The laws of physics can become extremely **counterintuitive.** A counterintuitive problem is one that appears simple and obvious, but in which the answer you feel turns out to be incorrect when examined more closely.

In this assignment, you will use Newton's Laws to analyze the motion of objects moving in a straight line (or nearly a straight line, in the case of an arrow.) The goal is to find a free-body diagram of each situation and try to build it. In this assignment, we are building only *qualitative* free-body diagrams.

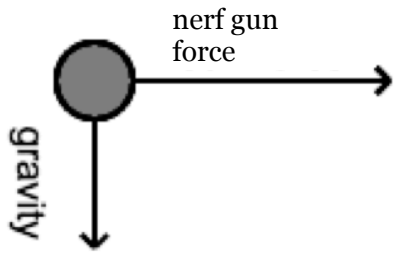
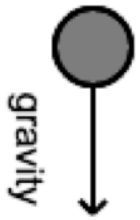
The table below displays consequences of Newton's First and Second Laws. This is not how Newton's First and Second Laws are typically presented, but for *qualitatively* analyzing free-body diagrams, these representations can be very useful.

LAW	If….	…then
Newton's First Law	Net force on a moving object is zero.	The object will move at a constant velocity.
Newton's Second Law	Net force on a moving object is in the SAME direction as velocity.	The speed of the object will increase.
Newton's Second Law	Net force on a moving object is in the OPPOSITE direction as velocity.	The speed of the object will decrease.

Principle of contact forces: all contact forces exist *only* when two objects are in contact. After two objects loose contact, a contact force does not continue to exist.

Problem 1:

Someone fires a nerf gun across the room to the right. Our goal is to draw a free-body diagram of the nerf bullet as it flies, beginning from the moment after it leaves the gun and ending the moment before it strikes the wall.

A	B
	

In option A, the net horizontal force on the nerf bullet is _____.

In option B, the net horizontal force on the nerf bullet is _____.

The direction of the horizontal velocity of the nerf bullet is _____.

If A were correct, then according to _____ Law, the nerf bullet would _____ horizontally because _____.

If B were correct, then according to _____ Law, the nerf bullet would _____ horizontally because _____.

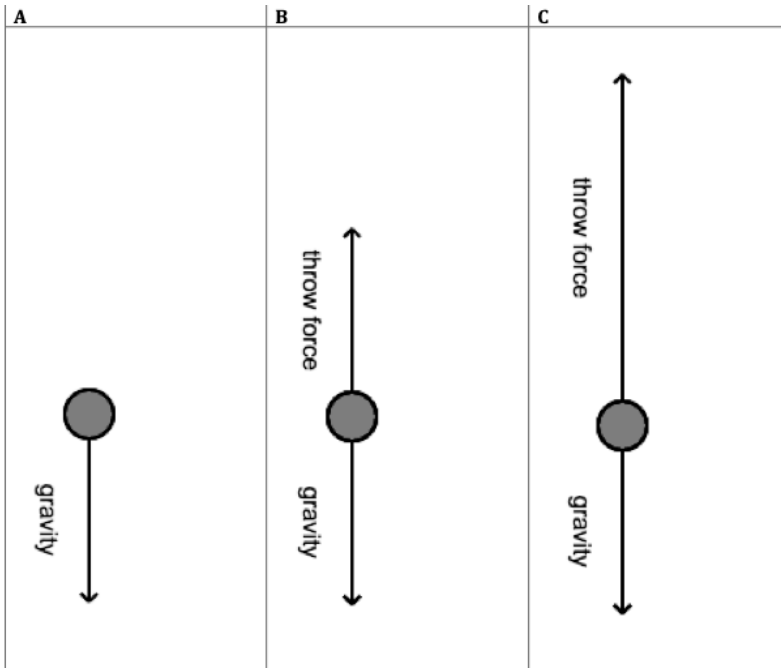
We can observe that, in real life, the nerf bullet _____.

Therefore, the correct answer must be _____.

The force(s) that do not exist in reality is (are) _____ because _____.

Problem 2:

Someone throws a ball directly into the air. Our goal is to draw a free-body diagram of the ball from the moment it leaves the person's hand until it reaches the top of its arc.



In option A, the net force on the ball is _____.

In option B, the net force on the ball is _____.

In option C, the net force on the ball is _____.

The direction of the velocity of the ball is _____.

