Dynamics Packet 1: Answer Key

Inertia and Mass

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

MOP Connection: Newton's Laws: sublevel 1

1. **Inertia** is **the tendency of an object to resist changes in its state of motion. It is the "stubborn act of the will" to keep on doing whatever the object is doing.**

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

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 differences will Shirley observe and how can this observation lead to the necessary conclusion?

   By pushing the bricks, Shirley can *feel* the inertia - the tendency of each brick to resist a change in its state of being at rest. Bricks of different mass will offer different degrees of resistance to the force that attempts to disrupt its state of rest. The brick with the greatest mass will offer more resistance. Shirley will be able to *feel* this resistance.

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? **Yes!** Explain your answer.

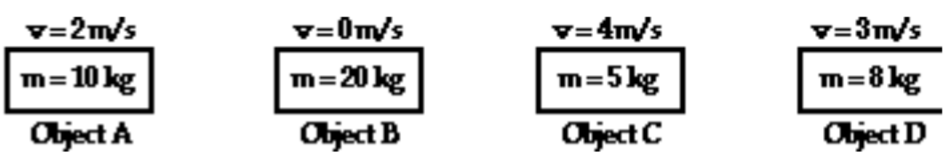
   Objects on the spaceship would still have mass and be able to exhibit the same degree of inertia as they exhibit on Earth. While their weight (a gravity *thing*) will be significantly diminished, their mass and tendency to resist a disruption from their state of motion will be just the same as on Earth.

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.

   A large-massed object (e.g., a moose) has considerable difficulty changing its state of motion. This is inertia. A change in direction is a change in the state of motion. By zigzagging, you can take advantage of the large inertia of the moose. You will make the turn but the moose will have a tendency to go straight. Now that's physics for better living!

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

7. Mass and velocity values for a variety of objects are listed below. Rank the objects from smallest to greatest inertia. **C** < **D** < **A** < **B**



   Objects with the least mass have the least amount of inertia; objects with the most mass have the greatest amount of inertia. The velocity or speed of the object has nothing to do with inertia.

Pre-Conceptions

Students typically have many pre-conceived notions regarding concepts in Physics. It has always proven useful to bring these ideas to the forefront of your mind and to make an effort to evaluate their correctness. The following statements pertain in one way or another to common notions regarding central concepts of this unit. Identify each statement as being either true (**T**) or false (**F**).

Force and Motion - What Do You Believe?

The following statements pertain in one way or another to common notions regarding force and motion. Identify each statement as being either true (**T**) or false (**F**).

T or F?	Statement
False	1. A force is required to keep an object moving in a given direction.
False	2. An upward moving object must be experiencing (or at least usually does experience) an upward force.
False	3. A rightward moving object must be experiencing (or at least usually does experience) a rightward force.
False	4. A ball is moving upwards and rightwards towards its peak. The ball experiences a force that is directed upwards and rightwards.
False	5. If a person throws a ball with his hand, then the force of the hand upon the ball is experienced by the ball for at least a little while after the ball leaves the hand.
False	6. A cannonball is shot from a cannon at a very high speed. The force of the explosion will be experienced by the cannonball for several seconds (or a least a little while).
False	7. If an object is at rest, then there are no forces acting upon the object.

Mass and Weight - What Do You Believe?

The following statements pertain in one way or another to common notions regarding mass and weight. Identify each statement as being either true (**T**) or false (**F**).

T or F?	Statement
False	1. Objects do NOT weigh anything when placed in a vacuum.
False	2. All objects weigh the same amount when placed in a vacuum, regardless of their mass.
True	3. An object weighs less on the moon than it does on the Earth.
True	4. The mass of an object on the moon is the same as its mass on the Earth.
False	5. A high-speed object (say, moving at 200 mi/hr) will weigh less than the same object when at rest.
False	6. A high-speed object (say, moving at 200 mi/hr) will possess measurably more mass than the same object when at rest.
False	7. Weight is measured in pounds; mass is measured in Newtons.
True	8. A free-falling object still has weight.
False	9. Weight is the result of air pressure exerted upon an object.

