## Homework 4-1

**Due: 11:59pm on Wednesday, November 12, 2014**

To understand how points are awarded, read the Grading Policy for this assignment.

# 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:

- (selected) true
- false

**Correct**

## Part B

The two forces in each pair act in opposite directions.

ANSWER:

- (selected) 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.

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### 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

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## PSS 7.1 Interacting-Objects Problems

**Learning Goal:**

To practice Problem-Solving Strategy 7.1 for interacting-objects problems.

A 1300 -$\mathrm{kg}$ car is pushing an out-of-gear 2200 -$\mathrm{kg}$ truck that has a dead battery. When the driver steps on the accelerator, the drive wheels of the car push horizontally against the ground with a force of 4550$\mathrm{N}$ . The rolling friction of the car can be neglected, but the heavier truck has a rolling friction of 750$\mathrm{N}$ , including the "friction" of turning the truck's drivetrain. What is the magnitude of the force the car applies to the truck?

PROBLEM-SOLVING STRATEGY 7.1 Interacting-objects problems

**MODEL:** Identify which objects are part of the system and which are part of the environment. Make simplifying assumptions.
**VISUALIZE:** Draw a pictorial representation.

- Show important points in the motion with a sketch. You may want to give each object a separate coordinate system. Define symbols, and identify what the problem is trying to find.
- Identify acceleration constraints.
- Draw an interaction diagram to identify the forces on each object and all action/reaction pairs.
- Draw a *separate* free-body diagram for each object.
- Connect the force vectors of action/reaction pairs with dashed lines. Use subscript labels to distinguish forces that act independently on more than one object.

**SOLVE:** Use Newton's second and third laws.

- Write the equations of Newton's second law for *each* object, using the force information from the free-body diagrams.
- Equate the magnitudes of action/reaction pairs.
- Include the acceleration constraints, the friction model, and other quantitative information relevant to the problem.
- Solve for the acceleration, and then use kinematics to find velocities and positions.

**ASSESS:** Check that your result has the correct units, is reasonable, and answers the question.

## Model

The car and the truck are separate objects that form the system. Since only the straight-line motion of the car and truck is involved in this problem, model them as particles. The earth and the road surface are part of the environment.

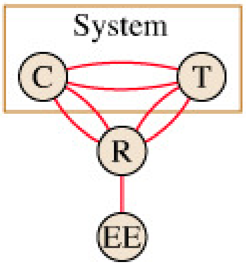
## Visualize

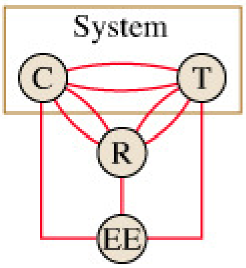
### Part A

Which of the following diagrams is the correct interaction diagram for the situation described in this problem? Each red line represents an interaction and an action/reaction pair of forces. The labels used in the diagrams are the following:

- C = car
- T = truck
- R = road surface
- EE = entire earth

ANSWER:


System
C
T
R
EE


System
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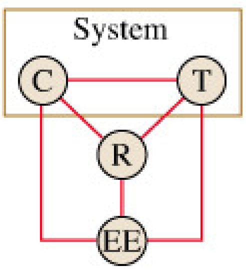
System
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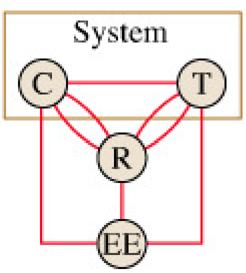
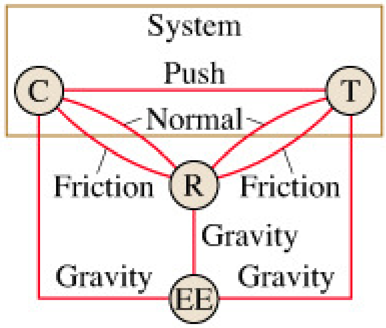

System
C
T
R
EE

## Correct

For each object in the system, three interaction lines cross the system boundary and thus represent external forces. These are the gravitational force from the entire earth, the upward normal force, and a friction force from the road surface. In addition, one interaction line connects the two objects in the system. This represents an internal interaction, that is, an action/reaction pair.




