Dynamics pre-class assignment

Due: 11:59pm on Thursday, May 19, 2022

You will receive no credit for items you complete after the assignment is due. Grading Policy

Exercise 4.20

A small car (mass 470 kg) is pushing a large truck (mass 1000 kg) due east on a level road. The car exerts a horizontal force of 1560 N on the truck.

Part A

What is the magnitude of the force that the truck exerts on the car?

Express your answer with the appropriate units.

ANSWER:

F = 1560 N

Correct

Newton's 3rd Law Discussed

Learning Goal:
To understand Newton's 3rd law, which states that a physical interaction always generates a *pair* of forces on the two interacting bodies.

In *Principia*, Newton wrote:
To every action there is always opposed an equal reaction: or, the mutual actions of two bodies upon each other are always equal, and directed to contrary parts.

(translation by Cajori)

The phrase after the colon (often omitted from textbooks) makes it clear that this is a statement about the nature of force. The central idea is that physical interactions (e.g., due to gravity, bodies touching, or electric forces) cause forces to arise between *pairs* of bodies. Each pairwise interaction produces a *pair* of opposite forces, one acting on each body. In summary, each physical interaction between two bodies generates a *pair* of forces. Whatever the physical cause of the interaction, the force on body A from body B is equal in magnitude and opposite in direction to the force on body B from body A.

Incidentally, Newton states that the word "action" denotes both (a) the force due to an interaction and (b) the changes in momentum that it imparts to the two interacting bodies. If you haven't learned about momentum, don't worry; for now this is just a statement about the origin of forces.

Mark each of the following statements as true or false. If a statement refers to "two bodies" interacting via some force, you are *not* to assume that these two bodies have the same mass.

Part A

Every force has one and only one 3rd law pair force.

ANSWER:

- (•) true
- ( ) false

Correct

Part B

The two forces in each pair act in opposite directions.

ANSWER:

- (•) true
- ( ) false

Correct

Part C

The two forces in each pair can either both act on the same body or they can act on different bodies.

ANSWER:

- ( ) true
- (•) false

Correct

Part D

The two forces in each pair may have different physical origins (for instance, one of the forces could be due to gravity, and its pair force could be due to friction or electric charge).

ANSWER:

- ( ) true
- (•) false

Correct

Part E

The two forces of a 3rd law pair *always* act on different bodies.

ANSWER:

- (•) true
- ( ) false

Correct

Part F

Given that two bodies interact via some force, the accelerations of these two bodies have the same magnitude but opposite directions. (Assume no other forces act on either body.)

Hint 1. $\vec{F} = m\vec{a}$

Remember $\vec{F} = m\vec{a}$: If the forces are equal in magnitude, must the accelerations also be of equal magnitude?

ANSWER:

- ( ) true
- (•) false

Correct

Newton's 3rd law can be summarized as follows: A physical interaction (e.g., gravity) operates between two interacting bodies and generates a *pair* of opposite forces, one on each body. It offers you a way to test for real forces (i.e., those that belong on the force side of $\Sigma\vec{F} = m\vec{a}$)--there should be a 3rd law pair force operating on some other body for each real force that acts on the body whose acceleration is under consideration.

Part G

According to Newton's 3rd law, the force on the (smaller) moon due to the (larger) earth is

ANSWER:

- ○ greater in magnitude and antiparallel to the force on the earth due to the moon.
- ○ greater in magnitude and parallel to the force on the earth due to the moon.
- ◉ equal in magnitude but antiparallel to the force on the earth due to the moon.
- ○ equal in magnitude and parallel to the force on the earth due to the moon.
- ○ smaller in magnitude and antiparallel to the force on the earth due to the moon.
- ○ smaller in magnitude and parallel to the force on the earth due to the moon.

Correct

A Push or a Pull?

Learning Goal:
To understand the concept of force as a push or a pull and to become familiar with everyday forces.

A force can be simply defined as *a push or a pull exerted by one object upon another*.

Although such a definition may not sound too scientific, it does capture three essential properties of forces:

- Each force is created by some object.
- Each force acts upon some *other* object.
- The action of a force can be visualized as a push or a pull.

