 Name: _____

Inertia and Mass

Read from **Lesson 1** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l1a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l1b.html

MOP Connection: Newton's Laws: sublevel 1

1. **Inertia** is _____

   _____

2. The amount of inertia possessed by an object is dependent solely upon its _____.

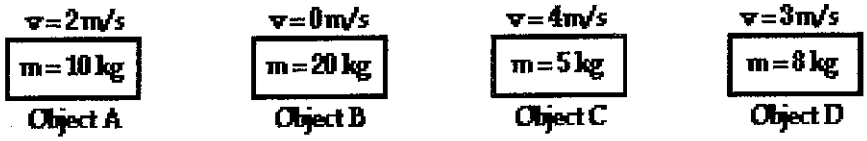
3. Two bricks are resting on edge of the lab table. Shirley Sheshort stands on her toes and spots the two bricks. She acquires an intense desire to know which of the two bricks are most massive. Since Shirley is vertically challenged, she is unable to reach high enough and lift the bricks; she can however reach high enough to give the bricks a push. Discuss how the process of pushing the bricks will allow Shirley to determine which of the two bricks is most massive. What difference will Shirley observe and how can this observation lead to the necessary conclusion?

4. Would Shirley Sheshort be able to conduct this same study if she was on a spaceship in a location in space far from the influence of significant gravitational forces? _____ Explain your answer.

5. If a moose were chasing you through the woods, its enormous mass would be very threatening. But if you zigzagged, then its great mass would be to your advantage. Explain why.

6. Inertia can best be described as _____.
   a. the force which keeps moving objects moving an stationary objects at rest.
   b. the willingness of an object to eventually lose its motion
   c. the force which causes all objects to stop
   d. the tendency of any object to resist change and keep doing whatever its doing

7. Mass and velocity values for a variety of objects are listed below. Rank the objects from smallest to greatest inertia. _____ < _____ < _____ < _____



 Name: _____

Balanced vs. Unbalanced Forces

Read from **Lesson 1** of the **Newton's Laws** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/newtlaws/u2l1c.html
http://www.physicsclassroom.com/Class/newtlaws/u2l1d.html

MOP Connection: Newton's Laws: sublevels 2 and 3

Review: An object at rest ... _____;

An object in motion .... _____;

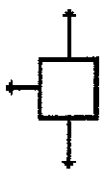
unless ... _____.

1. The amount of force required to keep a 6-kg object moving with a constant velocity of 2 m/s is __ N.
   a. 0.333 b. 2 c. 3 d. 6 e. 12
   f. ... nonsense! A force is NOT required to keep an object in motion.

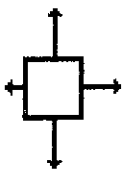
2. Renatta Oyle is having car troubles. She is notorious for the trail of oil drops that she leaves on the streets of Glenview. Observe the following oil traces and indicate whether Renatta's car is being acted upon by an unbalanced force. Give a reason for your answers.

	Unbalanced Force?
a. . . . .  **Reason:** _____	Yes or No
b. . . . .  **Reason:** _____	Yes or No
c. . . . .  **Reason:** _____	Yes or No

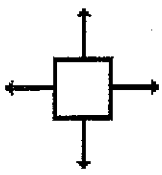
3. Each one of the dot diagrams in question #2 can be matched to a force diagram below. The force diagrams depict the individual forces acting upon the car by a vector arrow. The arrow direction represents the direction of the force. The arrow length represents the strength of the force. Match the dot diagrams from #2 to a force diagram; not every force diagram needs to be matched.