## Part B

Assuming that the car pushes the truck to the right, which of the following free-body diagrams is the correct diagram for the situation described in this problem? In each case, the diagram on the left refers to the car, and that on the right to the truck. Dashed lines connect action/reaction pairs. The following notation is used: $\vec{f}$ , $\vec{n}$, and $\vec{F}_{\rm G}$ are, respectively, friction, normal force, and gravity; subscripts C and T stand for "acting on car" and "acting on truck"; $\vec{F}_{\rm ConT}$ is the force exerted on the truck by the car; and $\vec{F}_{\rm TonC}$ is the force exerted on the car by the truck. Note that the force vectors are not drawn in scale.

### **Hint 1.** Draw the free-body diagram for the car

Complete the free body diagram of the car by drawing the forces that act on it. Assume the car pushes the truck to the right.

**Draw the vectors with their tails at the black dot, which represents the car. The orientation of your vectors will be graded. The length of your vectors will not be graded.**

ANSWER:

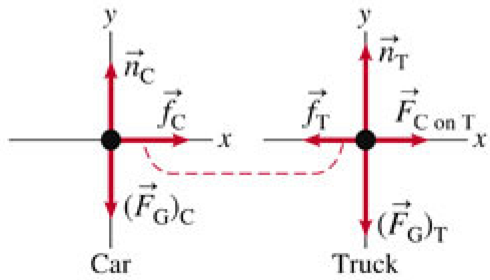
**Hint 2.** Draw the free-body diagram for the truck

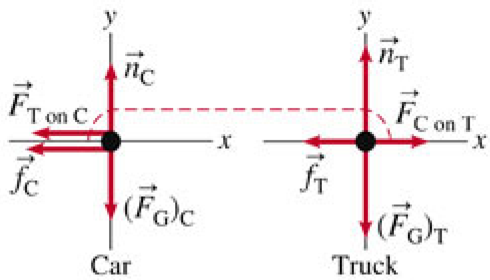
Complete the free-body diagram of the truck by drawing the forces that act on it. Assume the car pushes the truck to the right.

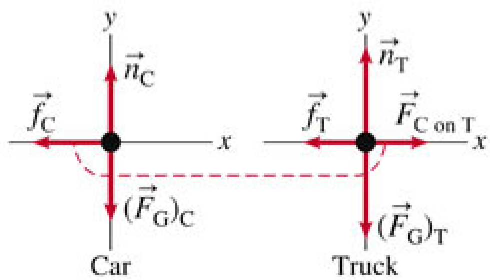
**Draw the vectors with their tails at the black dot, which represents the truck. The orientation of your vectors will be graded. The length of your vectors will not be graded.**

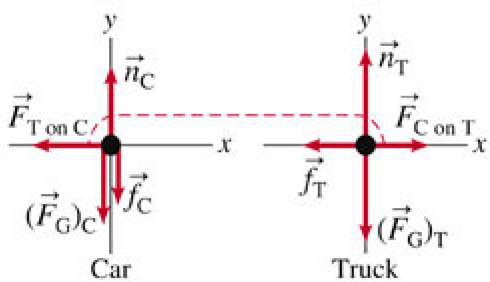
ANSWER:

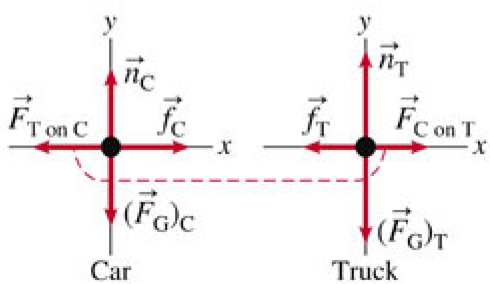
ANSWER:


y
$\vec{n}_C$
$\vec{f}_C$
x
$(\vec{F}_G)_C$
Car
y
$\vec{n}_T$
$\vec{f}_T$
$\vec{F}_{C\text{ on }T}$
x
$(\vec{F}_G)_T$
Truck


y
$\vec{n}_C$
$\vec{F}_{T\text{ on }C}$
$\vec{f}_C$
x
$(\vec{F}_G)_C$
Car
y
$\vec{n}_T$
$\vec{F}_{C\text{ on }T}$
$\vec{f}_T$
x
$(\vec{F}_G)_T$
Truck


y
$\vec{n}_C$
$\vec{f}_C$
x
$(\vec{F}_G)_C$
Car
y
$\vec{n}_T$
$\vec{f}_T$
$\vec{F}_{C\text{ on }T}$
x
$(\vec{F}_G)_T$
Truck


