FRAMING QUESTIONS

1. You are part of a team that will redesign the entrance hallway to your school. Your principal wants to suspend a 20-lb plaque with the name of the school high over the entrance by hanging it from the ceiling using thin fishing line so the people below will think the plaque is hanging in mid air. He shows you a fishing line that will hold 12 lbs, and wants to attach two lines to the sculpture to be safe. A wooden beam runs around the edge of the room near the ceiling. The lines would attach to opposite sides as shown in the figure. Will the design work?

2. You had fun last evening and caught a bunch of fireflies; you put them all in a jar (there is air in the jar). Now, if you place the jar on a scale, the scale will show you the most weight when:
   a) the fireflies are all sitting on the bottom of the jar.
   b) the fireflies are all flying around inside the jar.
   c) … weight of the jar is the same in both cases.

3. Now consider that you put the fireflies in a jar with no air, and they somehow can still fly. Now, if you place the jar on a scale, the scale will show you the most weight when:
   d) the fireflies are all sitting on the bottom of the jar.
   e) the fireflies are all flying around inside the jar.
   f) … weight of the jar is the same in both cases.

4. If gold were sold by weight (instead of mass), would you rather buy it on Earth or on the Moon?

5. A large crate is placed on the bed of a truck, but it is not tied down. The truck accelerates forward and the crate remains at rest relative to it. A) What force causes the crate to accelerate? B) If the driver slams on the brakes, what could happen to the crate?

6. A small sports car collides head on with a heavy truck. The greater force of impact acts on (a) the car, (b) the truck, (c) neither, the force is the same on both.

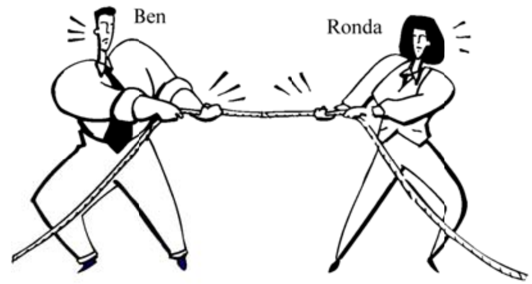
7. Which vehicle undergoes the greatest magnitude acceleration? (a) the car, (b) the truck, (c) neither, the accelerations are the same for both.

8. A weight lifter stands on a bathroom scale. He pumps a barbell up and down. What happens to the reading on the scale? Is it changing, or is it the same? Explain your answer. Now the weight lifter decides to throw the barbell into the air. How does the reading on the scale change?

Additional Framing Questions

1. If you shake a bowl of cereal several times, the biggest pieces of cereal end up on the surface, and the smaller ones end up at the bottom of the bowl. Why?

2. Ben and Ronda pull on opposite ends of a rope in a game of tug-of-war. Ben is stronger than Ronda. Who exerts the larger force on the rope?
    a) Ben
    b) Ronda
    c) both exert the same amount



Assume the rope has no mass.

3. Now assume that Ben and Ronda have the same mass. They stand 4 meters apart and attempt playing tug-of-war on frictionless ice. First they pull on opposite ends of the rope with equal force, and observe that each one slides 2 meters to a point midway between them. Next, they start 4 m apart, Ronda has the rope fastened around her waist and only Ben pulls. How far does each person slide?

4. True or false? If a net force of 20 N oriented toward North acts on an object moving west, the object moves North. Explain your answer.

5. When you are rowing a boat, the paddles are pushed backwards. Why is the boat moving forward?

4.1. Practice: **Force Challenge**

Directions: Follow the 5 steps in the “Analyzing Forces” reading page. Identify one receiver and one force acting on it. Make sure you don’t use the force of gravity for every example. In some cases, the receiver or agent is already identified for you.

A. 	Receiver: Force: Agent: Earth Effect/s:	B. 	Receiver: Force: Normal Agent: Effect/s:
C. 	Receiver: Force: Agent: Rope Effect/s:	D. 	Receiver: tire Force: Agent: Effect/s:
E. 	Receiver: panda Force: Agent: Effect/s:	F. 	Receiver: Thesaurus book Force: Agent:Dictionary Effect/s:
G. 	Receiver: bicycle seat Force: Agent: boy Effect/s:	H. 	Receiver: Force: Normal Agent: Effect/s:

I. 	Receiver: balloon Force: Agent: Effect/s:	J. 	Receiver: ball Force: Agent: Effect/s:
K. 	Receiver: Force: Agent: Effect/s:	L. 	Receiver: ball Force: Agent: Effect/s:
M. 	Receiver: Force: Agent: Effect/s:	N. 	Receiver: girl Force: Agent: Effect/s:
O. 	Receiver: toolbox Force: Agent: Effect/s:	P. 	Receiver: chair Force: Agent: Effect/s:
Q. 	Receiver: doorknob Force: Agent: Effect/s:	R. 	Receiver: Force: Agent: Effect/s:
S. 	Receiver: Force: Agent: Effect/s:	T. 	Receiver: Force: Agent: Effect/s:

4.2. Practice: **Gravitational Force and Gravitational Strength**

1. Many unit conversion tables contain the following conversion: 1 kg = 2.2 pounds. Explain what is wrong with this "equation." Write a statement that includes the terms "1 kg" and "2.2 pounds" that is correct.

2. It is commonplace to find statements on food cans such as "Net Weight: 16 oz. (454g)" Why do most people find this acceptable? Why do "physics types" object to such statements?

3. When you step on a bathroom scale here is US, your weight is given in pounds. Is this a correct unit for such a scale? What would happen to the reading on this device if you were to stand on it while on the moon? Is this what the scale should read? Why are all these standards and measurements used so often?

4.3. Practice: **Gravitational Force and Mass**

1. A box has a mass of 8.00 kg. Knowing that the gravitational field strength on Earth is 9.8 N/kg, calculate the force of gravity on the box.

2. A box of cereal has a mass of 250 g. What is the force of gravity on the box, knowing that the gravitational field strength on Earth is 9.8 N/kg?

3. The Earth exerts a gravitational force of 500 N on Amy. What is Amy's mass in kg?

4. The Earth exerts a gravitational force of 850 N on John. What is John's mass in g?

5. A rock has a mass of 5.00 kg on the moon. What is the mass of the rock on the earth?

6. The gravitational field strength on the Moon is 1.6 N/kg. If a rock on the moon weighs 200 N, how much does the same rock weigh on the earth?

7. Using the information provided below, fill out the table:

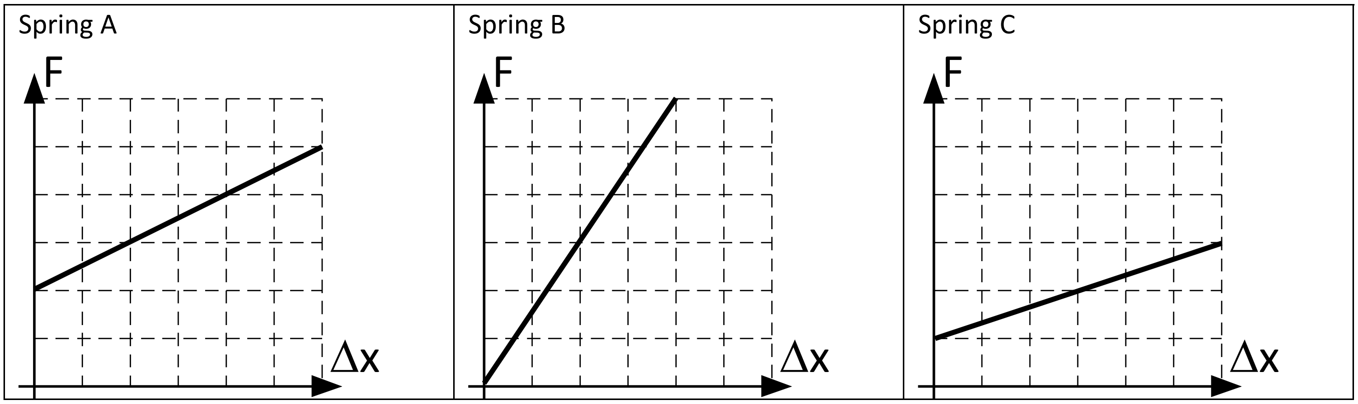
g (N/kg)	9.8 N/kg	9.8 N/kg	1.6 N/kg	273.4 N/kg	3.7 N/kg	25.8 N/kg
	Mass on Earth (m)	**Weight on Earth (F_g)**	**Weight on Moon**	**Weight on Sun**	**Weight on Mars**	**Weight on Jupiter**
A.	0.2 kg					
B.		6000 N				
C.						45000 N
D.			30 N			
E.					500 N	
F.				89000 N		