Balanced vs. Unbalanced Forces

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

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

Review: An object at rest **will stay at rest**;

An object in motion .... **will stay in motion**;

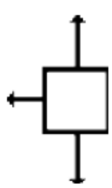
unless ...**unless acted upon by an unbalanced force.**

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.

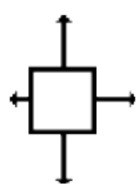
2. Renatta Oyle is having car troubles. She is notorious for the trail of oil drops that she leaves on the streets of Glenview. Observe the following oil traces and indicate whether Renatta's car is being acted upon by an unbalanced force. Give a reason for your answers.

	Unbalanced Force?
a.  **Reason:** **The car is speeding up; the spacing between consecutive positions is increasing.**	**Yes**
b.  **Reason:** **The car is moving at a constant speed; the spacing between consecutive positions is constant.**	No
c.  **Reason:** **The car is slowing down; the spacing between consecutive positions is decreasing.**	**Yes**

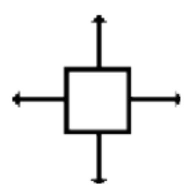
3. Each one of the dot diagrams in question #2 can be matched to a force diagram below. The force diagrams depict the individual forces acting upon the car by a vector arrow. The arrow direction represents the direction of the force. The arrow length represents the strength of the force. Match the dot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



Dot Diagram(s): C



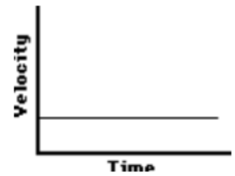
Dot Diagram(s): A

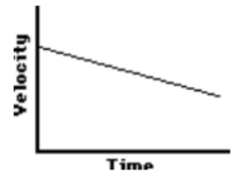


Dot Diagram(s): B

4. If the net force acting upon an object is 0 N, then the object MUST __E__. 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).

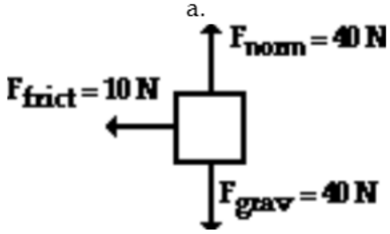




Unbalanced Force? <u>No</u>	Unbalanced Force? <u>Yes</u>	Unbalanced Force? <u>Yes</u>
Reason/Description: There is a constant velocity; unbalanced forces change the velocity.	Reason/Description: There is an acceleration; the vehicle is slowing down. Unbalanced forces cause this.	Reason/Description: There is an acceleration; the vehicle is speeding up. Unbalanced forces cause this.

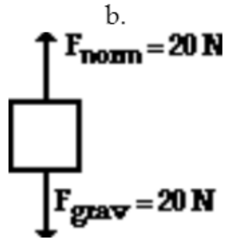
6. A free-body diagrams show all the individual forces acting upon an object. The net force is the *vector sum* of all these forces (∑F). Determine the net force and state if there is an acceleration.

a.



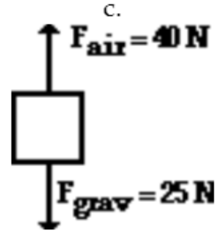
∑F = <u>10 N, left</u>
Accel'n? <u>Yes</u>

b.



∑F = <u>0 N</u>
Accel'n? <u>No</u>

c.



∑F = <u>15 N, up</u>
Accel'n? <u>Yes</u>

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*

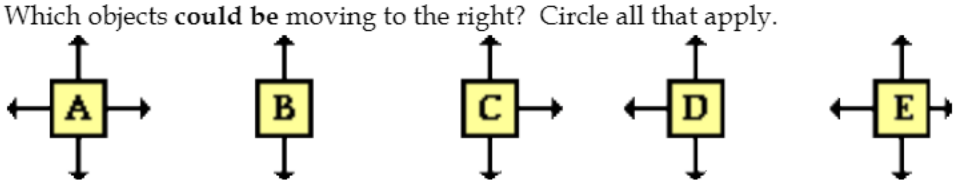
. . . .

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? <u>Anna</u> Explain.