y
$\vec{n}_C$
$\vec{F}_{T\text{ on }C}$
x
$\vec{f}_C$
$(\vec{F}_G)_C$
Car
y
$\vec{n}_T$
$\vec{F}_{C\text{ on }T}$
$\vec{f}_T$
x
$(\vec{F}_G)_T$
Truck


y
$\vec{n}_C$
$\vec{F}_{T\text{ on }C}$
$\vec{f}_C$
x
$(\vec{F}_G)_C$
Car
y
$\vec{n}_T$
$\vec{f}_T$
$\vec{F}_{C\text{ on }T}$
x
$(\vec{F}_G)_T$
Truck

## Correct

As the car pushes the truck with a force $\vec{F}_{\rm ConT}$, the truck pushes back on the car with a reaction force $\vec{F}_{\rm TonC}$. Since $\vec{F}_{\rm ConT}$ acts on the truck, it must be shown on the truck's free-body diagram; similarly, $\vec{F}_{\rm TonC}$ acts on the car, so it is shown on the car's free-body diagram.

There is also a second action/reaction pair that is not shown in the diagram above. When the car pushes against the ground with a force of 4550$\rm N$ , the ground pushes back on the car with a force of equal magnitude. To propel forward, the car must be pushing backward against the ground. So, the ground must respond by pushing the car forward. This forward-directed force exerted by the ground is $\vec{f}_{\rm C}$, a static friction force acting on the car's tires. It is a static friction force because, even though the tires are rolling, the bottom of each tire, where it contacts the road, is instantaneously at rest. Furthermore, note that it is this forward-directed static friction force that propels the system forward!

Now that you have identified all the forces acting on the system, don't forget to include the necessary acceleration constraints in your pictorial representation. In this problem, there is only one acceleration constraint: the car and the truck are both accelerating along the *x* direction and at the same rate, so

$$a_{\rm C} = a_{\rm T} = a_x.$$

## Solve

### Part C

What is the magnitude $F_{\rm ConT}$ of the force that the car exerts on the truck? Use the coordinate system shown in Part B, where upward is the positive *y* direction and to the right, the direction $\vec{F}_{\rm ConT}$ points, is the positive *x* direction.

**Express your answer in newtons to three significant figures.**

#### Hint 1. How to approach the problem

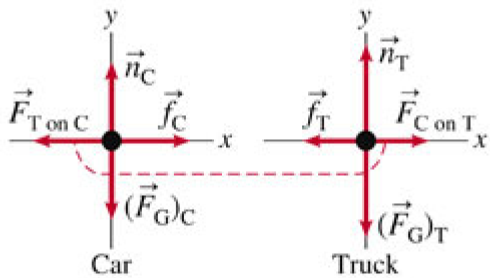
You've already identified all of the forces, their directions, and how they relate as third-law pairs. Begin by writing down Newton's second law for each component of the truck and then the car. Notice, however, that neither object has a vertical acceleration. Therefore, the *y*-component equations don't give you any information toward finding $F_{\rm ConT}$. They simply tell you that the normal force and the weight are equal and oppositely directed for each object.

Then, solve Newton's second law for the acceleration of each object (recalling that the acceleration does not have a *y* component) and substitute in the numerical values that you are given for the force magnitudes. Use the acceleration constraint to combine the two equations to give a single equation. Finally, eliminate $F_{\rm TonC}$ using the fact that the magnitudes of $\vec{F}_{\rm TonC}$ and $\vec{F}_{\rm ConT}$ are equal, and solve the resulting equation for $F_{\rm ConT}$.

#### Hint 2. Set up Newton's second law for the truck's *x* components

Write Newton's second law for the truck by adding the forces acting on the truck along the $x$ direction.

Use the coordinate system shown in Part B, where the positive *y* direction is upward, and the positive *x* direction is to the right. The signs of the forces in your expression are determined by this choice of coordinates.