8. If you were to drop a 5 kg rock on your toe, would you rather be on Mars or on Jupiter? Explain.

9. Do you think it is easier or harder to hammer a nail into a floorboard on the Moon than on Earth? Explain.

4.4. Practice: **Stretching forces**

1. Tanya bought three springs to use in her physics experiment. The only thing that the manufacturer provided is a graph of force vs stretch for each spring. Unfortunately there are no numbers on the graphs but the manufacturer specified that all graphs are drawn at the same scale. Help Tanya arrange the springs from the strongest to the weakest. The graph for each spring is shown below:

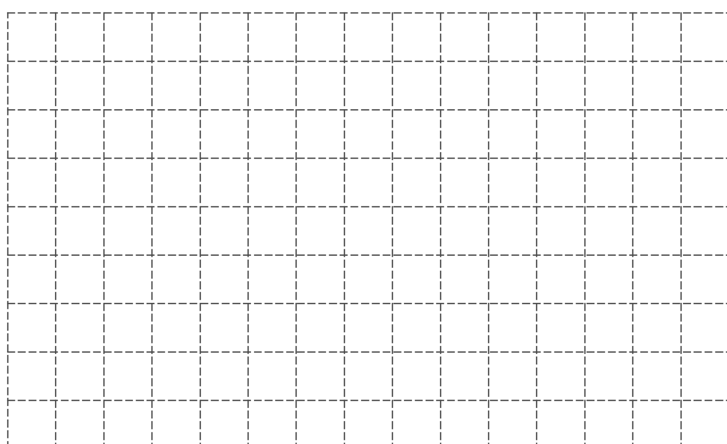


Strongest _______ ________ ________ Weakest

1. John must calculate the strength of a spring he needs to use in an experiment. He uses 5 different masses to hang on the spring and measures the stretch of the spring for each one of them. Using the table of data John obtained, draw a force vs stretch graph and calculate the strength of the spring.

Mass (g)	Stretch (cm)
50	2.5
250	12.5
100	5.0
25	1.25
150	7.5

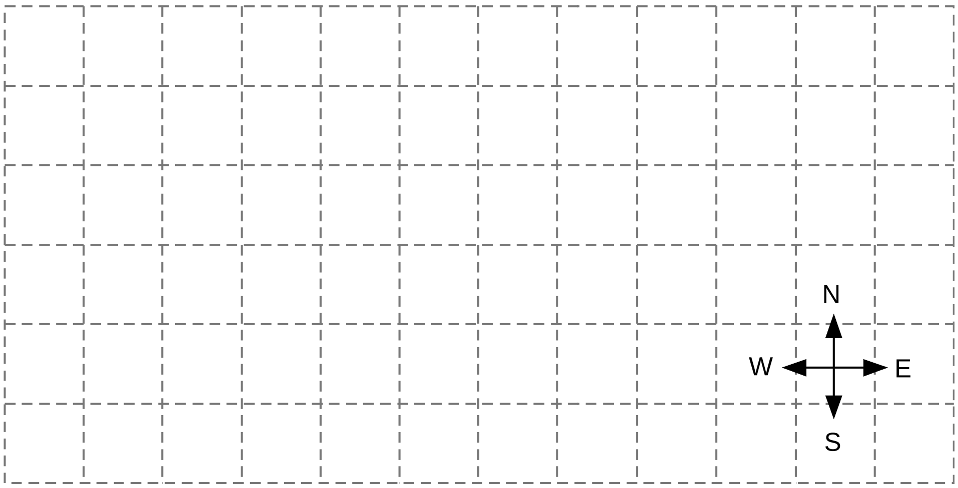
Title ____



2. If you hang an object from a spring of known elastic constant and it stretches 15 cm, can you find the mass of the object? What about its weight?

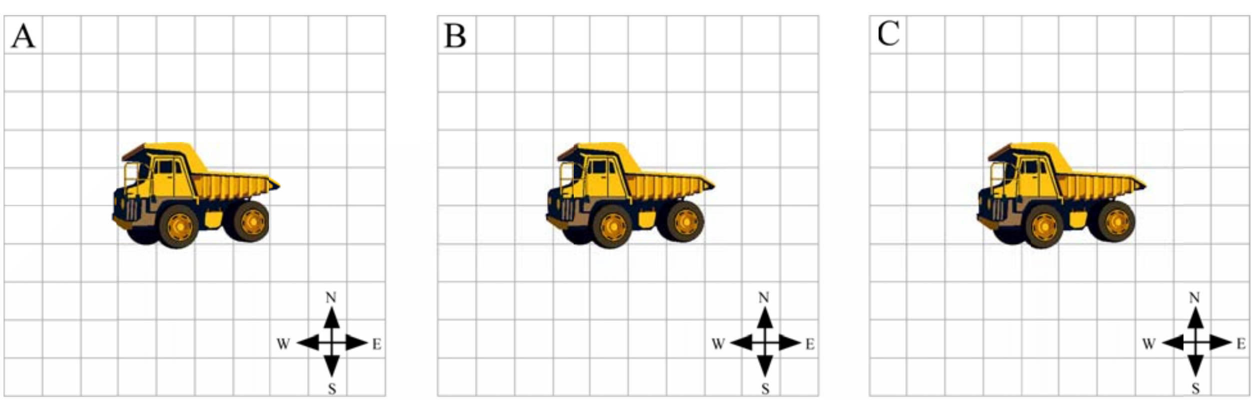
4.5. Practice: **Forces as Vectors**

1) Knowing that the size of one square is 10 N by 10 N, draw force vectors to represent the following:
    a) 20 N south
    b) 45 N south
    c) 15 N east



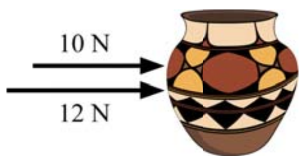
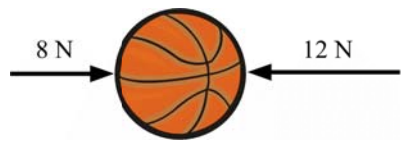
2) What is different about these two vectors: a force that is 5 Newtons, west, and a force that is 25 Newtons, north? Explain in words and draw arrows.

3) Karina is pulling on her toy truck with a force of 25 N. At the same time, her brother Lovell pulled on it with a force of 20 N. Can you think of three different diagrams (scenarios) that represent the forces described above? Explain what happens in each scenario as the result of the two forces acting on the truck.



4) If you want everybody to interpret the forces on the truck the same way, what important piece(s) of information should you specify?

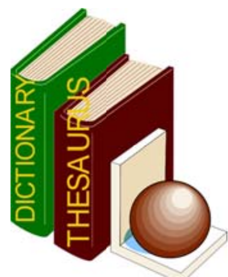
5) Can you figure out the total force acting on these objects? Explain what you understood by total force and how you figured it out.

6) If all the forces acting upon an object are balanced, then the object:
   a) must not be moving.
   b) must be moving with a constant velocity.
   c) must not be accelerating.
   d) none of these

4.6. Practice: **Force Diagrams I**

Identify your receiver with a dotted line. Be aware that if you cannot identify the agent for a force, it means that there is no force!

1. Draw a force diagram for a bird sitting motionless on a branch. 	2. Draw a force diagram for a lamp that is suspended from the ceiling. 
3. Draw a force diagram for Sarah as she clears a high jump. 	4. Draw a force diagram for the ball used as a book end. 
5. Draw a force diagram for the skier and skies during his jump. Ignore air resistance. 	6. Draw a force diagram for the sled and boxes together. Note that the child pulls on the sled at an angle. 
7. Draw a force diagram for the picture hanging on the wall. 	8. Draw a force diagram for Henry who hangs motionless from a tree branch. 

9. Draw a force diagram for the toolbox. 	10. Draw a force diagram for the chair that the cowboy sits on. 
11. Draw a force diagram for a balloon floating stationary in the air. 	12. Draw a force diagram for the worker sitting motionless on a sloped roof. 

4.7. Practice: **Force Diagrams II**

Identify your receiver with a dotted line. Be aware that if you cannot identify the agent for a force, it means that there is no force! Draw a force diagram in the space provided and discuss if forces acting on the receiver are balanced or not.

	Force Diagram	Are forces balanced or not?
A. Draw a force diagram for the hockey player sliding at constant speed across the ice. 		
B. Draw a force diagram for the bowling ball after it left Dan's hand. 		
C. Draw a force diagram for the ascending balloon. 		
D. Draw a force diagram for Allie (and sled) speeding down the hill. 		

E. Draw a force diagram for Dan who slides down the slide. 		

4.8. Practice: **Newton's First Law**

1. A sheet of paper can be withdrawn from under a container of milk without toppling it if the paper is jerked quickly. This best demonstrates that
   a) the milk carton has no acceleration.
   b) gravity tends to hold the milk carton secure.
   c) the milk carton has inertia.
   d) none of the above.