If A were correct, then according to _____ Law, the ball would _____ because _____.

If B were correct, then according to _____ Law, the ball would _____ because _____.

If C were correct, then according to _____ Law, the ball would _____ because _____.

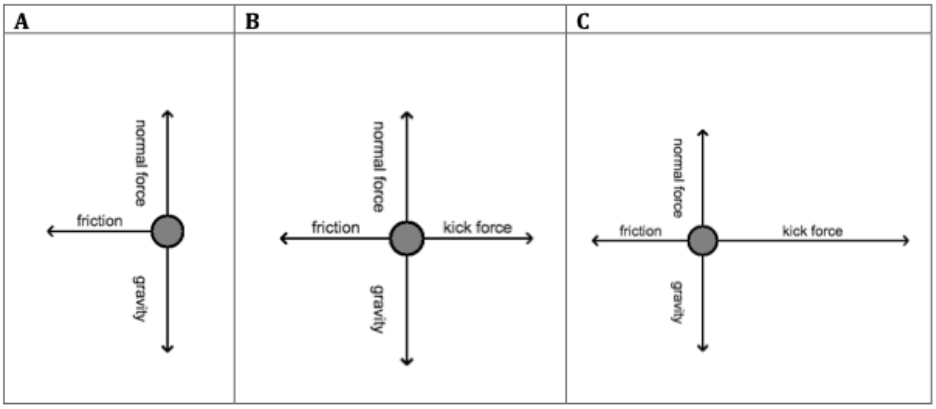
We can observe that, in real life, the ball _____.

Therefore, the correct answer must be _____.

The force(s) that do not exist in reality is (are) _____ because _____.

Problem 3:

Someone kicks a book on the floor across the room. Our goal is to draw a free-body diagram of the book from the moment it leaves the person's foot until it the moment is stops moving.



In option A, the net force on the book is _____.

In option B, the net force on the book is _____.

In option C, the net force on the book is _____.

The direction of the velocity of the book is _____.

If A were correct, then according to _____ Law, the book would _____ because _____.

If B were correct, then according to _____ Law, the book would _____ because _____.

If C were correct, then according to _____ Law, the book would _____ because _____.

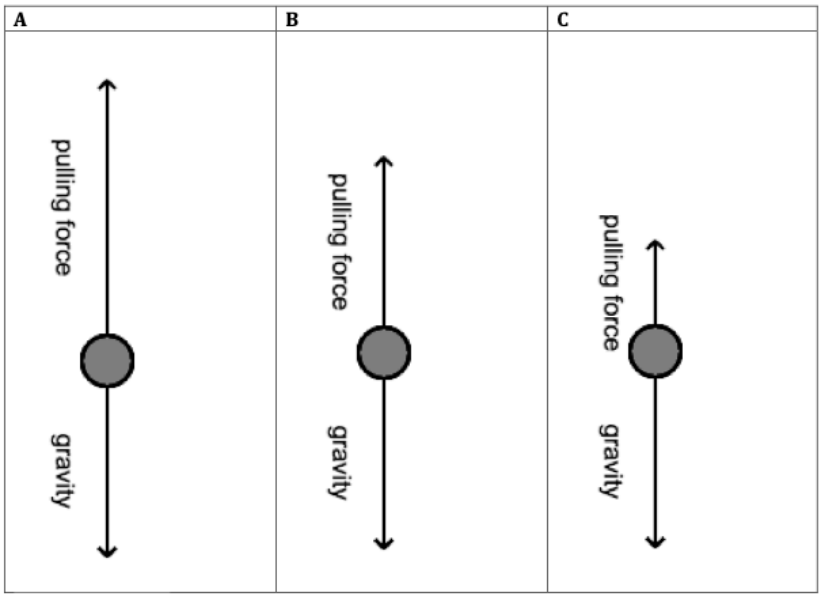
We can observe that, in real life, the book _____.

Therefore, the correct answer must be _____.

The force(s) that do not exist in reality is (are) _____ because _____.

Problem 4:

Someone is lifting a box. Our goal is to draw a diagram of the box while it is in motion at a constant velocity (frequently, people lift heavy objects at a nearly constant velocity).



In option A, the net force on the box is _____.

In option B, the net force on the box is _____.

In option C, the net force on the box is _____.

The direction of the velocity of the arrow is _____.

If A were correct, then according to _____ Law, the box would _____ because _____.