**Express your answer in terms of some or all of the following variables: $F_{\rm ConT}$, the magnitude of the force the car exerts on the truck; $n_{\rm T}$, the magnitude of the normal force on the truck; $f_{\rm T}$, the magnitude of the friction between the truck's tires and the ground; and $F_{\rm GT}$, the magnitude of the gravitational force of the truck.**

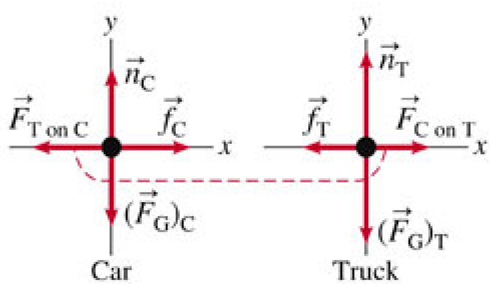
ANSWER:

$$\sum F_x = m_{\rm T} a_x = = \quad F_{\rm ConT} - f_T$$

### **Hint 3.** Set up Newton's second law for the car's *x* components

Write Newton's second law for the car by adding the forces acting on the car along the $x$ direction.

Use the coordinate system shown in Part B, where the positive *y* direction is upward, and the positive *x* direction is to the right. The signs of the forces in your expression are determined by this choice of coordinates.




**Express your answer in terms of some or all of the following variables: $F_{\rm TonC}$, the magnitude of the force the truck exerts on the car; $n_{\rm C}$, the magnitude of the normal force on the car; $f_{\rm C}$, the friction between the car's tires and the ground; and $F_{\rm GC}$, the magnitude of the weight of the car.**

ANSWER:

$$\sum F_x = m_{\rm C} a_x = = \quad f_C - F_{\rm TonC}$$

### **Hint 4.** Find the frictional force on the car

When the driver steps on the accelerator, the drive wheels of the car push against the ground with a force of 4550 $\rm N$ . What is the magnitude $f_{\rm C}$ of the frictional force exerted by the ground on the car's tires?

**Express your answer in newtons to three significant figures.**

#### **Hint 1.** The action/reaction pair

When the car pushes against the ground with the given force, the ground pushes back on the car with a force of equal *magnitude*, but opposite in *direction*.

What is the *magnitude* of the frictional force exerted by the ground on the car?

ANSWER:

$f_C$ = 4550 $\mathrm{N}$

ANSWER:

$F_{ConT}$ = 3140 $\mathrm{N}$

**Correct**

Assess

### Part D

What is the acceleration $a_T$ of the truck?

**Express your answer in meters per second squared to three significant figures.**

**Hint 1.** How to approach the problem

Since you have found $F_{ConT}$ , and you are given the frictional force acting on the truck, you can calculate the net force on the truck. Just use Newton's second law with this net force and the mass given in the introduction to find the truck's acceleration.

ANSWER:

$a_T$ = 1.09 $\mathrm{m/s^2}$

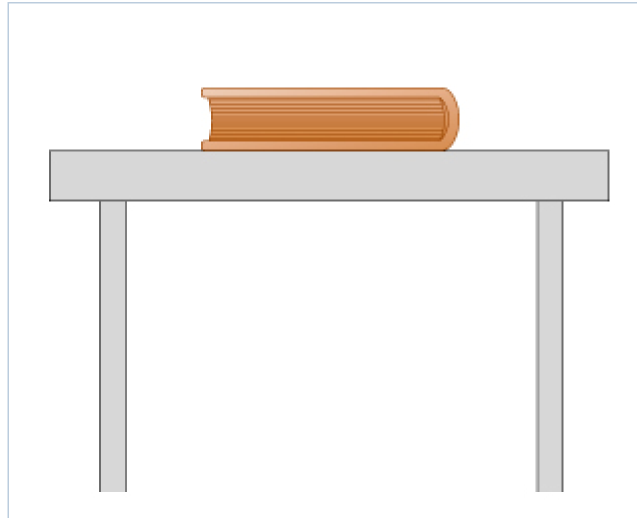
**Correct**

This is a reasonable acceleration for a truck being pushed by a car. If you had found something greater than 10 $\mathrm{m/s^2}$ , you should be suspicious, since that would imply that the truck were accelerating more quickly than if it had been dropped from a building. Similarly, if you had found an acceleration less than 0.1 $\mathrm{m/s^2}$ , you should be suspicious, as this is an extremely small acceleration for a car (even one pushing a truck).

Notice, also, that the force that the car exerts on the truck is smaller than the force that the ground exerts on the car. This should make sense to you: If the car exerted a greater force on the truck than the ground exerted on the car, the third-law partner (the force that the truck exerts on the car) would be so big that the net force on the car would be backward!

# A Book on a Table

A book weighing 5 N rests on top of a table.