Since each force is created by one object and acts upon another, *forces must be described as interactions*. The proper words describing the force interaction between objects A and B may be any of the following:

- "Object A acts upon object B with force $\vec{F}$."
- "Object A exerts force $\vec{F}$ upon object B."
- "Force $\vec{F}$ is applied to object B by object A."
- "Force $\vec{F}$ due to object A is acting upon object B."

One of the biggest mistakes you may make is to think of a force as "something an object *has*." In fact, at least two objects are always required for a force to exist.

Each force has a direction: *Forces are vectors.* The main result of such interactions is that the objects involved change their velocities: *Forces cause acceleration*. However, in this problem, we will not concern ourselves with acceleration--not yet.

Some common types of forces that you will be dealing with include the gravitational force (weight), the force of tension, the force of friction, and the normal force.

It is sometimes convenient to classify forces as either *contact forces* between two objects that are touching or as *long-range forces* between two objects that are some distance apart. Contact forces include tension, friction, and the normal force. Long-range forces include gravity and electromagnetic forces. Note that such a distinction is useful but not really fundamental: For

instance, on a microscopic scale the force of friction is really an electromagnetic force.

In this problem, you will identify the types of forces acting on objects in various situations.

First, consider a book resting on a horizontal table.

Part A

Which object exerts a downward force on the book?

ANSWER:

- ○ the book itself
- ◉ the earth
- ○ the surface of the table

Correct

Part B

The downward force acting on the book is _____.

ANSWER:

- ○ a contact force
- ◉ a long-range force

Correct

Part C

What is the downward force acting on the book called?

ANSWER:

- ○ tension
- ○ normal force
- ◉ weight
- ○ friction

Correct

Part D

Which object exerts an upward force on the book?

ANSWER:

- ○ the book itself
- ○ the earth
- ◉ the surface of the table

Correct

Part E

The upward force acting on the book is _____.

ANSWER:

- ◉ a contact force
- ○ a long-range force

Correct

Part F

What is the upward force acting on the book called?

ANSWER:

- ○ tension
- ◉ normal force
- ○ weight
- ○ friction

Correct

Now consider a different situation. A string is attached to a heavy block. The string is used to pull the block to the right along a rough horizontal table.

Part G

Which object exerts a force on the block that is directed toward the right?

ANSWER:

- ○ the block itself
- ○ the earth
- ○ the surface of the table
- ◉ the string

Correct

Part H

The force acting on the block and directed to the right is _____.

ANSWER:

- ◉ a contact force
- ○ a long-range force

Correct
To exert a tension force, the string must be connected to (i.e., touching) the block.

Part I

What is the force acting on the block and directed to the right called?

ANSWER:

- ◉ tension
- ○ normal force
- ○ weight
- ○ friction

Correct

Part J

Which object exerts a force on the block that is directed toward the left?

ANSWER:

- ○ the block itself
- ○ the earth
- ◉ the surface of the table
- ○ the string

Correct

Part K

The force acting on the block and directed to the left is _____.

ANSWER:

- ◉ a contact force
- ○ a long-range force

Correct

Part L

What is the force acting on the block and directed to the left called?

ANSWER:

- ○ tension
- ○ normal force
- ○ weight
- ◉ friction

Correct

Now consider a slightly different situation. The same block is placed on the same rough table. However, this time, the string is disconnected and the block is given a *quick push* to the right. The block slides to the right and eventually stops. The following questions refer to the motion of the block *after* it is pushed but *before* it stops.

Part M

How many forces are acting on the block in the horizontal direction?

ANSWER:

- ○ 0
- ◉ 1
- ○ 2
- ○ 3

Correct

Once the push has ended, there is *no force* acting to the right: The block is moving to the right because it was given a velocity in this direction by some force that is no longer applied to the block (probably, the normal force exerted by a student's hand or some spring launcher).

Once the contact with the launching object has been lost, the only horizontal force acting on the block is directed to the left--which is why the block eventually stops.

Part N

What is the force acting on the block that is directed to the *left* called?

ANSWER:

- ○ tension
- ○ normal force
- ○ weight
- ◉ friction

Correct

The force of friction does not disappear as long as the block is moving. Once the block stops, fricion becomes zero (assuming the table is perfectly horizontal).

Score Summary:

Your score on this assignment is 100%.
You received 100 out of a possible total of 100 points.