Dot Diagram(s): _____



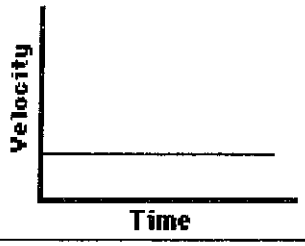
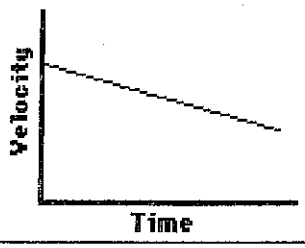
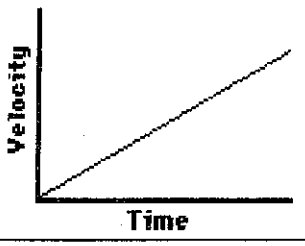
Dot Diagram(s): _____



Dot Diagram(s): _____

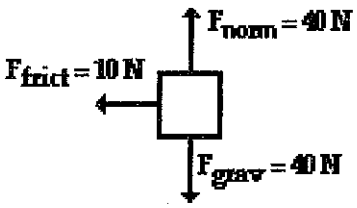
4. If the net force acting upon an object is 0 N, then the object MUST ____. Circle one answer.
   a. be moving b. be accelerating c. be at rest
   d. be moving with a constant speed in the same direction e. either c or d.

5. These graphs describe the motion of Carson Busses at various times during his trip to school. Indicate whether Carson's vehicle is being acted upon by an unbalanced force. Give a reason in terms of a description of what the car is doing (speeding up, slowing down, or constant velocity).

		
Unbalanced Force? Yes or No **Reason/Description:** _____	**Unbalanced Force? Yes or No** **Reason/Description:** _____	**Unbalanced Force? Yes or No** **Reason/Description:** _____

6. A free-body diagrams show all the individual forces acting upon an object. The net force is the *vector sum* of all these forces ($\sum F$). Determine the net force and state if there is an acceleration.

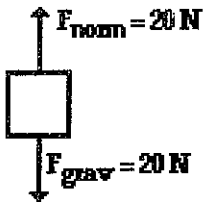
a.



$\sum F =$ _____

Accel'n? Yes or No

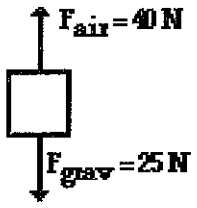
b.



$\sum F =$ _____

Accel'n? Yes or No

c.



$\sum F =$ _____

Accel'n? Yes or No

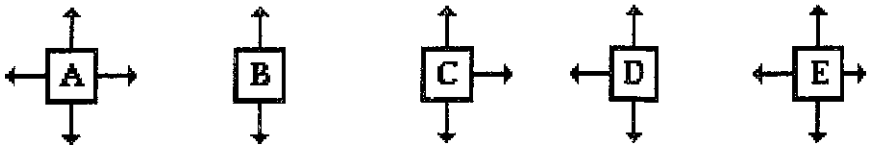
7. During an in-class discussion, Anna Litical suggests to her lab partner that the dot diagram for the motion of the object in #6b *could be*

. . . . . .

Anna's partner objects, arguing that the object in #6b could not have any horizontal motion if there are only vertical forces acting upon it. Who is right? _____ Explain.

8. During an in-class discussion, Aaron Agin asserts that the object in #6a **must** be moving to the left since the only horizontal force acting upon it is a "left-ward" force. Is he right? _____ Explain.

9. The diagrams below depict the magnitude and direction of the individual forces acting upon an object. Which objects **could be** moving to the right? Circle all that apply.



 Name: _____

Recognizing Forces

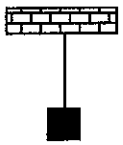
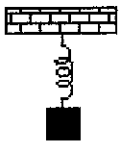
Read from **Lesson 2** of the **Newton's Laws** chapter at **The Physics Classroom**:

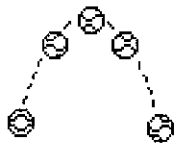
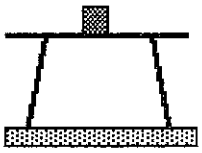
http://www.physicsclassroom.com/Class/newtlaws/u2l2a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l2b.html

MOP Connection: Newton's Laws: sublevel 4

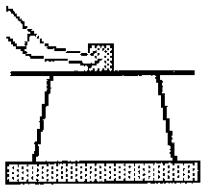
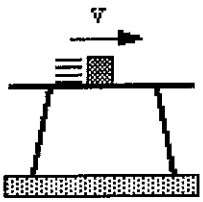
There are several situations described below. For each situation, fill in the list provided by indicating which forces are present and stating which features of the situation you used to determine the presence or absence of the force. To facilitate this exercise, utilize the Net Force Help Sheet. Upon completion of this assignment, check your answers using the available Web page.