## Part A

A downward force of magnitude 5 N is exerted on the book by the force of

ANSWER:

- the table
- gravity
- inertia

**Correct**

## Part B

An upward force of magnitude _____ is exerted on the _____ by the table.

ANSWER:

- 6 N / table
- 5 N / table
- 5 N / book
- 6 N / book

**Correct**

## Part C

Do the downward force in Part A and the upward force in Part B constitute a 3rd law pair?

**Hint 1.** The force of gravity

The force of gravity is another name for the force exerted by the earth (or any astronomical object) on objects near its surface.

**Hint 2.** Exploring Newton's 3rd law

Indicate whether the following statements about Newton's 3rd law are true, false, or indeterminate.

1. According to Newton's 3rd law, every real force has a unique pair force.
2. The pair force is called a "fictitious force."
3. The force and pair force must act on different point masses.
4. The force and the pair force must always have the same magnitude and must also act in exactly opposite directions.

**Enter t for true, f for false, or i for indeterminate for each statement, separating the answers with commas (e.g., if all but the first statement were true, you would enter f,t,t,t).**

ANSWER:

$t,f,t,t$

ANSWER:

- yes
- no

**Correct**

## Part D

The reaction to the force in Part A is a force of magnitude _____, exerted on the _____ by the _____. Its direction is _____ .

**Hint 1.** The force of gravity

The force of gravity is another name for the force exerted by the earth (or any astronomical object) on objects near its surface.

ANSWER:

- 5 N / earth / book / upward
- 5 N / book / table / upward
- 5 N / book / earth / upward
- 5 N / earth / book / downward

**Correct**

## Part E

The reaction to the force in Part B is a force of magnitude _____, exerted on the _____ by the _____. Its direction is _____.

ANSWER:

- 5 N / table / book / upward
- 5 N / table / earth / upward
- 5 N / book / table / upward
- 5 N / table / book / downward
- 5 N / earth / book / downward

**Correct**

## Part F

Which of Newton's laws could we have used to predict that the forces in Parts A and B are equal and opposite?

**Check all that apply.**

ANSWER:

- [x] Newton's 1st law
- [x] Newton's 2nd law
- [ ] Newton's 3rd law

**Correct**

Since the book is at rest, either Newton's 1st or 2nd law can tell us that the net force on it must be zero. This means that the force exerted on it by the earth must be equal and opposite to the force exerted on it by the table.

## Part G

Which of Newton's laws could we have used to predict that the forces in Parts B and E are equal and opposite?

**Check all that apply.**

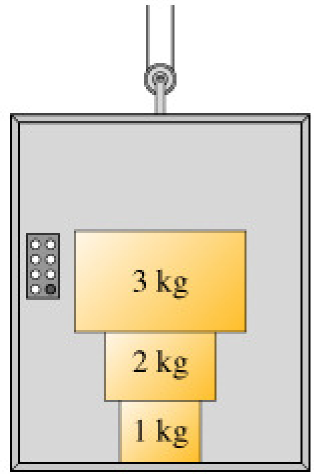
ANSWER:

- [ ] Newton's 1st law
- [ ] Newton's 2nd law
- [x] Newton's 3rd law

**Correct**

## Blocks in an Elevator Ranking Task

Three blocks are stacked on top of each other inside an elevator as shown in .




Answer the following questions with reference to the eight forces defined as follows.

- the force of the 3 $\mathrm{kg}$ block on the 2 $\mathrm{kg}$ block, $F_{3 \text{ on } 2}$,
- the force of the 2 $\mathrm{kg}$ block on the 3 $\mathrm{kg}$ block, $F_{2 \text{ on } 3}$,
- the force of the 3 $\mathrm{kg}$ block on the 1 $\mathrm{kg}$ block, $F_{3 \text{ on } 1}$,
- the force of the 1 $\mathrm{kg}$ block on the 3 $\mathrm{kg}$ block, $F_{1 \text{ on } 3}$,
- the force of the 2 $\mathrm{kg}$ block on the 1 $\mathrm{kg}$ block, $F_{2 \text{ on } 1}$,
- the force of the 1 $\mathrm{kg}$ block on the 2 $\mathrm{kg}$ block, $F_{1 \text{ on } 2}$,
- the force of the 1 $\mathrm{kg}$ block on the floor, $F_{1 \text{ on floor}}$, and
- the force of the floor on the 1 $\mathrm{kg}$ block, $F_{\text{floor on } 1}$.

