make a series of observations of the same phenomenon
a	11. fact	b. a hypothesis that has been tested over and over again and not contradicted
c	12. hypothesis	c. an educated guess that is not fully accepted until demonstrated by experiment

13. What should happen if a scientist finds evidence that contradicts a hypothesis, law, or principle?
The hypothesis, law, or principle must be changed or abandoned.

14. Which is more reliable, an idea of a scientist who has an excellent reputation or a single verifiable experiment that shows the idea is wrong?
a single verifiable experiment that shows the idea is wrong

15. In everyday speech, the word *theory* means a supposition that has not been verified.

16. In science, the word *theory* means a synthesis of a large body of information that encompasses well-tested and verified hypotheses about certain aspects of the natural world.

17. Is the following statement true or false? Once an idea becomes a theory, it cannot be changed. false

1.5 Scientific Hypotheses (page 4)

18. What must be true in order for a hypothesis to be scientific?
The hypothesis must be testable.

19. To determine whether a hypothesis is scientific or not, you should look to see if there is a test for proving it wrong.

20. Scientists perform a(n) experiment to test a(n) scientific hypothesis.

21. Is the following hypothesis scientific? Why? "Intelligent life exists on other planets somewhere in the universe." No; there is no test for proving it wrong.

Name ____________ Class ____________ Date ____________

1.6 Science, Technology, and Society (page 5)

22. Science is a method of answering theoretical questions; technology is a method of solving practical problems.

23. Write *S* or *T* to indicate whether the following statements describe science or technology.

T Involves the design and creation of something for the use and enjoyment of humans

S Has to do with discovering facts and relationships between observable phenomena in nature

1.7 Science, Art, and Religion (page 6)

Match each term to its definition.

	Term	Definition
c	**24.** science	a. concerned with the source, purpose, and meaning of everything
b	**25.** art	b. concerned with the value of human interactions as they pertain to the senses
a	**26.** religion	c. concerned with discovering and recording natural phenomena

27. The domain of science is natural order; the domain of religion is nature's purpose.

1.8 In Perspective (page 7)

28. Is the following statement true or false? Progress was much slower thousands of years ago than it is today. true

29. Thousands of years ago, the building of great structures such as the Pyramids was inspired by a vision of the cosmos.

30. Is the inspiration for progress today similar to or different from the inspiration thousands of years ago? similar to

Exercises

2.1 Force (pages 13–14)

1. A force is a ___push___ or a ___pull___.
2. A force is needed to change the state of ___motion___ of an object.
3. Is the following sentence true or false? If an object is sliding on ice, it will continue sliding until a force slows it down. ___true___
4. Define net force.
the combination of all forces acting on an object

Match the applied forces on an object with the letter of the corresponding net force on the object.

	Applied Forces	Net Force
d	5. 5 N to the right and 5 N to the left	a. 2 N to the left
a	6. 4 N to the right and 6 N to the left	b. 2 N to the right
b	7. 7 N to the right and 5 N to the left	c. 10 N to the right
c	8. 6 N to the right and 4 N to the right	d. 0 N (no change in motion)

9. Describe the forces that act on a rock at rest in your hand.
Your hand pushes upward on the rock with as much force as Earth's gravity pulls down on it.

10. Circle the letter that identifies the force acting upward on an object suspended from a spring scale.
a. gravity
b. equilibrium
(c.) tension
d. weight

11. A ___vector___ is an arrow that represents the magnitude and direction of a quantity.
12. Explain the difference between a vector quantity and a scalar quantity.
A vector quantity is a quantity that describes both magnitude and direction. A scalar quantity can be described by magnitude only and has no direction.

13. Write *V* beside each vector quantity. Write *S* beside each scalar quantity.
___S___ a. time
___S___ b. area
___V___ c. force
___S___ d. volume

2.2 Mechanical Equilibrium (page 16)

14. Express the equilibrium rule in words.

Whenever the net force on an object is zero, the object is said to be in mechanical equilibrium.

15. Express the equilibrium rule mathematically, and explain what the symbol in the rule means.

$\sum F = 0$; the symbol $\sum$ means "the sum of."

16. Circle the letter that describes the forces acting on a suspended object at rest.

a. The forces acting upward on the object are greater than the forces acting downward on the object.

b. The forces acting upward on the object are less than the forces acting downward on the object.

(c.) The forces acting upward and downward on the object are balanced.

d. No forces are acting on the object.