http://www.physicsclassroom.com/morehelp/recforce/recforce.html

Description of Situation	Force Present (P) or Absent (A)?		Explanation
 1. A block hangs <u>at rest</u> from the ceiling by a piece of rope. Consider the forces acting on the block.	**Gravity**	P or A?	_____
	Spring:	P or A?	_____
	Tension	P or A?	_____
	Normal:	P or A?	_____
	Friction	P or A?	_____
	Air Res.:	P or A?	_____
 2. A block hangs from the ceiling by a spring. Consider the forces acting on the block when it is at rest (at its equilibrium position).	**Gravity**	P or A?	_____
	Spring:	P or A?	_____
	Tension	P or A?	_____
	Normal:	P or A?	_____
	Friction	P or A?	_____
	Air Res.:	P or A?	_____

Description of Situation	Force Present (P) or Absent (A)?	Explanation
 3. A ball is shot into the air with a spring-loaded cannon. Consider the forces acting on the ball while it is <u>in the air</u>.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 4. A skydiver (who hasn't opened his parachute yet) falls <u>at terminal velocity</u>. Consider the forces acting on the <u>skydiver</u>.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 5. A block rests on top of a table. Consider only the forces acting upon the block.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	

Name: _____

Description of Situation	Force Present (P) or Absent (A)?	Explanation
 6. A block is being pushed across the top of a table. Consider only the forces acting upon the block.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 7. A block slides across the top of a table. Consider only the forces acting upon the block.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 8. The driver of a car has her foot on the gas pedal. The wheels are turning as the car accelerates down the road. Consider only the forces acting upon the car.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	

Description of Situation	Force Present (P) or Absent (A)?	Explanation
 9. A person is sitting on a sled and gliding across loosely packed snow along a horizontal surface. Consider only the forces acting on the person.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 10. The wheels of a car are locked as it skids to a stop while moving across a level highway. Consider only the forces acting on the car.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	
 11. A bucket of water, attached by a rope, is being pulled out of a well. Consider only the forces acting on the bucket.	**Gravity** P or A? **Spring:** P or A? **Tension** P or A? **Normal:** P or A? **Friction** P or A? **Air Res.:** P or A?	

Mass and Weight

Read from **Lesson 2** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l2b.html#mass

MOP Connection: Newton's Laws: sublevel 6

1. The standard metric unit for mass is _____ and the standard metric unit for weight is _____.

2. An object's mass refers to _____ and an object's weight refers to _____. Fill in each blank.
   a. the amount of space it takes up
   b. the force of gravitational attraction to Earth
   c. how dense an object is
   d. the amount of stuff present in the object

3. Complete the following table showing the relationship between mass and weight.

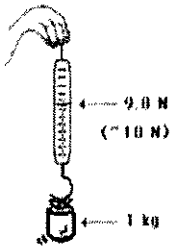
Object	Mass	Approx. Weight
Melon	1 kg	
Apple		~1.0 N
Pat Eatladee	25 kg	

4. Different masses are hung on a spring scale calibrated in Newtons.

   The force exerted by gravity on 1 kg = ~10 N.

   The force exerted by gravity on 5 kg = ~_____ N.

   The force exerted by gravity on 70 kg = ~_____ N.



5. The value of g in the British system is 32 ft/sec^2. The unit of force is pounds. The unit of mass is the slug. Use your weight in pounds to calculate your mass in units of slugs. **PSYW**

6. You might be wondering about your metric weight. Using conversion factors, convert your weight in pounds to units of N. (Use 1 N = 0.22 pounds) **PSYW**

7. What is the mass and weight of a 10-kg object on earth?
   Mass = _____ Weight = _____

   What is the mass and weight of a 10-kg object on the moon where the force of gravity is 1/6-th that of the Earth's?
   Mass = _____ Weight = _____