If horizontal forces are balanced, then there is no acceleration. There could however be a horizontal motion. The object is either at rest (as Anna's partner insists) **OR** moving at a constant velocity.

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? <u>No</u> Explain.
Regrettably, Aaron believes that forces cause motion and a leftward force is consistent with a leftward motion. This thinking causes Isaac Newton to roll over in his grave. The fact is that forces cause accelerations. The fact that the force is friction is an indicator that the object is probably moving to the right and slowing down, consistent with a leftward acceleration and leftward net force.

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.



<u>ABCDE</u> Any of these objects could be moving to the right since a net force does not indicate which way an object is moving. Objects D and E could be moving right and slowing down. Objects A and B could be moving right at a constant speed. Object C could be moving right and speeding up.

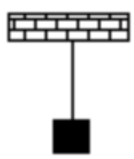
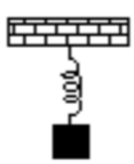
Recognizing Forces

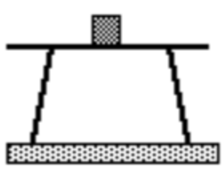
Read from **Lesson 2** of the **Newton's Laws** chapter at **The Physics Classroom**:

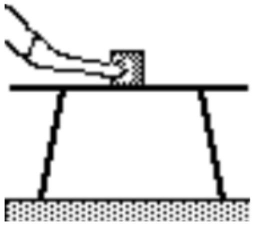
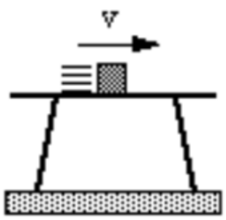
MOP Connection: Newton's Laws: sublevel 4

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.cfm

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	<u>P</u>	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	<u>A</u>	There are no springs touching the object; thus, there is no spring force.
	Tension	<u>P</u>	A taut rope is attached to the object; this is the cause of the tension force.
	Normal:	<u>A</u>	The block is not being directly supported on any of its sides by a stable surface.
	Friction	<u>A</u>	The object is not moving across a surface so it does not experience friction.
	Air Res.:	<u>A</u>	If an object is not moving (relative to the surrounding air), then there is no F_{air}.
 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	<u>P</u>	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	<u>P</u>	A stretched spring is attached to the block; this is the cause of the spring force.
	Tension	<u>A</u>	There are no strings (or ropes or ...) connected to the object and pulled tight.
	Normal:	<u>A</u>	The block is not being directly supported on any of its sides by a stable surface.
	Friction	<u>A</u>	The object is not moving across a surface so it does not experience friction.
	Air Res.:	<u>A</u>	If an object is not moving (relative to the surrounding air), then there is no F_{air}.

Description of Situation	Force Present (P) or Absent (A)?		Explanation
	Gravity	P	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the ball in the air; thus, there is no spring force.
	Tension	A	There are no strings (or ropes or ...) connected to the object and pulled tight.
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>.	Normal:	A	The ball is not being supported on any of its sides by a stable surface.
	Friction	A	The object is not moving across a surface so it does not experience surface friction.
	Air Res.:	P	If an object is moving (through air), then there is a F_{air}.; it is often a small force.
	Gravity	P	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the object; thus, there is no spring force.
	Tension	A	There are no strings (or ropes or ...) connected to the object and pulled tight.
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>.	Normal:	A	The skydiver is not being supported on any of its sides by a stable surface.
	Friction	A	The object is not moving across a surface so it does not experience surface friction.
	Air Res.:	P	If an object is moving (through air), then there is a F_{air}.
	Gravity	P	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the object; thus, there is no spring force.
	Tension	A	There are no strings (or ropes or ...) connected to the object and pulled tight.
5. A block rests on top of a table. Consider only the forces acting upon the block.	Normal:	P	The block is being directly supported by a stable surface (the table).
	Friction	A	The object is not moving or trying to moveacross a surface so there is no F_{frict}.
	Air Res.:	A	If an object is not moving (relative to the surrounding air), then there is no F_{air}.