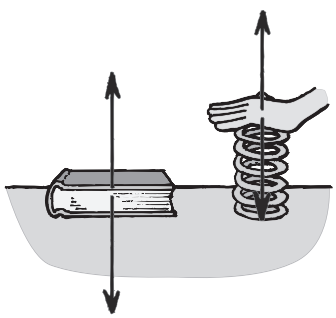
2.3 Support Force (page 17)

17. Identify the two forces acting on a book at rest on a table. State the direction of each force.

a. The weight of the book due to gravity acts downward.

b. The support force provided by the table acts upward on the book.

18. The ___support___ force is the upward force that balances the weight of an object on a surface. Another name for this force is the ___normal___ force.



19. Look at the drawing above. Explain how the force of the table pushing up on the book is similar to what happens when the spring is compressed.

When the spring is compressed, it pushes upward on your hand. Similarly, the book sitting on the table compresses the atoms of the table. The atoms then push upward on the book.

20. Circle the letter that describes an object at rest on a horizontal surface.

(a.) The support force is equal to the object's weight.

b. The support force is greater than the object's weight.

c. The support force is less than the object's weight.

2.4 Equilibrium for Moving Objects (pages 18–19)

21. If an object is moving at a ___constant___ speed in a ___straight-line___ path, it is in a state of equilibrium.

22. Is the following sentence true or false? If a desk is pushed at a constant speed across a horizontal floor, the force of friction must be equal in magnitude and opposite in direction to the pushing force on the desk. ___True___

23. Objects at rest are said to be in ___static___ equilibrium.

24. Objects moving at constant speed in a straight-line path are said to be in ___dynamic___ equilibrium.

2.5 Vectors (pages 19–22)

25. Suppose a gymnast with a weight of 300 N is suspended by a single vertical rope. What is the tension in the rope? ___300 N___

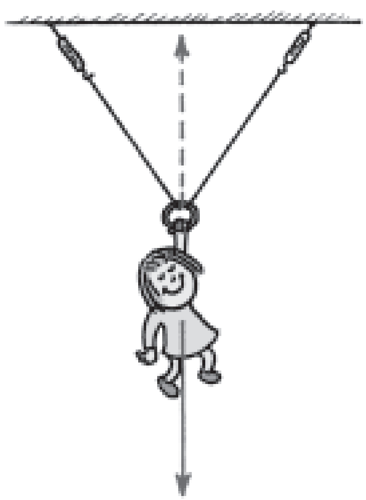
26. Now suppose the same gymnast hangs from two vertical ropes. What are the tensions in the ropes? ___150 N in each rope___

27. Define resultant. ___the sum of two or more vectors___

28. State the parallelogram rule.

To find the resultant of two vectors, construct a parallelogram wherein the two vectors are adjacent sides. The diagonal of the parallelogram shows the resultant.

29. The gymnast shown below is suspended from two non-vertical ropes. The solid vector represents the gymnast's weight. What does the dashed vector represent? ___the resultant of the tensions in both ropes___



Name ______________________ Class ________________ Date ____________

Exercises

3.1 Aristotle on Motion (pages 29–30)

Fill in the blanks with the correct terms.

1. Aristotle divided motion into two types: ____natural motion____ and ____violent motion____.
2. Natural motion on Earth was once thought to be either ____straight up____ or ____straight down____.
3. Aristotle thought that it was natural for heavy things to ____fall____ and for light things to ____rise____.
4. Aristotle also thought that ____circular____ motion was natural for objects beyond Earth and that the planets and stars moved in perfect circles around ____Earth____.
5. What force was thought to have caused a horse and cart to experience violent motion? ____the pull of the horse____
6. Before the 1500s, the proper state of objects was thought to be one of ____rest____, unless they were being pushed or pulled or were moving toward their natural resting place.
7. Is the following statement true or false? Early thinkers thought that violent motion was imposed motion. ____true____
8. Is the following statement true or false? It was commonly thought by many ancient thinkers that if an object moved "against its nature," then a force of some kind was responsible. ____true____

3.2 Copernicus and the Moving Earth (page 30)

Determine if each of the following statements is true or false.

____true____ 9. Copernicus thought that Earth and other planets move around the sun.

____false____ 10. Copernicus thought that Earth was at the center of the universe.

____true____ 11. Copernicus did not publish his ideas until he was near death.

____false____ 12. Copernicus lived a long and happy life after his works were published.

13. Why did Copernicus do most of his work in secret?
Copernicus' ideas were very controversial, so he worked in secret to avoid persecution.

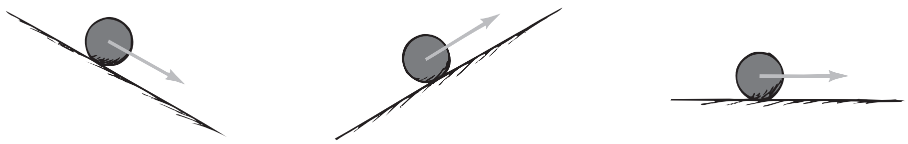
3.3 Galileo on Motion (pages 30–32)

14. What was one of Galileo's great contributions to physics?
demolishing the notion that a force is necessary to keep an object moving
15. A force is any ____push____ or ____pull____.