8. Conclusion: The _____ of an object is independent of the object's location in space.

Newton's Second Law of Motion

Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

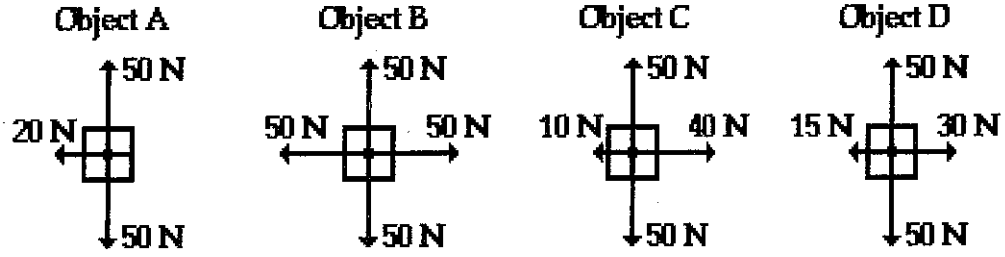
http://www.physicsclassroom.com/Class/newtlaws/u2l3a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3b.html

MOP Connection: Newton's Laws: sublevel 7

1. The acceleration of an object is _____ related to the net force exerted upon it and _____ related to the mass of the object. In equation form: $a = F_{net} / m$.
   a. directly, inversely b. inversely, directly c. directly, directly d. inversely, inversely

2. Use Newton's second law to predict the effect of an alteration in mass or net force upon the acceleration of an object.
   a. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2. The new acceleration will be _____ m/s^2.
   b. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4. The new acceleration will be _____ m/s^2.
   c. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon decreased by a factor of 2. The new acceleration will be _____ m/s^2.
   d. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass increased by a factor of 2. The new acceleration will be _____ m/s^2.
   e. An object is accelerating at a rate of 8 m/s^2 when it suddenly has its mass decreased by a factor of 4. The new acceleration will be _____ m/s^2.
   f. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 2 and its mass decreased by a factor of 4. The new acceleration will be _____ m/s^2.
   g. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 4 and its mass increased by a factor of 2. The new acceleration will be _____ m/s^2.
   h. An object is accelerating at a rate of 8 m/s^2 when it suddenly has the net force exerted upon increased by a factor of 3 and its mass decreased by a factor of 4. The new acceleration will be _____ m/s^2.

3. These force diagrams depict the magnitudes and directions of the forces acting upon four objects. In each case, the down force is the force of gravity. Rank these objects in order of their acceleration, from largest to smallest: _____ > _____ > _____ > _____



 Name: _____

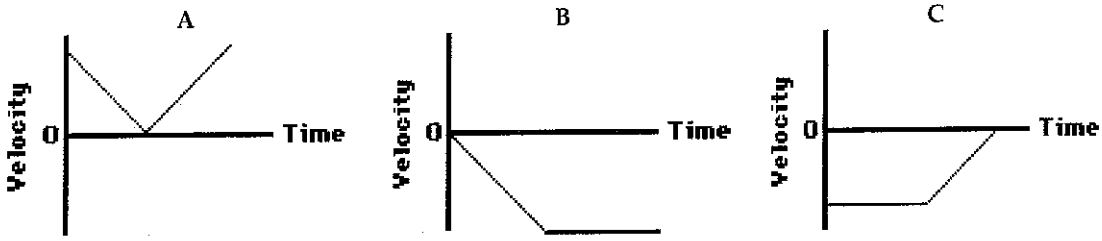
Net Force and Acceleration

Read from **Lesson 3** of the **Newton's Laws** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/newtlaws/u2l3a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3b.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3c.html

MOP Connection: Newton's Laws: sublevels 3 (front), 8 and 9 (back)

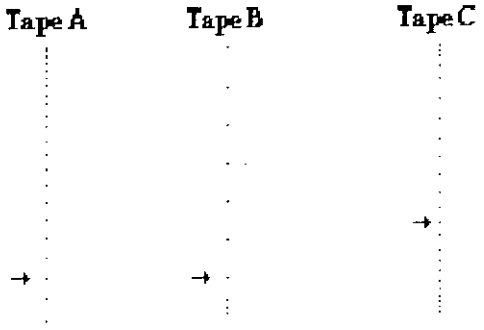
1. Luke Autbeloe drops a 5.0 kg fat cat (weight = ~50.0 N) off the high dive into the pool below (which on this occasion is filled with water). Upon encountering the water in the pool, the cat encounters a 50.0 N **upward** restraining force. Which one of the velocity-time graph best describes the motion of the cat? _____ Accompany your answer with a description of the cat's motion.