Explain your answer:

2. A school bus is moving at constant velocity. Inside the bus, a student drops a tennis ball from his hand. The ball hits the floor
   a) exactly below the student's hand.
   b) ahead of the student's hand.
   c) behind the student's hand.
   d) more information is needed to solve this problem.
   e) none of the above.

Explain your answer:

3. If your automobile runs out of fuel while you are driving, the engine stops but you do not come to an abrupt stop. The concept that most explains why this occurs is
   a) inertia.
   b) gravity.
   c) acceleration.
   d) resistance.

Explain your answer:

4. According to Newton's law of inertia, a rail road train in motion should continue going forever even if its engine is turned off. We never observe this because railroad trains
   A) move too slowly.
   B) are much too heavy.
   C) must go up and down hills.
   D) always have forces that oppose their motion.

Explain your answer:

5. Whirl a rock at the end of a string and it follows a circular path in a horizontal plane. If the string breaks, the tendency of the rock is to

A) continue to follow a circular path.
B) follow a straight-line path.
C) increase its speed
D) revolve in a smaller circle

Explain your answer:

6. When a rocket ship accelerating in outer space runs out of fuel it

A) accelerates for a short time, then slows down to a constant velocity.
B) accelerates for a short time, slows down, and eventually stops.
C) no longer accelerates.

Explain your answer:

7. Compared to a 1-kg block of solid iron, a 2-kg block of solid iron has twice as much

A) inertia.
B) mass.
C) volume.
D) all of the above.
E) none of the above.

Explain your answer:

8. If one object has twice as much mass as another object, it also has twice as much

A) inertia.
B) velocity.
C) acceleration due to gravity.
D) all of the above.

Explain your answer:

4.9. Practice: **Identifying Pairs of Forces**

1. Wherever there is an action force, there must be a reaction force which
A) always acts in the same direction.
B) is slightly smaller in magnitude than the action force.
C) is slightly larger in magnitude than the action force.
D) is exactly equal in magnitude.

Explain:

2. An archer shoots an arrow. Consider the action force to be exerted by the bowstring against the arrow. The reaction to this force is the
A) combined weight of the arrow and bowstring.
B) air resistance against the bow.
C) friction of the ground against the archer's feet.
D) grip of the archer's hand on the bow.
E) arrow's push against the bowstring.

Explain:

3. A player catches a ball. Consider the action force to be the impact force of the ball against the player's glove. The reaction to this force is the
A) player's grip on the glove.
B) force the glove exerts on the ball.
C) friction of the ground against the player's shoes.
D) muscular effort in the player's arms.
E) none of these

Explain:

4. A player hits a ball with a bat. The action force is the impact force of the bat against the ball. The reaction to this force is the
A) air resistance on the ball.
B) weight of the ball.
C) force that the ball exerts on the bat.
D) grip of the player's hand against the ball.
E) weight of the bat.

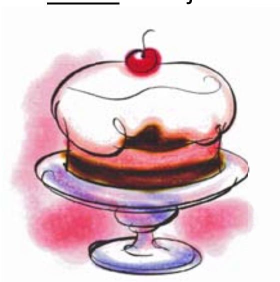
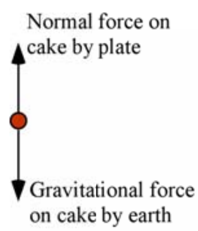
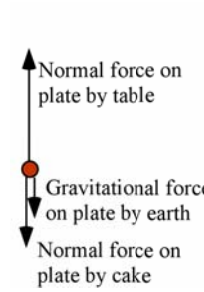
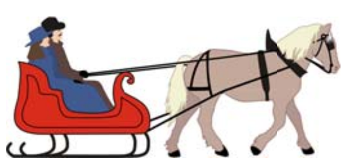
Explain:

5. For all the pictures shown below:

a) Select two objects that interact with each other.

b) Draw force diagrams for each object separately, clearly labeling each force with the receiver and agent's name.

c) Identify the action reaction pair of forces for the two interacting objects.

<table>
<tr><td rowspan="2">Example
Object 1<u>: Cake</u> & Object 2: P<u>late</u>
</td><td>Force Diagram for cake:

</td><td>Force Diagram for plate:

</td></tr>
<tr><td colspan="2">Action force: normal force on cake by plate
Reaction force: normal force on plate by cake</td></tr>
<tr><td rowspan="2">A.
__________ & ____________
</td><td>Force Diagram for</td><td>Force Diagram for</td></tr>
<tr><td colspan="2">Action Force:
Reaction Force:</td></tr>
<tr><td rowspan="2">B.
_________ & __________
</td><td>Force Diagram for</td><td>Force Diagram for</td></tr>
<tr><td colspan="2">Action Force:
Reaction Force:</td></tr>
<tr><td rowspan="2">C.
_________ & __________
</td><td>Force Diagram for</td><td>Force Diagram for</td></tr>
<tr><td colspan="2">Action Force:
Reaction Force:</td></tr>
</table>

<table>
<tr><td rowspan="2">D.
__________ & ____________
</td><td>Force Diagram for</td><td>Force Diagram for</td></tr>
<tr><td colspan="2">Action Force:
Reaction Force:</td></tr>
<tr><td rowspan="2">E.
___________ & ___________
</td><td>Force Diagram for</td><td>Force Diagram for</td></tr>
<tr><td colspan="2">Action Force:
Reaction Force:</td></tr>
</table>

6. A large truck and a small car collide. For each situation below (1 and 2) choose one answer (A though G) that best describes the forces between the car and the truck.

A. The truck exerts a greater amount of force on the car than the car exerts on the truck.
B. The car exerts a greater amount of force on the truck than the truck exerts on the car.
C. Neither exerts a force on the other; the car gets smashed simply because it is in the way of the truck.
D. The truck exerts a force on the car but the car doesn't exert a force on the truck.
E. The truck exerts the same amount of force on the car as the car exerts on the truck.
F. Not enough information is given to pick one of the answers above.
G. None of the answers above describes the situation correctly.

Case 1: the truck is much heavier than the car.
They are both moving at the same speed when they collide. Which choice describes the forces?_______________
The car is moving much faster than the heavier truck when they collide. Which choice describes the forces? _______________
The truck is moving much faster than the car when they collide. Which choice describes the forces? _______________
The car is standing still when the truck hits it. Which choice describes the forces? _______________
The heavier truck is standing still when the car hits it. Which choice describes the forces? _______________

Case 2: the truck is a small pickup truck and has the same mass as the car.
They are both moving at the same speed when they collide. Which choice describes the forces? _______________

The car is moving much faster than the truck when they collide. Which choice describes the forces? _______________

The truck is moving much faster than the car when they collide. Which choice describes the forces? _______________

The car is standing still when the truck hits it. Which choice describes the forces? _______________

The truck is standing still when the car hits it. Which choice describes the forces? _______________

7. A large truck breaks down and receives a push back to town from a small compact car. For each situation below (1 through 4) choose one of the choices A through F that correctly describes the forces between the car and the truck.

A. The force of the car pushing against the truck is equal to that of the truck pushing back against the car.
B. The force of the car pushing against the truck is less than that of the truck pushing back against the car.
C. The force of the car pushing against the truck is greater than that of the truck pushing back against the car.
D. The car's engine is running so it applies a force as it pushes against the truck, but the truck's engine isn't running so it can't push back with a force against the car.
E.Neither the car nor the truck exerts any force on each other. The truck is pushed forward simply because it is in the way of the car.
F.None of these descriptions is correct.

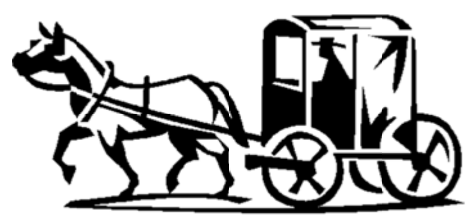
The car is pushing on the truck, but not hard enough to make the truck move. _______________

The car, still pushing the truck, is speeding up to get to cruising speed. _______________

The car, still pushing the truck, is at cruising speed and continues to travel at the same speed. _______________

The car, still pushing the truck, is at cruising speed when the truck puts on its brakes and causes the car to slow down. _______________

8. Farmer Brown hitches Old Dobbin to his wagon one day, then says, "OK, Old Dobbin, let's go!" Old Dobbin turns to Farmer Brown and says "Do you remember how Newton's Third Law says that every action force has an equal and opposite reaction force?," says Old Dobbin. Ignoring Farmer Brown's impatience, he continues, "If the wagon's pull is always equal and opposite of my pull, then the net force will always be zero, so the wagon can never move! Since it is at rest, it must always remain at rest! Get over here and unhitch me, since I have just proven that Newton's Laws say that it is impossible for a horse to pull a wagon!" At this point, Farmer Brown throws up his hands in dismay and turns to you. "Please help me!" he says, "I really should have paid more attention in physics class! I know that Newton's Laws are correct, and I know that horses really can pull wagons."