16. Explain what friction is and how it acts.

Friction is the force that acts between materials that touch as they move past each other. Friction is caused by irregularities in the surfaces that are touching. All irregularities obstruct motion causing a force (friction) that opposes motion.

17. In the drawings below, describe each type of slope on the top line. On the bottom line, describe the slope's affect on speed.



a. Slope downward
Speed increases

b. Slope upward
Speed decreases

c. No slope
Speed does not change

18. Based on his experiments with rolling balls, Galileo was able to conclude that when friction is present, a ___force___ is needed to keep an object moving.

19. Describe the property of inertia in your own words.

A body in motion will stay in motion unless acted on by a force. Likewise, a body at rest will stay at rest unless acted on by a force. Or, every object resists change to its state of motion.

3.4 Newton's Law of Inertia (pages 33–35)

20. What is another name for Newton's first law of motion?

the law of inertia

21. State Newton's first law of motion.

Newton's first law states that every object continues in a state of rest, or of uniform speed in a straight line, unless it is acted on by a nonzero net force.

22. Use Newton's first law of motion to explain what happens to dishes on a table when the tablecloth is quickly pulled from beneath them.

Dishes on a tabletop are at rest. They tend to remain at rest even when the tablecloth is pulled from beneath them because friction between the dishes and the tablecloth is not significant enough to move the dishes very much.

23. Objects in a state of rest tend to remain at rest; only a ___force___ will change that state.

24. Use Newton's first law of motion to explain why an air hockey puck slides on the game table with no apparent loss in speed. Name two things that can cause the puck to change its state of motion.

In the absence of forces, a moving object such as the air hockey puck will move indefinitely in a straight line. The puck will change its motion if it is struck or if it hits the side of the playing table.

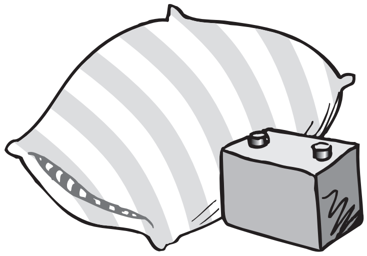
25. Once an object is moving in a force-free environment, for how long will it move in a straight line? ___indefinitely___

3.5 Mass—A Measure of Inertia (pages 36–38)

26. Circle the letter of each sentence that is true about the mass of an object.

(a.) The amount of inertia an object has depends on its mass.
(b.) The more mass an object has, the greater its inertia.
c. Volume and mass are the same quantity.
(d.) Mass is usually measured in kilograms.

27. Which item below has more mass? Which has more volume? Which has the greater inertia?



The battery has greater mass and thus greater inertia. The pillow has greater volume.

28. Is the following sentence true or false? Mass is a measure of the gravitational force acting on an object. false

29. Mass is a measure of the amount of material in an object and depends on the number of and kind of atoms that compose it.

30. Is the following sentence true or false? A stone has the same mass on Earth and on the moon, but its weight is less on the moon. true

31. Mass is the quantity of matter in an object.

32. Weight is the force of gravity on an object.

Match each phrase with the correct word.

	Phrase	Word
c	**33.** traditional unit of weight in the United States	a. kilogram
b	**34.** measure of matter in most parts of the world	b. mass
a	**35.** SI unit of mass	c. pound
d	**36.** SI unit of force	d. newton

3.6 The Moving Earth Again (pages 38–39)

37. If Earth is rotating at 30 km/s, explain how a bird sitting on a tree can drop down vertically and grab a worm that is crawling on the ground.

Earth, the bird, the tree, the ground, and the worm are all rotating as one unit. Because everything is rotating as one unit, Earth's rotation does not affect the bird's ability to descend vertically to grab the worm.

38. A girl is sitting on a bus that is traveling at 30 km/h. She is throwing her tennis ball gently into the air and catching it. Circle the letter of each true statement.

a. The tennis ball is moving faster than the girl riding on the bus.

(b.) The tennis ball is behaving as if the bus were at rest.

c. The inertia of the tennis ball changes when it is thrown.

(d.) Gravity affects only the vertical motion of the tennis ball.

Match the ideas on motion with the correct scientist.

	Idea	**Scientist**
a	**39.** did not recognize inertia	a. Aristotle
b	**40.** developed the law of inertia	b. Newton
a	**41.** believed that horizontal motion was "unnatural"	c. Galileo
c	**42.** was one of the first to recognize that no force was needed to keep an object in motion	