Description of Situation	Force Present (P) or Absent (A)?	Explanation
	Gravity **P**	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring: **A**	There are no springs touching the object; thus, there is no spring force.
	Tension **A**	There are no strings (or ropes or ...) connected to the object and pulled tight.
6. A block is being pushed across the top of a table. Consider only the forces acting upon the block.	Normal: **P**	Even when moving, the block is still being directly supported by a stable surface.
	Friction **P**	The object is moving across a surface and thus experiencing friction.
	Air Res.: **P**	If an object is moving (through air), then there is a F_{air}; it is often a small force.
	Gravity **P**	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring: **A**	There are no springs touching the object; thus, there is no spring force.
	Tension **A**	There are no strings (or ropes or ...) connected to the object and pulled tight.
7. A block slides across the top of a table. Consider only the forces acting upon the block.	Normal: **P**	Even when moving, the block is still being directly supported by a stable surface.
	Friction **P**	The object is moving across a surface and thus experiencing friction.
	Air Res.: **P**	If an object is moving (through air), then there is an F_{air}; it is often a small force.
	Gravity **P**	The force of gravity acts upon all objects; the Earth and the object attract.
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.	Spring: **A**	There are no springs touching the object; thus, there is no spring force.
	Tension **A**	There are no strings (or ropes or ...) connected to the object and pulled tight.
	Normal: **P**	Even when moving, the car is still being directly supported by the road surface.
	Friction **P**	As the wheels turn, they grip the road due to friction, resulting in a forward force.
	Air Res.: **P**	If an object is moving (through air), then there is an F_{air}.

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	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the object; thus, there is no spring force.
	Tension	A	There are no strings (or ropes or ...) connected to the object and pulled tight.
	Normal:	P	The person is still being directly supported by the sled surface.
	Friction	P	The sled is slows down due to friction. The person would slide forward across the seat if he did not experience friction as well..
	Air Res.:	P	If an object is moving (through air), then there is an F_{air}; it is often a small force.
 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	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the object; thus, there is no spring force.
	Tension	A	There are no strings (or ropes or ...) connected to the object and pulled tight.
	Normal:	P	Even when moving, the car is still being directly supported by the road surface.
	Friction	P	The wheels are skidding across the road and thus experiencing friction.
	Air Res.:	P	If an object is moving (through air), then there is an F_{air}.
 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	The force of gravity acts upon all objects; the Earth and the object attract.
	Spring:	A	There are no springs touching the object; thus, there is no spring force.
	Tension	P	A taut rope is attached to the bucket; this is the cause of the tension force.
	Normal:	A	The object is not being supported on any of its sides by a stable surface.
	Friction	A	The object is not moving across a surface so it does not experience surface friction.
	Air Res.:	P	If an object is moving (through air), then there is an F_{air}; it is often a small force.

Mass and Weight

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

MOP Connection: Newton's Laws: sublevel 6

1. The standard metric unit for mass is **kilogram** and the standard metric unit for weight is **Newton**.

2. An object's mass refers to **the amount of stuff present in the object** and an object's weight refers to **the force of gravitational attraction to Earth**. 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.

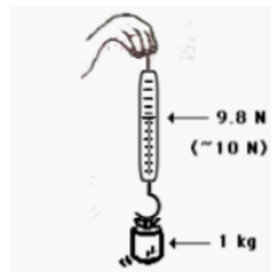
Object	Mass	Approx. Weight
Melon	**1 kg**	**9.8 N**
Apple	**0.10 kg**	**~1.0 N**
Pat Eatladee	**25 kg**	**245 N**

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 = ~50 N. (more precisely, 49 N)

   The force exerted by gravity on 70 kg = ~700 N. (more precisely, 686 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**

   Answers will vary. The calculation for a 160-pound person is:

   Mass = Weight/g = (160 lbs)/(32 ft/s^2) = **5.0 slug**

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**

   Answers will vary. The calculation for a 160-pound person is:

   160 lb • (1.0 N/0.22 lb) = **730 N** (727.27 … N)

7. What is the mass and weight of a 10-kg object on earth?
   Mass = **10 kg** Weight = **98 N** (mass multiplied by 9.8)

   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 = **10 kg** Weight = **16 N** (one-sixth of 98 N)

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