### Part A

Assume the elevator is at rest. Rank the magnitude of the forces.

**Rank from largest to smallest. To rank items as equivalent, overlap them.**

**Hint 1.** Newton's 3rd law

Newton's 3rd law states that when two objects exert forces on each other, these forces are always equal in magnitude and opposite in direction.

**Hint 2.** Contact forces

If two objects touch each other, they exert forces on each other according to Newton's 3rd law. If two objects do not touch each other, they cannot exert forces on each other. (Here we are assuming that the forces of gravity and electromagnetism between the objects are negligible.) For instance, the blocks with masses 1 $\mathrm{kg}$ and 3 $\mathrm{kg}$ are not in contact, therefore, the force $F_{1 \text{ on } 3}$ must be zero. While statements such as "block 3 applies a force to block 1 that is transferred through block 2" might sound reasonable, in physics such statements don't make sense.

ANSWER:

**Correct**

## Part B

Now, assume the elevator is moving upward at increasing speed. Rank the magnitude of the forces.

**Rank from largest to smallest. To rank items as equivalent, overlap them.**

**Hint 1.** Effects of acceleration

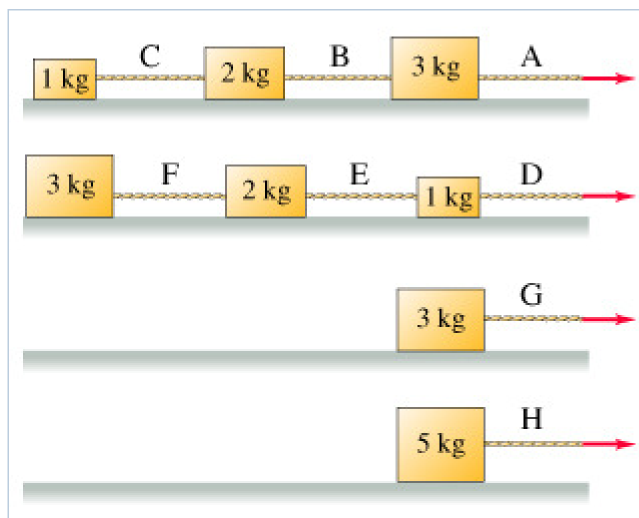
If the elevator is accelerating, the net force on each block cannot be zero. However, note that the forces you are asked to compare do not comprise the net force on any of the blocks.

ANSWER:

**Correct**

## Kinetic Friction Ranking Task

Below are eight crates of different mass. The crates are attached to massless ropes, as indicated in the picture, where the ropes are marked by letters. Each crate is being pulled to the right at the same constant speed. The coefficient of kinetic friction between each crate and the surface on which it slides is the same for all eight crates.




### Part A

Rank the ropes on the basis of the force each exerts on the crate immediately to its left.

**Rank from largest to smallest. To rank items as equivalent, overlap them.**

**Hint 1.** General problem-solving strategy

To make reasonable comparisons among forces you should proceed as follows:

1. Isolate individual objects via free-body diagrams.
2. Identify the forces that act on each object.
3. Determine the acceleration of each object.
4. Finally, apply Newton's 2nd law to each object.

You may ultimately be able to do this in your head, but if you are not at that stage, you should draw the necessary free-body diagrams to analyze this problem.

### **Hint 2.** Evaluate the effect of friction

The coefficient of friction between each crate and the surface on which it slides is identical. Based on this fact, is the frictional force acting on each crate identical?

ANSWER:

- ○ yes
- ◉ no

### **Hint 3.** Examine the top chain of crates

Examine the entire chain of three masses pulled by rope A, and consider the total frictional force impeding this chain's motion. To what value of mass is this force proportional?

ANSWER:

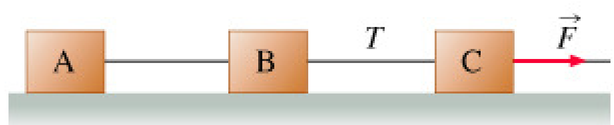
- ○ 1 $\mathrm{kg}$
- ○ 2 $\mathrm{kg}$
- ○ 3 $\mathrm{kg}$
- ○ 4 $\mathrm{kg}$
- ○ 5 $\mathrm{kg}$
- ◉ 6 $\mathrm{kg}$

ANSWER:

**Correct**

## Pulling Three Blocks

Three identical blocks connected by ideal strings are being pulled along a horizontal frictionless surface by a horizontal force $\vec{F}$. The magnitude of the tension in the string between blocks B and C is $T$ = 3.00$\mathrm{N}$ . Assume that each block has mass $m$ = 0.400$\mathrm{kg}$ .