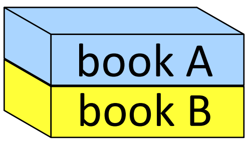
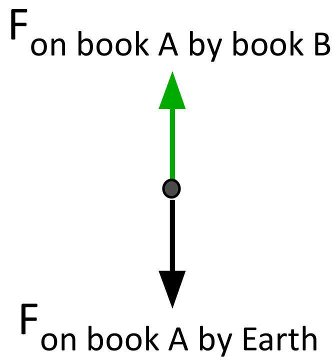
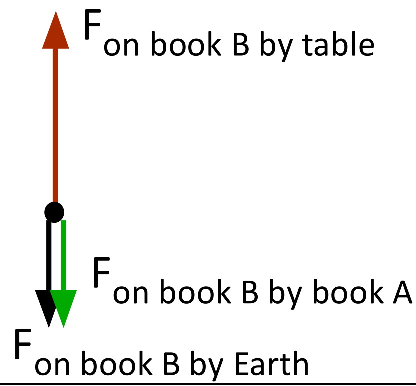


Help Farmer Brown by drawing separate force diagrams for the wagon, the horse, and the horse and the cart together. Then explain in words the flaw in the horse's reasoning.

4.10. Practice: **Identifying Pairs of Forces II**

For each of the following problems, draw a physical diagram; construct a separate force diagram for each object, labeling each force with its type, agent and receiver. Label any Newton's 3rd law pairs that occur in your force diagrams.

1. One book lies on top of another book, which rests on a table. System: the two books.

Physical Diagram	Force Diagram: top book	Force Diagram: bottom book
		

2. A person exerts an upward force to hold a bag of groceries. System: person's hand and bag of groceries.

Physical Diagram	Force Diagram: hand	Force Diagram: bag of groceries

3. A broom is pushing against a bowling ball and makes it move. System: broom and bowling ball

Physical Diagram	Force Diagram: broom	Force Diagram: bowling ball

4. (a) Eric holds a ball in his hand, and is in the process of throwing the ball upward. System: hand and ball.

Physical Diagram	Force Diagram: hand	Force Diagram: ball

(b) The ball just left Eric’s hand. System: ball and hand.

Physical Diagram	Force Diagram: hand	Force Diagram: ball

(c) The ball is on its way down. System: ball and hand.

Physical Diagram	Force Diagram: hand	Force Diagram: ball

(d) The ball has just hit the ground, and is slowing down. System: ball and ground.

Physical Diagram	Force Diagram: hand	Force Diagram: ball

5. You are pushing a box across a very rough floor. System: you and the box.

Physical Diagram	Force Diagram: you	Force Diagram: box

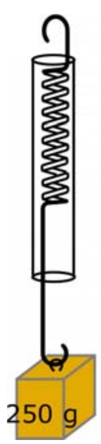
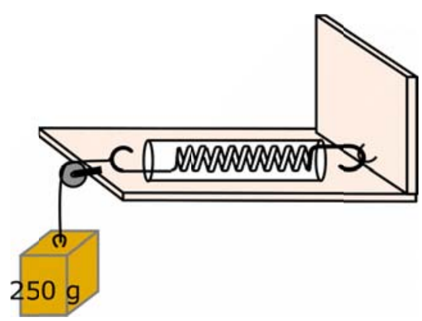
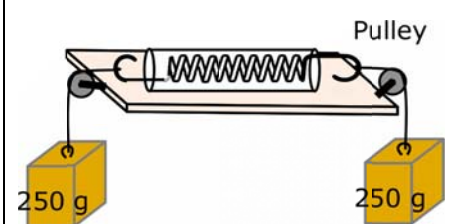
6. You are sitting on a chair on the ground. Draw well-separated diagrams for your body, the chair and the whole earth. Show the relative sizes of the forces via the lengths of the force arrows.

Force Diagram: you	Force Diagram: chair	Force Diagram: Earth/ground

7. You are standing on the ground in a shed. You are pulling vertically downward on a string that is attached to the bottom of a block. The block is attached to the ceiling by a rope. Draw well-separated diagrams for your body, the string, the block, the rope, the shed and the earth.

Physical Diagram	Force Diagram: you	Force Diagram: string
	Force Diagram: block	Force Diagram: rope
	Force Diagram: shed	Force Diagram: Earth

8. A mass of 250 g is hung from a spring in the following configurations. What do you think the spring scale will read in each case? Each spring scale reads forces, not masses. Draw force diagrams and explain your reasoning.

		
A.	B.	C.

4.11. Practice: **Newton's Third Law Problems**

1. While driving down the road, an unfortunate butterfly strikes the windshield of your car. You are thinking: this is a case of Newton's third law of motion! The butterfly hit the car windshield and the car windshield hit the butterfly. Which of the two forces is greater: the force on the butterfly or the force on the car's windshield? Explain.

2. Andy goes hunting for the first time. He has just learned Newton's Third Law and is now ready to explain to his dad why the gun recoils when it is fired. He tells his dad that the recoil is the result of action-reaction force pairs. As the gases from the gunpowder explosion expand, the gun pushes the bullet forwards and the bullet pushes the gun backwards. His dad has a question for Andy (and you must answer it): How are the forces that act on the gun and on the bullet related and why?

3. A karate chop delivers a blow of 3000 N to a board that breaks. The force that acts on the hand during this event is
A) zero.
B) 1500 N.
C) 3000 N.
D) 6000 N.

Explain:

4. Arnold Strongman and Suzie Small each pull very hard on opposite ends of a rope in a tug-of-war. The greater force on the rope is exerted by
A) Arnold, of course.
B) Suzie, surprisingly.
C) both exert the same force.

Explain:

5. A big truck and a small car traveling at the same speed have a head-on collision. The impact force is
A) greater on the small car.
B) greater on the big truck.
C) the same for both.

Explain:

6. A 10.0 N force is pulling vertically up on the ring of spring scale that weighs 2.0 N. If an 8.0 N mass is attached to the bottom hook of the scale, the scale reading would be
A) 0 N.
B) 2.0 N.
C) 8.0 N.
D) 10.0 N
E) 12.0 N

Explain:

7. A horse pulling a wagon forward exerts 500 N of force on the heavy wagon. The wagon pulls back on the horse with an equal force.
A) The wagon moves forward because these forces are not an action-reaction pair.
B) The wagon moves forward because there is an unbalanced force on the wagon.
C) The wagon moves forward because the horse pulls on the wagon a brief time before the wagon reacts.
D) The wagon cannot move because these forces are equal and opposite.

Explain:

4.12. Practice: **Newton's Second Law Problems**

1. A 10-kg brick and a 1-kg book are dropped in a vacuum. The force of gravity on the 10-kg brick is
A) the same as the force on the 1-kg book.
B) 10 times as much
C) one-tenth as much.
D) zero.

Explain your answer:

2. If an object's mass is decreasing while a constant force is applied to the object, would its acceleration decrease, increase, or remain the same? Explain.

3. An object is propelled along a straight-line path in space by a force. If the object sweeps up extra particles and its mass becomes twice as much, its acceleration
A) quadruples.
B) doubles.
C) stays the same.
D) halves.
E) none of these

Explain your answer:

4. The force of friction on a sliding object is 10 newtons. Would the applied force needed to maintain a constant velocity be more than 10 N, less than 10 N or 10 N? Explain.

5. A 10-N falling object encounters 4 N of air resistance. The net force on the object is
A) 6 N upwards.
B) 4 N upwards.
C) 6 N downwards.
D) 10 N downwards.
E) none of these.

Explain your answer:

6. A 10-N falling object encounters 10 N of air resistance. The net force on the object is
A) 0 N.
B) 4 N.
C) 6 N.
D) 10 N.
E) none of these

Explain your answer:

7. An apple weighs 1 N. When held at rest above your head, what is the net force on the apple?

8. An apple at rest weighs 1 N. Tammy throws it up in the air.
a) What is the net force on the apple on its way up? What is the direction of the acceleration?

b) What is the net force on the apple during the time is falling? What is the direction of the acceleration?

10. A 1-kg rock that weighs 9.8 N is thrown straight upward at 20 m/s. Neglecting air resistance, would the net force that acts on it when it is half way to the top of its path be less than 9.8 N, 9.8 N, or more than 9.8 N?

11. Which case has zero acceleration?
A) A car stopped in front of your house.
B) A child biking past your house at constant velocity.
C) Sledding down a very steep hill.
D) B and C only
E) A and B only

Explain your answer:

12. Whenever the net force on an object is zero, would its acceleration be less than zero, zero, or more than zero? Explain.

13. Your car is coasting on level ground at 60 km/h and you apply the brakes until the car slows to 40 km/h. If you suddenly release the brakes now, would the car tend to momentarily regain its higher initial speed, continue moving at 40 km/h, or decrease in speed if no other forces act? Explain.