If B were correct, then according to _____ Law, the box would _____ because _____.

If C were correct, then according to _____ Law, the box would _____ because _____.

We can observe that, in real life, the box _____.

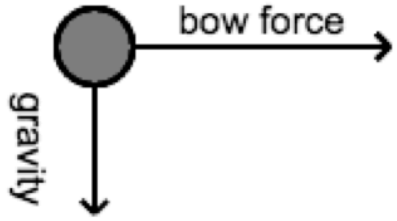
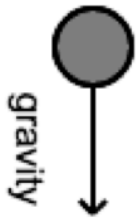
Therefore, the correct answer must be _____.

The force(s) that do not exist in reality is (are) _____ because _____.

Answers

Problem 1:

Someone fires a nerf gun across the room to the right. Our goal is to draw a free-body diagram of the nerf bullet as it flies, beginning from the moment after it leaves the gun and ending the moment before it strikes the wall.

A	B
	

In option A, the net horizontal force on the nerf bullet is to the right.

In option B, the net horizontal force on the nerf bullet is zero.

The direction of the horizontal velocity of the nerf bullet is to the right.

If A were correct, then according to Newton's Second Law, the nerf bullet would speed up horizontally because net horizontal force is to the right.

If B were correct, then according to Newton's First Law, the nerf bullet would move at a constant velocity horizontally because net horizontal force is zero.

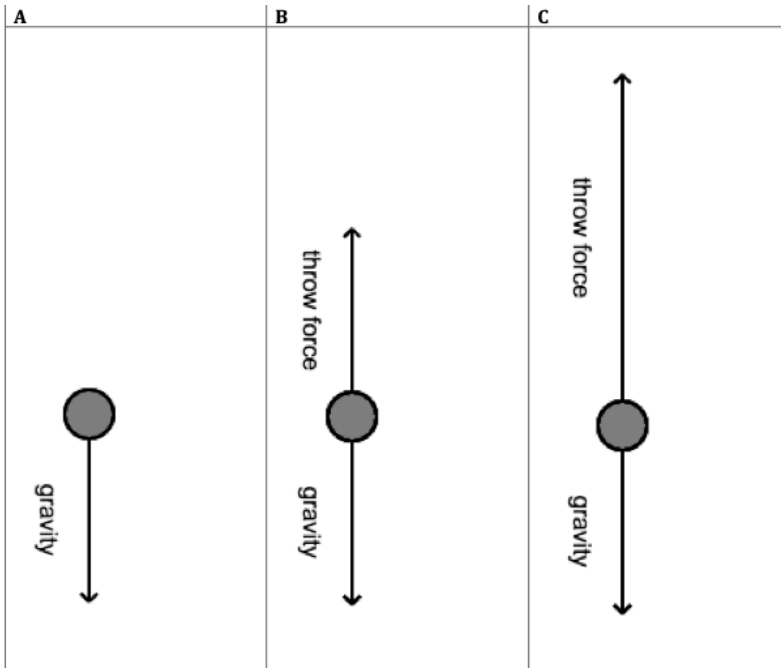
We can observe that, in real life, the nerf bullet moves at a constant velocity horizontally.

Therefore, the correct answer must be B.

The force(s) that do not exist in reality is (are) the bow force because the bow is no longer in contact with the arrow.

Problem 2: Answers

Someone throws a ball directly into the air. Our goal is to draw a free-body diagram of the ball from the moment it leaves the person's hand until it reaches the top of its arc.



In option A, the net force on the ball is downward.

In option B, the net force on the ball is zero.

In option C, the net force on the ball is upwards.

The direction of the velocity of the ball is upwards.

If A were correct, then according to Newton's Second Law, the ball would slow down because net force and velocity are opposite.

If B were correct, then according to Newton's First Law, the ball would move at a constant velocity because net force is zero.

If C were correct, then according to Newton's Second Law, the ball would speed up because net force and velocity are in the same direction.