### Part A

What is the magnitude $F$ of the force?

**Express your answer numerically in newtons.**

**Hint 1.** Find the acceleration of block B

What is the magnitude $a_{\mathrm{B}}$ of the acceleration of block B?

**Express your answer numerically in meter per second squared.**

**Hint 1.** Consider blocks A and B as a unit

Since blocks A and B are not moving with respect to each other, you can treat them as one larger "object." This larger object has the same acceleration as either block A or block B alone. The advantage of such an approach is that the larger object has only one force acting on it (the tension 3.00$\mathrm{N}$ in the rope).

ANSWER:

$a_{\mathrm{B}}$ = 3.75 $\mathrm{m/s^2}$

**Hint 2.** Find the acceleration of all three blocks

Which of the following expressions gives the magnitude $a$ of the acceleration of the three blocks?

**Hint 1.** Consider all three blocks as a unit

Since the three blocks are not moving with respect to one another, you can treat them as one larger "object" of mass equal to the sum of the masses of all three blocks. The only horizontal force acting on this larger object is $\vec{F}$, so you can use Newton's 2nd law to determine an expression for its acceleration.

ANSWER:

- ○ $a = \frac{F}{m}$
- ○ $a = \frac{F}{2m}$
- ◉ $a = \frac{F}{3m}$
- ○ $a = \frac{T}{3m}$

ANSWER:

$F$ = 4.50 $\mathrm{N}$

**Correct**

## Part B

What is the tension $T_{\mathrm{AB}}$ in the string between block A and block B?

**Express your answer numerically in newtons**

**Hint 1.** How to approach the question

The tension $T_{\mathrm{AB}}$ is the only horizontal force acting on block A. Thus, you can find the acceleration of block A and then apply Newton's 2nd law. Note that all three blocks have the same acceleration.

ANSWER:

$T_{AB}$ = 1.50 N

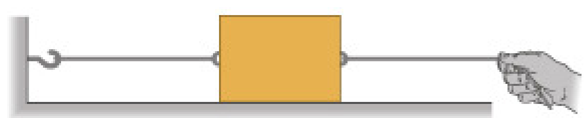
**Correct**

## Video Tutor: Suspended Balls: Which String Breaks?

First, launch the video below. You will be asked to use your knowledge of physics to predict the outcome of an experiment. Then, close the video window and answer the question at right. You can watch the video again at any point.


### Part A

A heavy crate is attached to the wall by a light rope, as shown in the figure. Another rope hangs off the opposite edge of the box. If you slowly increase the force on the free rope by pulling on it in a horizontal direction, which rope will break? Ignore friction and the mass of the ropes.

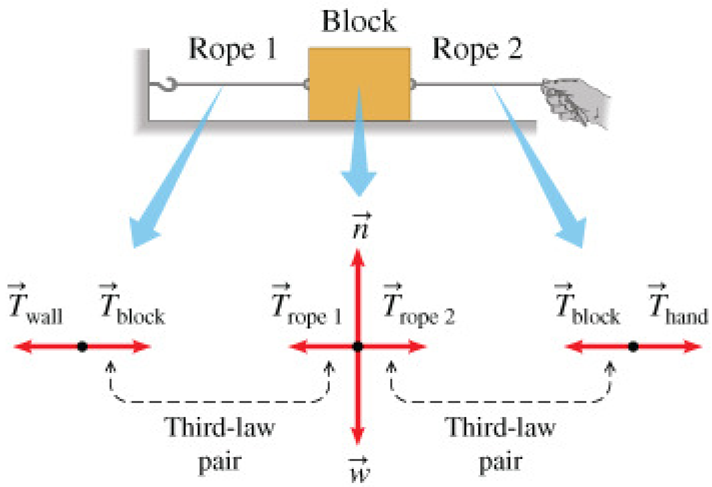


**Hint 1.** How to approach the problem

Because you *slowly* increase the force you exert on the rope, the block's inertia does not affect the outcome.

Why is that the case? As you pull harder, the ropes stretch a bit, so the block slides slightly toward you. But the changes are so gradual that the *accelerations* of the block and ropes are practically zero at any instant.

