SI Physics - Full Discipline Demo

Newton's Laws of Motion

Final Report - Answer Guide

Institution	Science Interactive University
Session	SI Physics - Full Discipline Demo
Course	SI Physics - Full Discipline Demo
Instructor	Sales SI Demo

Test Your Knowledge

Match each term with the best description.

Acceleration

Inertia

Velocity

Measure of the body’s resistance to changes in its motion 1

Speed of an object in a particular direction 2

Rate of change of an object’s velocity 3

Correct answers:

1 Inertia 2 Velocity 3 Acceleration

Categorize each statement as belonging to Newton’s first, second, or third law of motion.

- A body at rest tends to stay at rest
- Acceleration is inversely proportional to the mass of an object
- An object moves in a straight line unless acted upon by a net force
- Forces exerted on an object result in the object pushing back with same force in opposite direction
- Law of action and reaction
- Law of force and acceleration
- Law of inertia

Newton’s First Law	Newton’s Second Law	Newton’s Third Law
1	2	3

Correct answers:

1 Law of inertia A body at rest tends to stay at rest

An object moves in a straight line unless acted upon by a net force

2 Law of force and acceleration

Acceleration is inversely proportional to the mass of an object

3 Law of action and reaction

Forces exerted on an object result in the object pushing back with same force in opposite direction

Exploration

Inertia is a body's resistance to _____.

- force of mass
- gravity
- deceleration
- motion changes ✔

According to Newton's first law, if there is no net force acting on an object, then the object maintains a constant velocity.

- True ✔
- False

Acceleration is directly proportional to the _____ of an object.

- velocity
- net force ✔
- speed
- mass

Newton's third law of motion is directly related to _____.

- velocity and force
- action and reaction ✔
- force and acceleration

Exercise 1

Define velocity and acceleration. Explain how acceleration can be used to interpret the velocity of an object.

Velocity is the speed of an object in a particular direction. Acceleration is the rate of change of an object's velocity. Acceleration can reflect either a change in the speed of an object (speeding up or slowing down) or it can be the result of a change in the direction an object is moving, even if the speed remains constant.

Assuming a frictionless surface, explain how Newton's three laws of motion are in action as an air hockey puck slides across the table and then hits the side of the table wall.

Newton's 1st law of motion is in action as the puck is sliding across the table. Since there are no net forces acting on the puck it moves in a straight line at constant velocity. When the puck hits the wall, it exerts a force on the wall and the wall exerts the exact same force back on the puck (equal but opposite reaction), according to Newton's 3rd law of motion. After hitting the wall, the puck moves in a new direction. Its velocity has changed in direction, so acceleration has occurred due to the force of the wall on the puck, according to Newton's 2nd law of motion.

Data Table 1: Net Force and Newton's Laws
(SAMPLE ANSWER BELOW)

Scenario	Net Force	Net Force Explanation	Newton's Law	Law Explanation
A book sitting on a table	0	The downward force of gravity is perfectly balanced by the upward normal force.	1st law	This is a good example of the law of inertia. The balanced force of gravity and normal force result in a zero net force, so the book remains at rest since no other force is acting on the book.
A puck sliding across frictionless ice	0	In the absence of friction, there are no net forces acting on the puck and it will continue to move at constant speed.	1st law	This is another example of the law of inertia. There is no net force on the puck since the ice is assumed frictionless. Because of this there is nothing to stop or slow the motion of the puck. According to Newton's 1st law, the puck will continue to move at constant velocity in a straight line.
A child sitting on a merry-go- round turning at constant speed	Nonzero	Although the speed is constant, the direction of the motion is continually changing, so a net force is acting on the child.	2nd law	The velocity of the child is tangential to the edge of the merry-go-round at all times; thus, although the speed remains constant, the velocity is continually changing since the direction is continually changing. Changing velocity means nonzero acceleration, so Newton's 2nd law explains that there must be a net force on the child.
A man	0	The force of the man leaning	3rd law	The man at the wall represent an