Description of cat's motion while falling through air:

Description of cat's motion after hitting the water:

2. Which one of the following dot diagrams best describes the motion of the falling cat from the time that they are dropped to the time that they hit the ground? _____ The arrows on the diagram represent the point at which the cat hit the water. Support your answer with sound reasoning:



3 Several of Luke's friends were watching the motion of the falling cat. Being "physics types", they began discussing the motion and made the following comments. Indicate whether each of the comments are correct or incorrect? Support your answers.

Student Statement:	**Correct? Yes or No**
a. Once the cat hit the pool, the forces are balanced and the cat will stop. Reason: _____	
b. Upon hitting the pool, the cat will accelerate upwards because the pool applies an upward force. Reason: _____	
c. Upon hitting the pool, the cat will bounce upwards due to the upwards force. Reason: _____	

5. A 2.0-N force is applied to a 1.0 kg book in order to move it across a desk with an acceleration of 0.5 m/sec^2. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

FBD:

$\Sigma F_X =$ _____ $\Sigma F_y =$ _____

$a_X =$ _____ $a_y =$ _____

6. A 1.5-N force is applied to a 1.0 kg book in order to move it across a desk at constant velocity. Consider frictional forces. Neglect air resistance. Diagram the forces acting on the book.

FBD:

$\Sigma F_X =$ _____ $\Sigma F_y =$ _____

$a_X =$ _____ $a_y =$ _____

7. A 70.0-kg skydiver is descending with a constant velocity. Consider air resistance. Diagram the forces acting upon the skydiver.

FBD:

$\Sigma F_X =$ _____ $\Sigma F_y =$ _____

$a_X =$ _____ $a_y =$ _____

8. A 30-N force is applied to drag a 20-kg sled across loosely packed snow with an acceleration of 1.0 m/s^2. Diagram the forces acting upon the sled.

FBD:

$\Sigma F_X =$ _____ $\Sigma F_y =$ _____

$a_X =$ _____ $a_y =$ _____

9. An 800-kg car is coasting to the right with a leftward acceleration of 1 m/s^2. Diagram the forces acting upon the car.

FBD:

$\Sigma F_X =$ _____ $\Sigma F_y =$ _____

$a_X =$ _____ $a_y =$ _____

Newton's Third Law

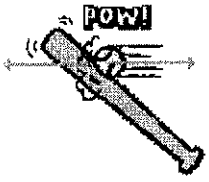
Read from **Lesson 4** of the **Newton's Laws** chapter at **The Physics Classroom**:

http://www.physicsclassroom.com/Class/newtlaws/u2l4a.html
http://www.physicsclassroom.com/Class/newtlaws/u2l4b.html

MOP Connection: Newton's Laws: sublevel 12

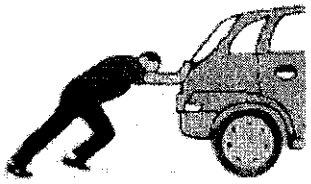
A force is a push or pull resulting from an interaction between two objects. Whenever there is a force, there are two objects involved - with both objects pushing (or pulling) on each other in opposite directions. While the direction of the pushes (or pulls) is opposite, the strength or magnitude is equal. This is sometimes stated as Newton's Third Law of motion: *for every action, there is an equal and opposite reaction*. A force is a push or a pull and it always results from an interaction between two objects. These forces always come in pairs.

1. For each stated *action force,* identify the *reaction force*.



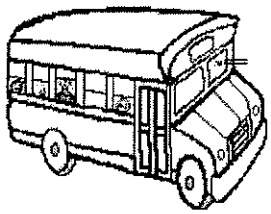
Bat hits ball.

_____



Man pushes car.

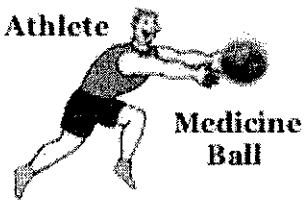
_____

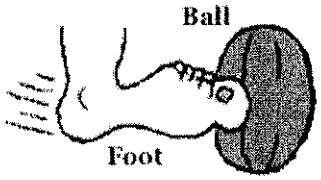


Bus hits bug.