14. When you hang from a pair of gym rings, the upward support forces of the rings will always
A) each be half your weight.
B) each be equal to your weight.
C) add up to equal your weight.

Explain your answer:

15. A car has a mass of 2000 kg and accelerates at 2 meters per second per second. What is the magnitude of the net force exerted on the car?

16. A tow truck exerts a force of 3000 N on a car, accelerating it at 2 meters per second per second. What is the mass of the car?

17. A girl pulls on a 10-kg wagon with a constant horizontal force of 30 N. If there are no other horizontal forces, what is the wagon's acceleration in meters per second per second?

18. A force of 1 N accelerates a mass of 1 kg at the rate of 1 m/s^2. The acceleration of a mass of 2 kg acted upon by a net force of 2 N is
A) half as much. B) twice as much. C) the same. D) none of these.

Explain your answer:

19. An object following a straight-line path at constant speed
A) has a net force acting upon it in the direction of motion.
B) has zero acceleration.
C) has no forces acting on it
D) none of these

Explain your answer:

20. A man weighing 800 N stands at rest on two bathroom scales so that his weight is distributed evenly over both scales. The reading on each scale is
A) 200 N.
B) 400 N.
C) 800 N.
D) 1600 N.
E) none of these

Explain your answer:

21. When a woman stands at rest with both feet on a scale, it reads 500 N. When she gently lifts one foot, the scale reads
A) less than 500 N.
B) more than 500 N.
C) 500 N.

Explain your answer:

22. A 10-N block and a 1-N block lie on a horizontal frictionless table. To provide them with equal horizontal acceleration, we would have to push with
A) equal forces on each block.
B) 10 times as much force on the heavier block.
C) 10 squared or 100 times as much force on the heavier block.
D) 1/10 as much force on the heavier block.
E) none of these

Explain your answer:

23. A block is dragged without acceleration in a straight-line path across a level surface by a force of 6 N. What is the force of friction between the block and the surface?
A) less than 6 N
B) more than 6 N
C) 6 N
D) need more information to say

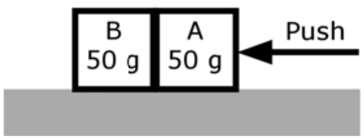
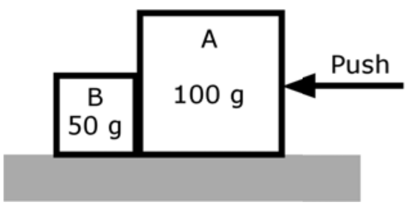
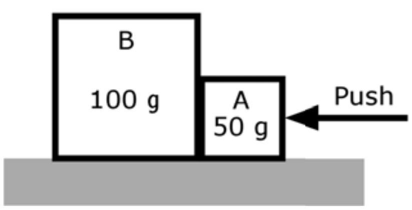
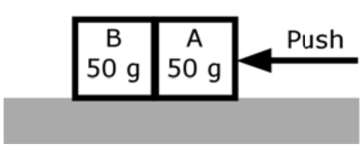
24. Suppose a particle is being accelerated through space by a 10-N constant force. Suddenly the particle encounters a second force of 10 N in the opposite direction from the first force. The particle with both forces acting on it
A) is brought to a rapid halt.
B) decelerates gradually to a halt.
C) continues at the speed it had when it encountered the second force.
D) theoretically tends to accelerate toward the speed of light.
E) none of these

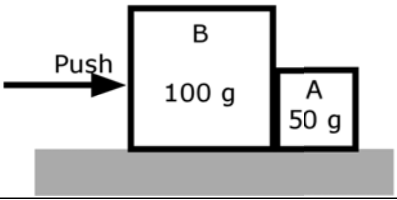
4.13. Practice: **Newton's Third and Second Laws with Blocks**

For each of the situations below compare the forces exerted by the blocks on each other as they move on a table with some friction. Note: the 100 g block experiences twice as much frictional force as the 50 g block. For each of the problems A through F, select from the following choices:

a) block A exerts a greater force
b) block B exerts a greater force
c) the forces are equal

Also draw separate force diagrams for block A, for block B, and for a system that includes both blocks.

<table>
<tr><th></th><th>Block A</th><th>Block B</th><th>Block A+B together</th></tr>
<tr><td>1. Both blocks move with constant speed to the left

</td><td></td><td></td><td></td></tr>
<tr><td>2. Both blocks move with constant speed to the left

</td><td></td><td></td><td></td></tr>
<tr><td>3. Both blocks move with constant speed to the left.

</td><td></td><td></td><td></td></tr>
<tr><td>4. Both blocks move with constant acceleration to the left.

</td><td></td><td></td><td></td></tr>
</table>

5. Both blocks move with constant acceleration to the right. 			

4.14. Practice: **Balanced Forces**

1. Draw force diagrams for the following situations:

An object lies motionless on a flat, horizontal surface. 	Two equal forces in opposite directions along the horizontal act on an object that lies motionless on a flat surface. 

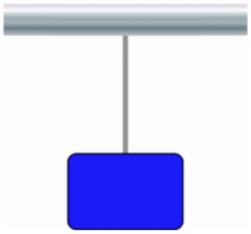
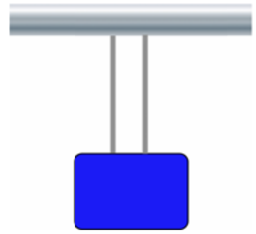
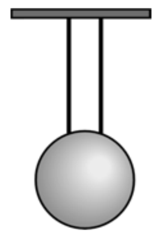
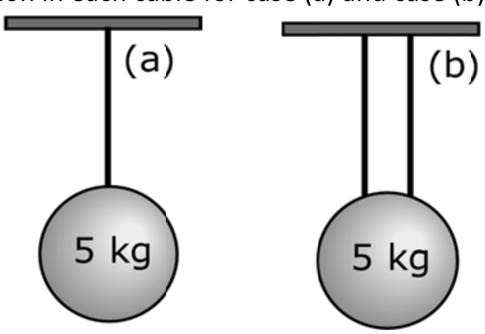
2. A swing is suspended by two ropes. Amy and Ryan sit together on the swing. The swing's weight is 60 N. Amy's weight is 520 N and Ryan's is 640 N. Draw a diagram indicating all forces acting on your system (Amy, Ryan, swing). If the tension in the two support ropes are equal, calculate those tensions.

3. Qi and Jared sit on a board that is suspended by two cables. Qi weighs 590 N and Jared weighs 850 N. The board weighs 180 N. The tension in one of the ropes is 670 N. Draw a diagram for all forces acting on the system (Qi, Jared, board).
   a) Calculate all the downward forces.

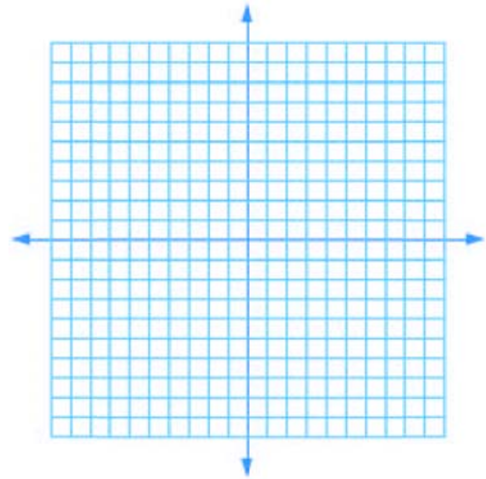
   b) Calculate all the upward forces.

   c) Use the idea that the net force is zero to calculate the tension in the second rope.

4. Draw force diagrams for the following situations:

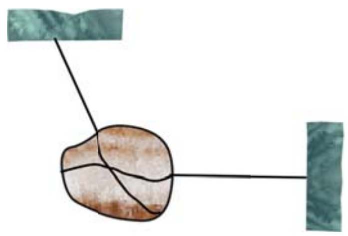
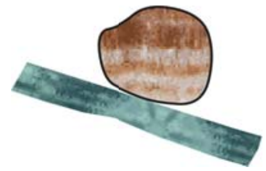
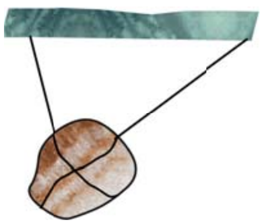
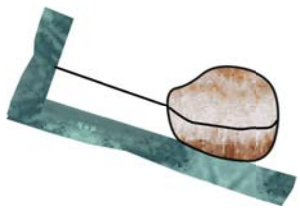
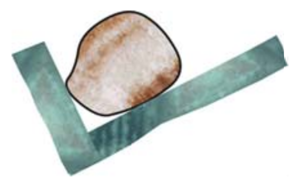
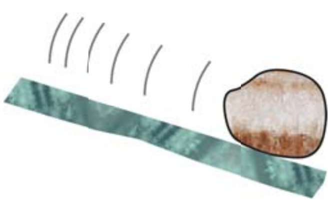
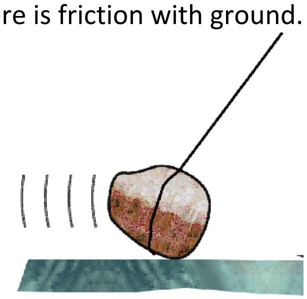
A. An object is suspended from the ceiling by a rope. 	B. An object is suspended from the ceiling by two parallel ropes. 
C. The tension in the cable is 100 N. Find the mass of the tire. 	D. The tension in the cable on the left is 30 N. Draw a force diagram and then calculate the mass of the ball.  Hint: how is the tension in the second cable compared to the tension in the first one?
E. Draw the force diagrams and figure out the tension in each cable for case (a) and case (b). 	F. An owl is sitting on a branch in a tree. The owl's mass is 1.2 kg. Draw a force diagram of the owl and calculate the normal force acting on it. 