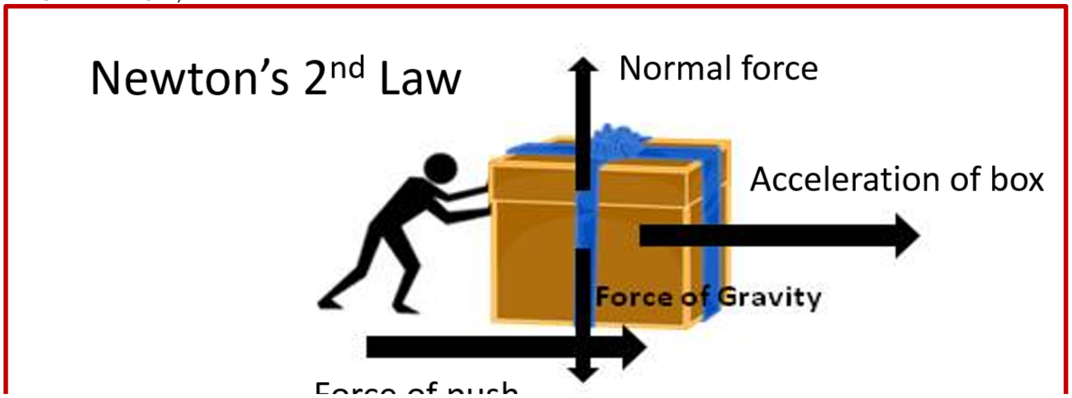
leaning against a wall		against the wall is exactly balanced by the force of the wall pushing back on the man.		action/reaction pair. The man exerts a force on the wall and the wall pushes back with the exact same force in the opposite direction according to Newton’s 3rd law.
A rock falling at constant terminal velocity	0	At terminal velocity, the downward force of gravity is perfectly balanced by the upward force of air resistance, and there is no acceleration.	1st law	Since the net force is zero, the rock will continue to fall at constant velocity in a straight line, according to Newton’s 1st law, until a net force acts on it (which will occur when the rock hits the ground).
A car driving around a curve at a constant speed of 40 mph	Nonzero	Although the speed is constant, the direction of the motion is continually changing, so a net force is acting on the car.	2nd law	As the car drives around the curve, it is constantly changing its direction, which means that the velocity is changing even though the speed is constant. A changing velocity means there is nonzero acceleration, which in turn means there is a nonzero net force.
A man pushing a box across a frictionless surface	Nonzero	The box is accelerating horizontally in the same direction as the force from pushing the box, resulting in an unbalanced net force.	2nd law	The force from pushing accelerates the box horizontally in the same direction as the force. Acceleration is directly proportional to the net force acting on the box according to Newton’s 2nd law.
A soccer ball placed on the grass	0	The downward force of gravity is balanced by the upward normal force, yielding a net force of zero keeping the ball at rest.	1st law	This is another example of the law of inertia. The balanced forces result in a zero net force keeping the ball at rest, according to Newton’s 1st law. The ball will remain at rest until an unbalanced external force, such as a kick, is applied to move the ball.
Air inside and outside of an inflated balloon	0	The force of the air in the balloon pushing outward is exactly balanced by the inward force of the air surrounding the balloon plus the force of the stretched rubber of the balloon pushing inward, resulting in a zero net force.	3rd law	The air inside and the air outside of the balloon plus the force of the stretched balloon itself represent an action/reaction pair. The force of the air inside of the balloon pushes outward to produce its inflated size, and the force of the air outside of the balloon pushes inward on the balloon, as does the stretched material of the balloon.

Photo 1: Newton’s Law Sketch

(SAMPLE ANSWER BELOW)

Photo 2: Newton's Law Sketch

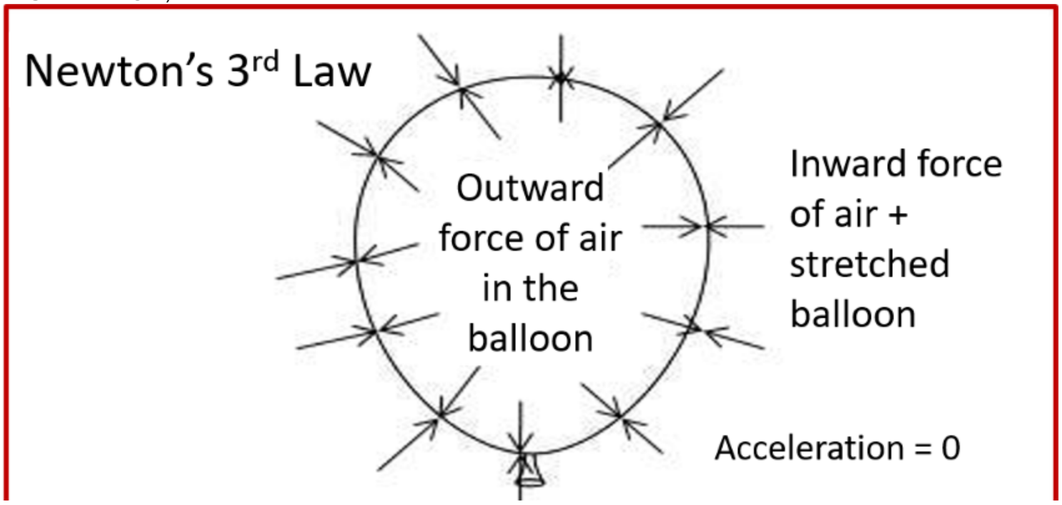
(SAMPLE ANSWER BELOW)



Force of push

Photo 3: Newton’s Law Sketch

(SAMPLE ANSWER BELOW)



Competency Review

A _____ does not represent a change in velocity.

- person on a spinning merry-go-round
- skate boarder gliding to a stop
- truck driving due north at 75mph ✔
- billiard ball bouncing off the side of a pool table

A hockey puck sliding across frictionless ice is a good example of _____.

- Newton’s first law ✔
- Newton’s second law
- Newton’s third law

A car going around a curve at a constant speed of 40 mph does not experience acceleration.

- True
- False ✔

Net force refers to the _____.

- most important force
- strongest force
- total of all the forces ✔
- pairing of forces

If the net force is zero, then the _____ of the object will be zero.