Shown here are free-body diagrams for the ropes and block:




What does Newton's third law say about the tension forces exerted *by the block* on the two ropes?

ANSWER:

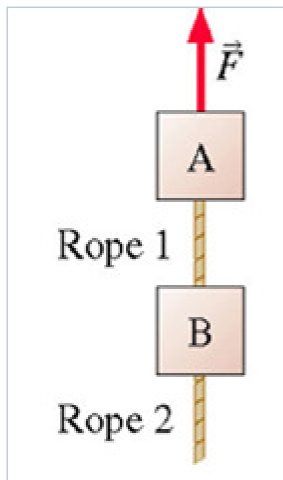
- Both ropes are equally likely to break.
- The rope attached to the wall will break.
- The rope that you are pulling on will break.

**Correct**

Since the attached rope doesn't have to support any weight (as it did in the vertical case), the tension is the same in both ropes.

## Problem 7.13

The figure shows two $1.0 \mathrm{kg}$ blocks connected by a rope. A second rope hangs beneath the lower block. Both ropes have a mass of $250 \mathrm{g}$ . The entire assembly is accelerated upward at $3.0 \mathrm{m/s^2}$ by force $\vec{F}$.




### Part A

What is $F$?

**Express your answer to two significant figures and include the appropriate units.**

ANSWER:

$F$ = 32 $\mathrm{N}$

Correct

## Part B

What is the tension at the top end of rope 1?

**Express your answer to two significant figures and include the appropriate units.**

ANSWER:

$T$ = 19 $\mathrm{N}$

Correct

## Part C

What is the tension at the bottom end of rope 1?

**Express your answer to two significant figures and include the appropriate units.**

ANSWER:

$T$ = 16 $\mathrm{N}$

Correct

## Part D

What is the tension at the top end of rope 2?

**Express your answer to two significant figures and include the appropriate units.**

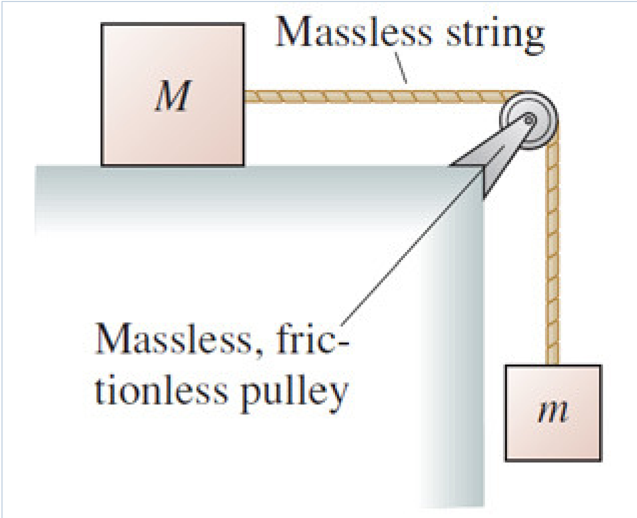
ANSWER:

$T$ = 3.2 $\mathrm{N}$

Correct

# Problem 7.36

The block of mass $M$ in the following figure slides on a frictionless surface.




## Part A

Find an expression for the tension in the string.

**Express your answer in terms of the variables $m$, $M$, and appropriate constants.**

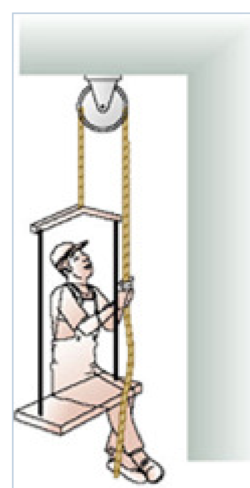
ANSWER:

$T = \frac{mg}{1+\frac{m}{M}}$

**Correct**

# Problem 7.46

A house painter uses the chair and pulley arrangement of the figure to lift himself up the side of a house. The painter's mass is 74$\mathrm{kg}$ and the chair's mass is 11$\mathrm{kg}$ .



## Part A

With what force must he pull down on the rope in order to accelerate upward at $0.20 \mathrm{m/s^2}$ ?

**Express your answer to two significant figures and include the appropriate units.**

ANSWER:

$F$ = 430 $\mathrm{N}$

**Answer Requested**

**Score Summary:**

Your score on this assignment is 90.0%.
You received 9 out of a possible total of 10 points.