_____

2. Identify by words the action-reaction force pairs in each of the following diagrams.





3. **TRUE** or **FALSE**:

   As you sit in your seat in the physics classroom, the Earth pulls down upon your body with a gravitational force; the reaction force is the chair pushing upwards on your body with an equal magnitude.

   If False, correct the answer.

4. Shirley Bored sits in her seat in the English classroom. The Earth pulls down on Shirley's body with a gravitational force of 600 N. Describe the reaction force of the force of gravity acting upon Shirley.

5. Use Newton's third law (law of action-reaction) and Newton's second law (law of acceleration: $a = F_{net}/m$) to complete the following statements by filling in the blanks.

   a. A bullet is loaded in a rifle and the trigger is pulled. The force experienced by the bullet is _____ (less than, equal to, greater than) the force experienced by the rifle. The resulting acceleration of the bullet is _____ (less than, equal to, greater than) the resulting acceleration of the rifle.

   b. A bug crashes into a high-speed bus. The force experienced by the bug is _____ (less than, equal to, greater than) the force experienced by the bus. The resulting acceleration of the bug is _____ (less than, equal to, greater than) the resulting acceleration of the bus.

   c. A massive linebacker collides with a smaller halfback at midfield. The force experienced by the linebacker is _____ (less than, equal to, greater than) the force experienced by the halfback. The resulting acceleration of the linebacker is _____ (less than, equal to, greater than) the resulting acceleration of the halfback.

   d. The 10-ball collides with the 14-ball on the billiards table (assume equal mass balls). The force experienced by the 10-ball is _____ (less than, equal to, greater than) the force experienced by the 14-ball. The resulting acceleration of the 10-ball is _____ (less than, equal to, greater than) the resulting acceleration of the 14-ball.

Newton's Second Law Problem-Solving

Study from **Lessons 3** of the **Newton's Laws** chapter at **The Physics Classroom:**

http://www.physicsclassroom.com/Class/newtlaws/u2l3c.html
http://www.physicsclassroom.com/Class/newtlaws/u2l3d.html

For the following problems, construct a free-body diagram and show your work clearly.

1. A rightward force of 302 N is applied to a 28.6-kg crate to accelerate it across the floor. The coefficient of friction between the crate and the floor is 0.750. Determine the acceleration of the crate.

2. During a football workout, two linemen are pushing the coach on the sled. The combined mass of the sled and the coach is 300 kg. The coefficient of friction between the sled and the grass is 0.800. The sled accelerates at a rate of 0.580 m/s/s. Determine the force applied to the sled by the lineman.

3. A 405-N rightward force is use to drag a large box across the floor with a constant velocity of 0.678 m/s. The coefficient of friction between the box and the floor is 0.795. Determine the mass of the box.

4. A 6.58×10^3 N upward tension force is exerted on a 521-kg downward-moving freight elevator. Determine the acceleration of the elevator.

5. A basketball star exerts a force of 3225 N (average value) upon the gym floor in order to accelerate his 76.5-kg body upward. (a) Determine the acceleration of the player. (b) Determine the final speed of the player if the force endures for a time of 0.150 seconds.

6. At the end of the Giant Drop free fall ride, riders experience a large upward normal force to bring their falling bodies to a stop. Determine the normal force value required to accelerate a 52.1-kg physics student with an upward acceleration of 27.4 m/s/s.

7. A hockey player accelerates a puck (m = 0.167 kg) from rest to a velocity of 50 m/s in 0.0121 sec. Determine the acceleration of the puck and the force applied by the hockey stick to the puck. Neglect resistance forces.

8. A falling skydiver is accelerating in the downward direction at 3.29 m/s/s. The mass of the skydiver (including parachute gear) is 67.2 kg. Determine the air resistance force on the skydiver (and accompanying parachute).

9. A 67.2-kg falling skydiver opens his parachute and instantly slows down at a rate of 7.2 m/s/s. Determine the air resistance force on the skydiver (and accompanying parachute).