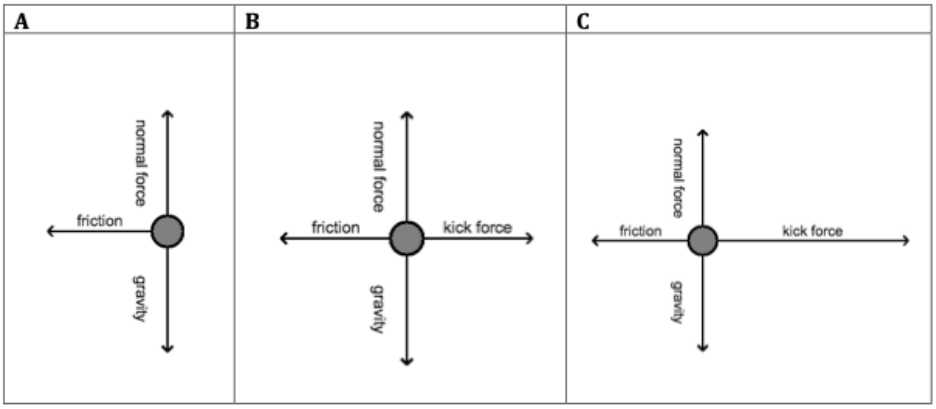
We can observe that, in real life, the ball move at a constant velocity.

Therefore, the correct answer must be A.

The force(s) that do not exist in reality is (are) the throw force because the hand throwing the ball is not in contact with it.

Problem 3: Answers

Someone kicks a book on the floor across the room. Our goal is to draw a free-body diagram of the book from the moment it leaves the person's foot until it the moment is stops moving.



In option A, the net force on the book is to the left.

In option B, the net force on the book is zero.

In option C, the net force on the book is to the right.

The direction of the velocity of the book is to the right.

If A were correct, then according to Newton's Second Law, the book would slow down because net force and velocity are in opposite directions.

If B were correct, then according to Newton's First Law, the book would move at a constant velocity because net force is zero.

If C were correct, then according to Newton's Second Law, the book would speed up because net force and velocity are in the same direction.

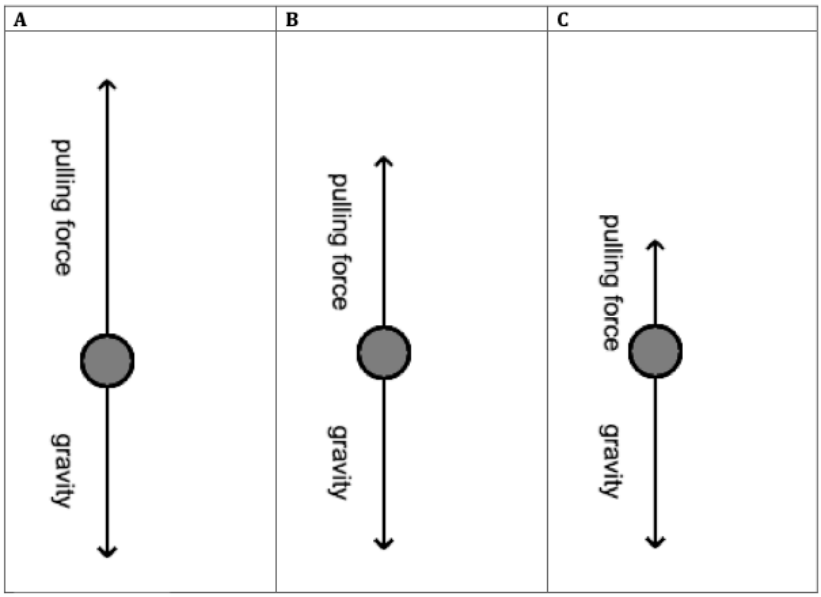
We can observe that, in real life, the book slows down.

Therefore, the correct answer must be A.

The force(s) that do not exist in reality is (are) the kick force because the foot is no longer in contact with the book.

Problem 4: Answers

Someone is lifting a box. Our goal is to draw a diagram of the box while it is in motion at a constant velocity (frequently, people lift heavy objects at a nearly constant velocity).



In option A, the net force on the box is upwards.

In option B, the net force on the box is zero.

In option C, the net force on the box is downwards.

The direction of the velocity of the arrow is upwards.

If A were correct, then according to Newton's Second Law, the box would speed up because net force and velocity are in the same direction.

If B were correct, then according to Newton's First Law, the box would move at a constant velocity because net force is zero.

If C were correct, then according to Newton's Second Law, the box would slow down because net force and velocity are in opposite directions.

We can observe that, in real life, the box moves at a constant velocity.

Therefore, the correct answer must be B.

The force(s) that do not exist in reality is (are) all of the forces shown exist, because B is correct because the relative magnitudes of forces is correctly shown in B.