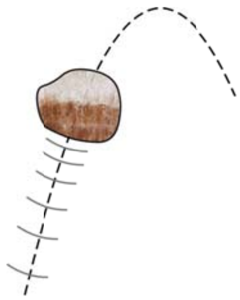
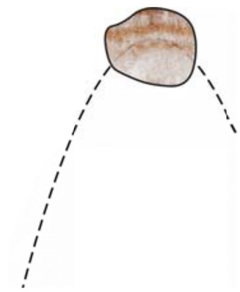
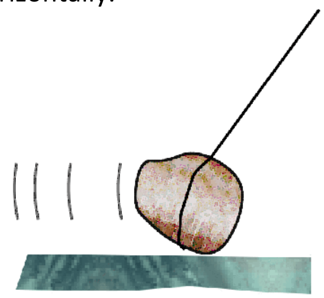
5. A block is sitting at rest on a level floor. The normal force on the block is 3.00 N. Draw a picture, identify the system, define the system with a curve, draw a force diagram and then calculate the mass of the block.



4.15. Practice: **Force Diagrams related to Motion**

1. Draw a force diagram for each one of the cases shown below: Indicate the direction of the acceleration for each object.

A. Equilibrium 	B. Equilibrium 	C. Friction prevents sliding 
D. Equilibrium 	E. Equilibrium 	F. Equilibrium 
G. Rock is sliding on a frictionless incline 	H. Rock is falling. No air resistance. 	I. Rock is falling with constant speed. Air resistance is present. 
J. Rock is sliding at constant speed on a frictionless surface 	K. Rock is slowing down because of friction. 	L. Rock pulled by a rope moves horizontally at constant velocity. There is friction with ground. 

M. Rock is rising in a parabolic trajectory. 	N. Rock is at the top of a parabolic trajectory. 	O. Rock is tied to a rope and pulled so that it accelerates horizontally. 

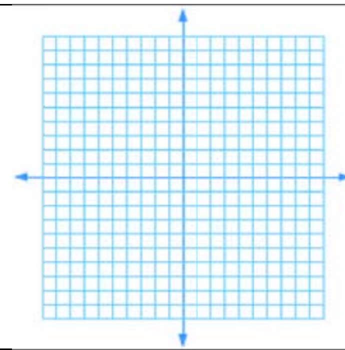
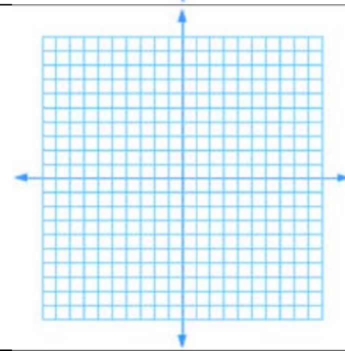
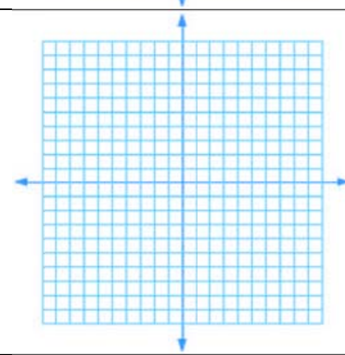
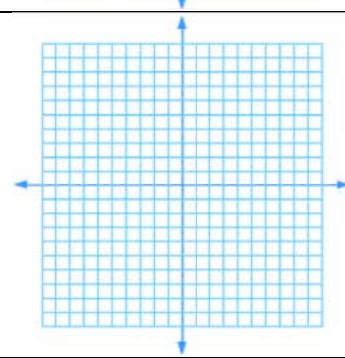
2. For the following problems, draw a picture of the system described and a force diagram.

Picture	Draw the force diagram for:	Verbal description
A.	Book	A book is at rest on a table top.
B.	Backpack	A student rests a backpack upon his shoulder. The pack is suspended motionless by one strap from one shoulder.
C.	Book	A rightward force is applied to a book in order to move it across a desk at constant velocity.
D.	Skydiver	A skydiver is descending with a constant velocity. Consider air resistance.

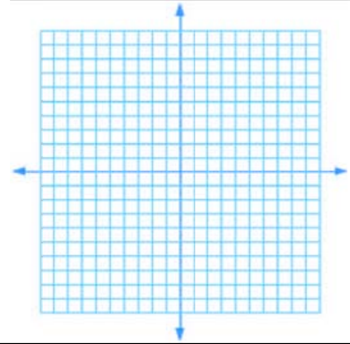
E. 	Person	
F. 	Bird	
G. 	Pot	
H. 	Child	
I. 	Skier	

4.16. Practice: **Force Diagrams, Motion Diagrams and Newton's Laws**

1. For each of the situations below, draw a picture and then the force diagram.

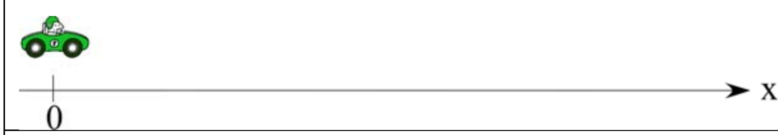
A. A rightward force is applied to a book in order to move it across a desk with a rightward acceleration. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.	
B. A force is applied to the right to drag a sled across loosely-packed snow with a rightward acceleration. Diagram the forces acting upon the sled.	
C. A football is moving upwards towards its peak after having been booted by the punter. Diagram the forces acting upon the football as it rises upward towards its peak.	
D. A car is coasting to the right and slowing down. Diagram the forces acting upon the car.	

E. An egg falls from a nest in a tree. Neglect air resistance. Diagram the forces acting on the egg as it falls.



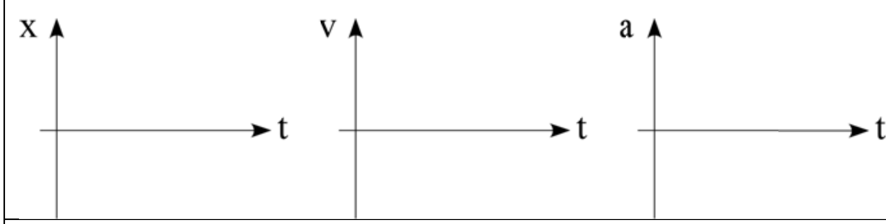
2. In the following problems you are given a representation of the motion that occurs. Fill in the rest of the table.

A. Picture of motion (the points are drawn at equal 1 second time intervals)



Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



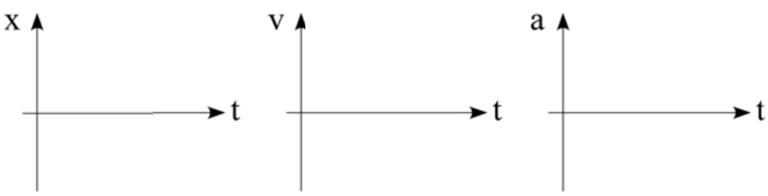
Force diagram:

Verbal description of motion:

B.Picture of motion (the points are drawn at equal 1 second time intervals)

Motion diagram (including position, velocity and acceleration)

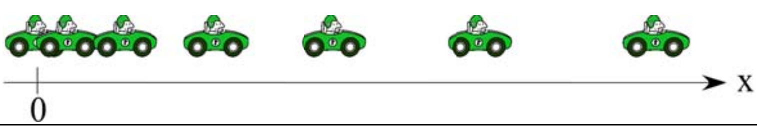
Position, velocity and acceleration vs time graphs



Force diagram:

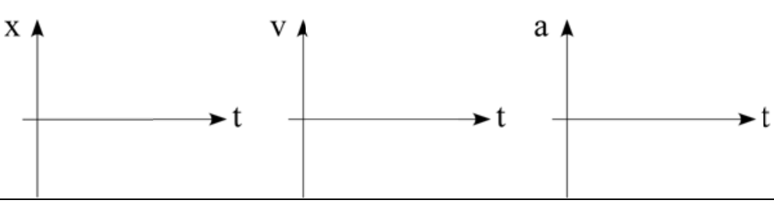
Verbal description of motion:

C. Picture of motion (the points are drawn at equal 1 second time intervals)



Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



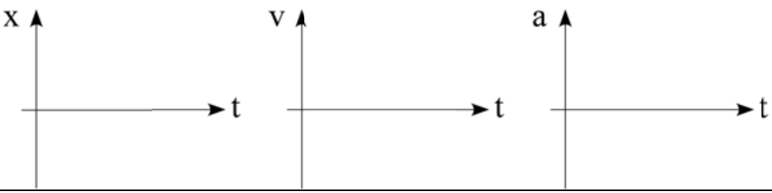
Force diagram:

Verbal description of motion:

D. Picture of motion (the points are drawn at equal 1 second time intervals)

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



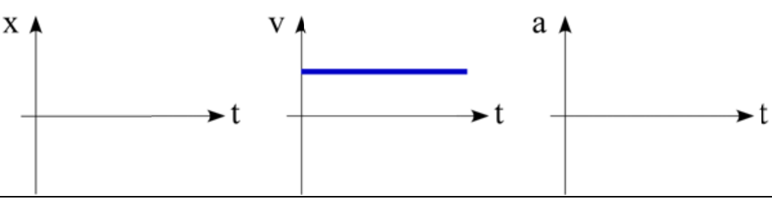
Force diagram

Verbal description of motion

E. Picture of motion

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



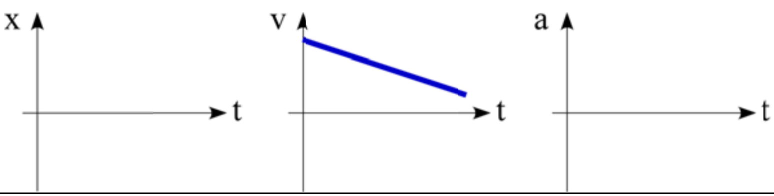
Force diagram:

Verbal description of motion

F. Picture of motion

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



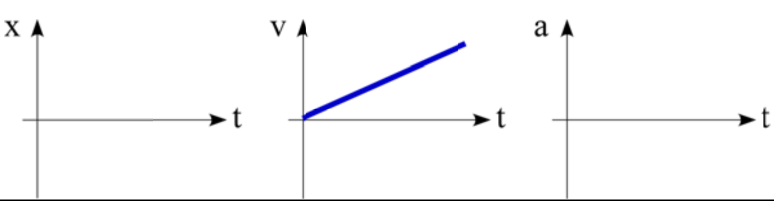
Force diagram

Verbal description of motion

G. Picture of motion

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



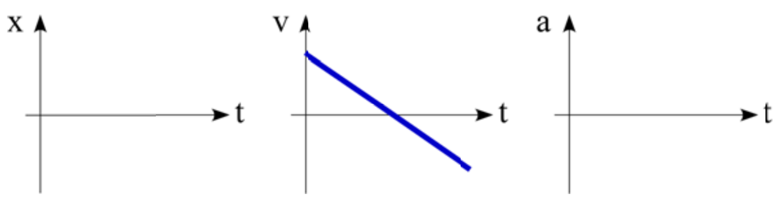
Force diagram:

Verbal description of motion and force diagram

H. Picture of motion

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



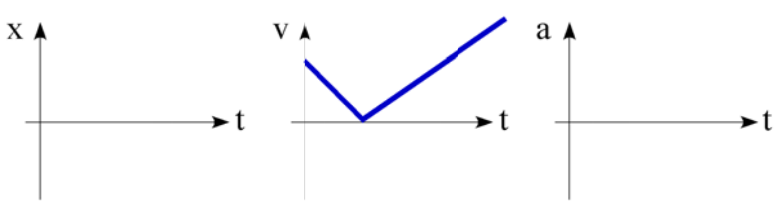
Force diagram

Verbal description of motion

I. Picture of motion

Motion diagram (including position, velocity and acceleration)

Position, velocity and acceleration vs time graphs



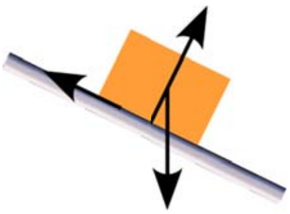
Force diagram

Verbal description of motion

3. In the following table you are given either the motion diagram, force diagram, verbal description, or a graph. Fill in the rest of the table.

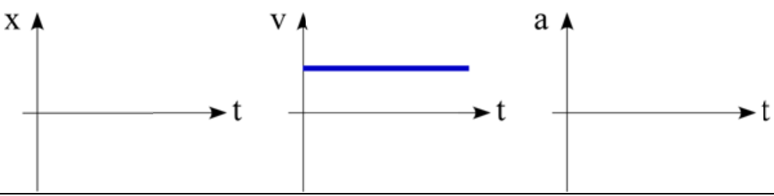
A. Motion Diagram

Force Diagram (you must label all forces)



Verbal Description

Position, velocity and acceleration vs time graphs

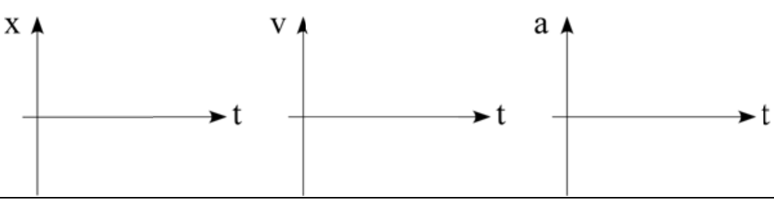


B. Motion Diagram

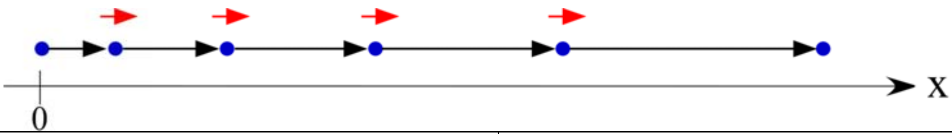
Force Diagram (you must label all forces)

Verbal Description:
You throw a ball up into the air. Describe what happens from the instant it leaves your hand up until it reaches its highest point.

Position, velocity and acceleration vs time graphs



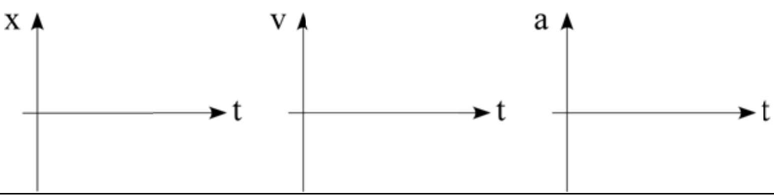
C. Motion Diagram of an airplane on a runway



Force Diagram (you must label all forces)

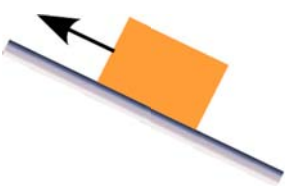
Verbal Description

Position, velocity and acceleration vs time graphs



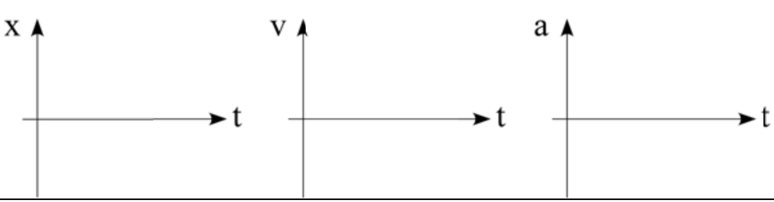
D. Motion Diagram

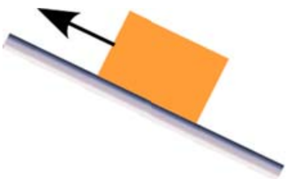
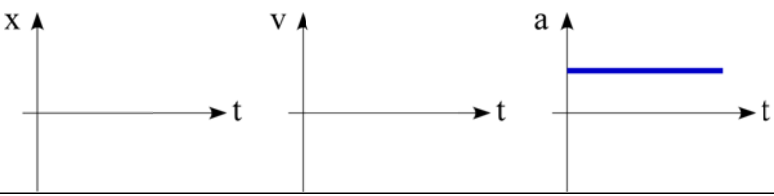
Force Diagram (you must label and draw all forces)



Verbal Description:
A box is pulled up a ramp that has no friction. Continue the description of its motion:

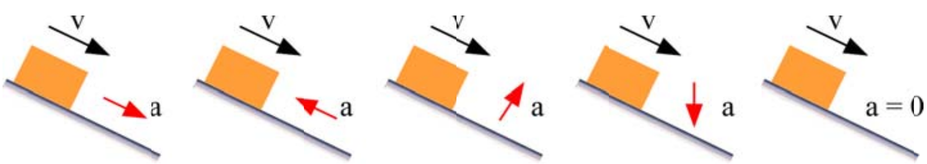
Position, velocity and acceleration vs time graphs



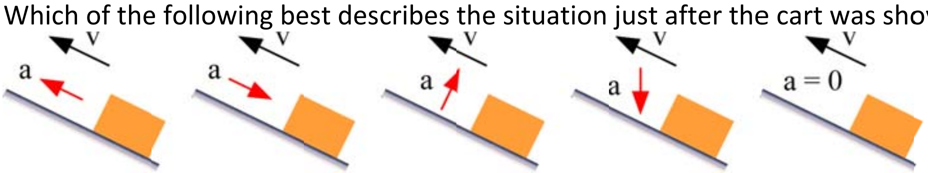
<table>
<tr><td colspan="2">E. Motion Diagram</td></tr>
<tr><td>Force Diagram (you must label and draw all forces)
</td><td>Verbal Description:</td></tr>
<tr><td colspan="2">Position, velocity and acceleration vs time graphs

</td></tr>
</table>

4. The motion of a cart in three different situations is described below. Match the diagram to the motion described and explain your reasoning.