- speed
- velocity
- acceleration ✔
- All of the above

A mosquito, flying at 1 mph, flies directly into the windshield of a car travelling at 45 mph. Both the mosquito and the car experience the same_____.

- force ✔
- acceleration
- force and acceleration
- None of the above

A heavy object accelerating from 0 to 60 m/s in 2 minutes experiences a larger net force than a light object accelerating at the same rate.

- True ✔
- False

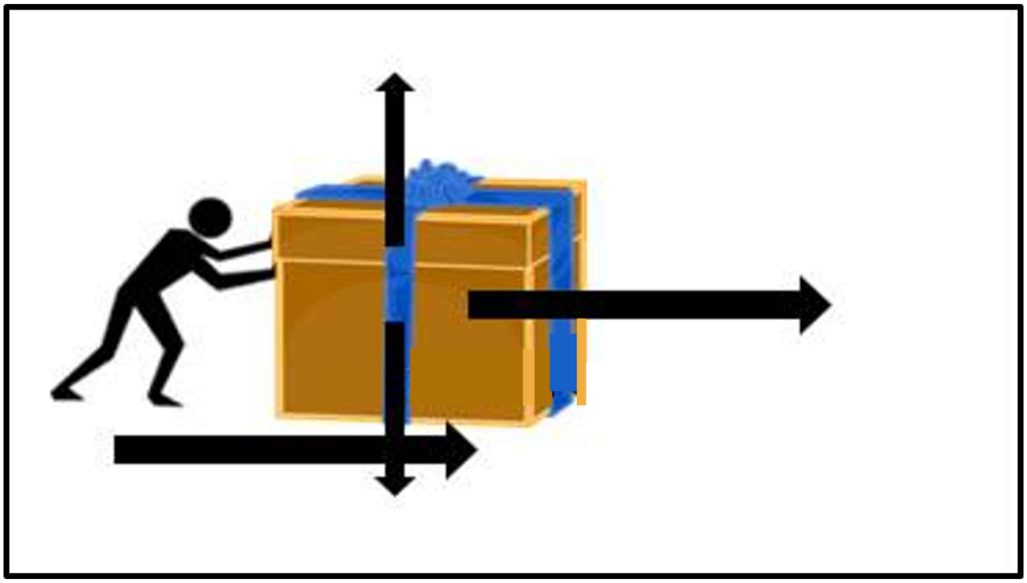
Because forces always come in balanced pairs, acceleration is equal for any two interacting objects.

- True
- False ✔

Newton’s second law can be demonstrated by a(n) _____.

- soccer ball on the grass
- inflated balloon
- truck turning a curve at a constant speed of 15 mph ✔
- man leaning against a wall

Which of Newton's laws is demonstrated by the sketch below?



- Newton's first law
- Newton's second law ✔
- Newton's third law

Extension Questions

Using all three of Newton's laws of motion, carefully describe the motion of a baseball beginning when the ball is resting in the pitcher's glove as he stands on the mound until the ball is hit by the batter (assume the ball is hit). Ignore what kind of pitch is thrown and air resistance. The answer should focus on the forces and motion of the ball (not the players), and should include which of Newton's laws each motion/force follows. (SAMPLE ANSWER BELOW)

As the ball sits in the glove of the pitcher, it is acted upon by the downward force of gravity. Based on Newton's 3rd law (N3), the ball pulls upward on the Earth with exactly the same force. The force of gravity is perfectly balanced by the upward normal force of the glove on the ball. There is no net force, so the ball remains at rest in the glove based on Newton's 1st law (N1). When ready to pitch, the pitcher's hand lifts the ball out of the glove. The ball is now being acted on by a net force from the pitcher's hand and experiences motion, per Newton's 2nd law (N2). The upward force of the pitcher's hand on the ball is stronger than the downward pull of gravity, so the ball moves up, out of the glove, and behind the pitcher's head. Its inertia is continually changing due to the net force (N1). During this movement, the ball is exerting a force on the pitcher's hand equal and opposite to the force the hand exerts on the ball (N2). Because the ball's mass is smaller, its acceleration is larger, resulting in a net movement of the ball. As the pitcher throws the ball forward, he exerts a large force on the ball, causing it to accelerate to a high speed (N2). The moment the ball is released, this external force stops once the ball reaches the same velocity as the pitcher's hand. Now, the force of gravity is the only force acting on the ball. The force of gravity is unbalanced and in the downward direction, this causes the path of the ball to bend slightly downward as it travels towards the batter. The ball exerts a force on the Earth equal and opposite to the force of gravity (N3); again, due to the mass of the Earth, the effect on the Earth is negligible (N2). In the horizontal direction, there are no net forces, so the ball moves at the same speed and in the same direction as it did when it was released by the pitcher's hand (N1). It continues until it reaches the plate, where the batter swings the bat and hits the ball. The bat exerts a net force on the ball, causing it to change both speed and direction (N1). On impact, the ball's velocity is reduced to zero (this is a large deceleration) (N1 and N2). The force of the bat then causes the ball to accelerate and move in a new direction (N1 and N2). The ball exerts the same force on the bat (N3), which causes the bat to slow slightly as the batter finishes the swing.