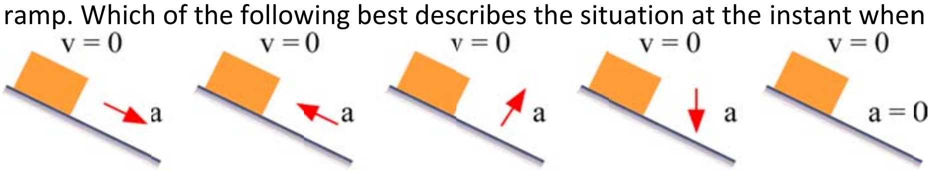
A. A cart is released from the top of a frictionless ramp. Which of the following best describes the situation after the cart was released? Explain your reasoning.



B. After the cart reaches the bottom of the ramp, a boy gives it a shove and sends it moving up the ramp. Which of the following best describes the situation just after the cart was shoved?

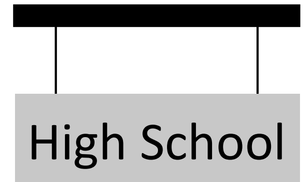


C. After it was shoved upward in the previous problem, the cart reaches the highest point it can reach on the ramp. Which of the following best describes the situation at the instant when the cart is at its highest point?



FRAMING QUESTIONS

1. You are part of a team that will redesign the entrance hallway to your school. Your principal wants to suspend a 20-lb plaque with the name of the school high over the entrance by hanging it from the ceiling using thin fishing line so the people below will think the plaque is hanging in mid air. He shows you a fishing line that will hold 12 lbs, and wants to attach two lines to the sculpture to be safe. A wooden beam runs around the edge of the room near the ceiling. The lines would attach to opposite sides as shown in the figure. Will the design work?



2. You had fun last evening and caught a bunch of fireflies; you put them all in a jar (there is air in the jar). Now, if you place the jar on a scale, the scale will show you the most weight when:
   a) the fireflies are all sitting on the bottom of the jar.
   b) the fireflies are all flying around inside the jar.
   c) … weight of the jar is the same in both cases.

3. Now consider that you put the fireflies in a jar with no air, and they somehow can still fly. Now, if you place the jar on a scale, the scale will show you the most weight when:
   a) the fireflies are all sitting on the bottom of the jar.
   b) the fireflies are all flying around inside the jar.
   c) … weight of the jar is the same in both cases.

4. If gold were sold by weight (instead of mass), would you rather buy it on Earth or on the Moon?

5. A large crate is placed on the bed of a truck, but it is not tied down. (a) As the truck accelerates forward, the crate remains at rest relative to it. What force causes the crate to accelerate? (b) If the driver slams on the brakes, what could happen to the crate?

6. A small sports car collides head on with a heavy truck. The greater force of impact acts on (a) the car, (b) the truck, (c) neither, the force is the same on both.

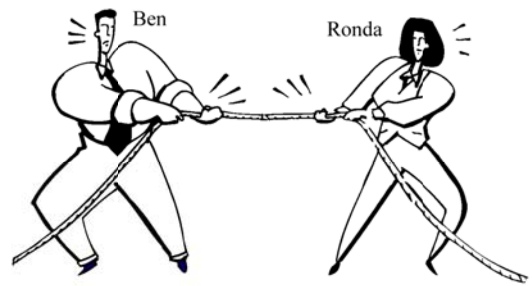
7. Which vehicle undergoes the greatest magnitude acceleration? (a) the car, (b) the truck, (c) neither, the accelerations are the same for both.

8. A weight lifter stands on a bathroom scale. He pumps a barbell up and down. What happens to the reading on the scale? Is it changing, or is it the same? Explain your answer. Now the weight lifter decides to throw the barbell into the air. How does the reading on the scale change?

Additional Framing Questions

6. If you shake a bowl of cereal several times, the biggest pieces of cereal end up on the surface, and the smaller ones end up at the bottom of the bowl. Why?

7. Ben and Ronda pull on opposite ends of a rope in a game of tug-of-war. Ben is stronger than Ronda. Who exerts the larger force on the rope?
   d) Ben
   e) Ronda
   f) both exert the same amount



Assume the rope has no mass.

8. Now assume that Ben and Ronda have the same mass. They stand 4 meters apart and attempt playing tug-of-war on frictionless ice. First they pull on opposite ends of the rope with equal force, and observe that each one slides 2 meters to a point midway between them. Next, they start 4 m apart, Ronda has the rope fastened around her waist and only Ben pulls. How far does each person slide?

9. True or false? If a net force of 20 N oriented toward North acts on an object moving west, the object moves North. Explain your answer.

10. When you are rowing a boat, the paddles are pushed backwards. Why is the boat moving forward?

Forces Unit – Review

What is a force?

A force is nothing else than a push or a pull applied by one object to another.

Type of Forces

Symbol	Name	Type of force
F_N or F_n	**Normal force**	Contact force
F_G or F_g	**Gravitational force (or weight force)**	Non-contact force (field force)
F_f	**Friction force**	Contact force
F_T	**Tension force**	Contact force
F_e	**Elastic force**	Contact force

Analyzing forces

Steps to follow when analyzing forces acting on an object:

1. Determine the object that is the **receiver** (has forces applied to it).
2. Identify the **agents** (objects that apply forces to the receiver).
3. For each agent, identify the **force** it applies. (Note: remember that we live on Earth and therefore Earth (**agent**) always applies a force (**gravity**) to every single object (**receiver**) on its surface).
4. Represent the direction of the force with an arrow starting on the receiver.
5. Describe the **effect** of the identified forces on the receiver.

Force Diagrams

Steps to follow when drawing force diagrams:

1. Draw a picture of the problem, showing the object and everything in the environment that touches the object – ropes, tables, springs are all part of the environment.
2. Identify the system – which is the object or objects of interest – and draw a closed curve around the system. The object should be inside the curve and everything else outside the curve.
3. Locate every point in the system at the boundary of the curve where the environment touches the system. These are the points where the environment exerts contact forces on the system.
4. Identify by name all the contact forces at each point of contact (there may be more than one force), then give each one an appropriate symbol.
5. Identify any long-range forces acting on the object. Name the force and write its symbol in the picture.
6. Indicate the object by a point and draw the force diagram.

Calculating forces

Force of gravity on Earth can be determined from: $F_g = mg$ where g = 9.8 N/kg.

Elastic force can be calculated from: $F_e = k\Delta x$ where k = elastic constant and Δx is the stretch or compression of the spring.

Netwon's Laws:

Newton's first law tells us what happens when no net external force acts on an object:

a) Things that are sitting still will not move on their own, they need an outside force to make them move.
b) Things that are moving in a straight line will not stop, slow down or speed up on their own, they need an external force to change their motion.

c) Things that are moving in a straight line will not change direction unless a force makes them do so.

Newton's second law tells us what happens when a net external force does act on an object:

a) Objects that are sitting still can begin to move: the object had a velocity of zero to begin with, and after a force is applied, it accelerates to a higher velocity.
b) Objects that are moving can be made to slow down (force is applied to change a high velocity to low velocity), speed up, or stop.
c) Objects that are moving in one direction can be made to change direction – this is also a change in velocity, namely, the amount of velocity may not have changed, but the direction has, so there is a net acceleration.

Newton's second law also gives us the connection between the net force, mass and acceleration:

Force = (mass) x (acceleration) or in equation form $F = ma$

Newton's Third Law explains how two objects/systems interact with each other. Every time an object A pushes or pulls on object B, object B pushes or pulls back on object A. Forces in nature always act in pairs; one force is called action and the other one reaction. The two forces are always equal, in opposite directions and act on different objects.