MASSACHUSETTS COMPREHENSIVE ASSESSMENT SYSTEM

PRACTICE TEST

Introductory Physics

High School

Student Name

School Name

District Name

MASSACHUSETTS
Department of Elementary and Secondary Education

High School Introductory Physics

PRACTICE TEST

SESSION 1

This practice session contains 21 questions.

Directions

Read each question carefully and then answer it as well as you can. You must record all answers in this Practice Test Booklet.

For some questions, you will mark your answers by filling in the circles in your Practice Test Booklet. Make sure you darken the circles completely. Do not make any marks outside of the circles. If you need to change an answer, be sure to erase your first answer completely.

If a question asks you to show or explain your work, you must do so to receive full credit. Write your response in the space provided. Only responses written within the provided space will be scored.

If you do not know the answer to a question, you may go on to the next question. When you are finished, you may review your answers and go back to any questions you did not answer.

1 A musical instrument produces a sound with a frequency of 1318 Hz. The speed of the sound wave is 340 m/s.

What is the wavelength of the sound that the instrument produces?

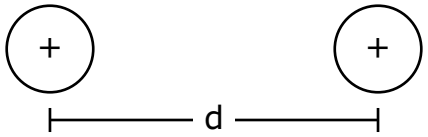
Ⓐ 0.003 m

Ⓑ 0.258 m

Ⓒ 978.0 m

Ⓓ 1658 m

2 Two positive charges are held at a distance, d, as shown.



The charges are released and allowed to move freely. Which of the following best describes how the characteristics of the system will most likely change after the charges are released?

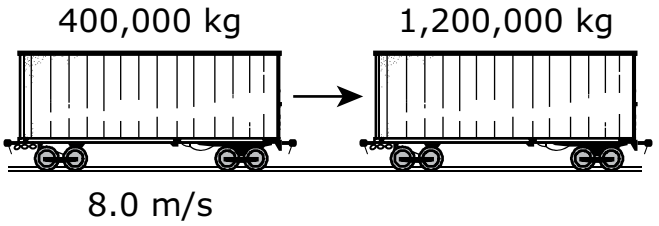
Ⓐ The distance and the electric forces between the charges will both increase.

Ⓑ The distance and the electric forces between the charges will both decrease.

Ⓒ The distance between the charges will increase and the electric forces between the charges will decrease.

Ⓓ The distance between the charges will decrease and the electric forces between the charges will increase.

3 A railroad car with a mass of 400,000 kg is moving at a speed of 8.0 m/s toward a stationary railroad car with a mass of 1,200,000 kg, as shown in the diagram.



The moving car connects to the stationary car. Both cars then move in the same direction the first car was moving.

What is the speed of both railroad cars after they connect?

Ⓐ 1.0 m/s

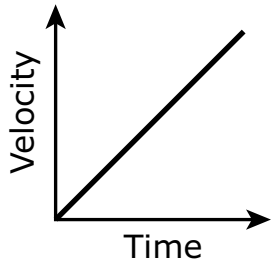
Ⓑ 2.0 m/s

Ⓒ 4.0 m/s

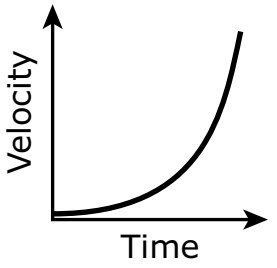
Ⓓ 8.0 m/s

4 Which graph represents the motion of an object that has zero net force acting on it?

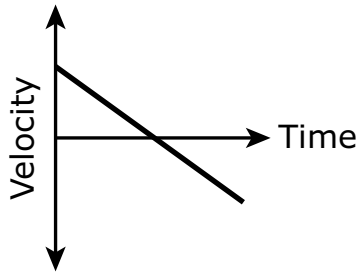
Ⓐ



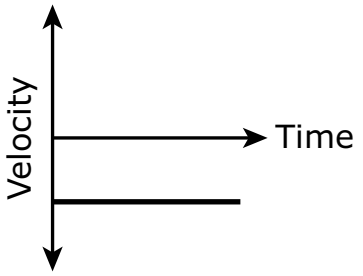
Ⓑ



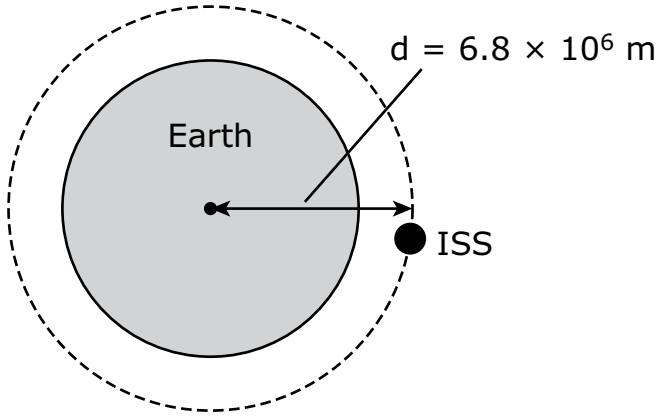
Ⓒ



Ⓓ



5 The International Space Station (ISS) orbits Earth at an average distance of 6.8×10^6 m from the center of Earth, as shown in the diagram.



(not to scale)

The mass of the ISS is 4.2×10^5 kg, and the mass of Earth is 6.0×10^{24} kg. What is the magnitude of the average gravitational force that acts on the ISS?

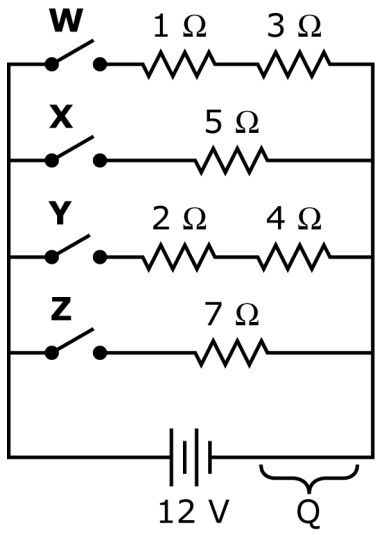
Ⓐ 4.0×10^{-14} N

Ⓑ 4.0×10^{-3} N

Ⓒ 3.7×10^6 N

Ⓓ 3.7×10^{23} N

6 The diagram shows a circuit with four switches: W, X, Y, and Z.



A student wants the largest possible current to pass through location Q when the student closes two of the switches.

Select the **two** switches the student should close.

Ⓐ W

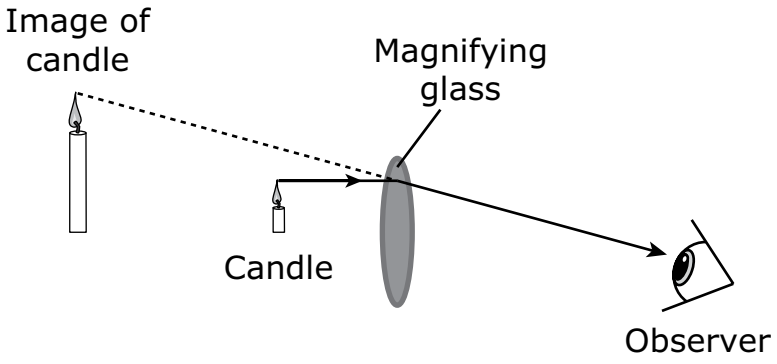
Ⓑ X

Ⓒ Y

Ⓓ Z

This question has two parts.

7 A magnifying glass was used to create an enlarged image of a candle. The diagram shows the candle and the image of the candle that an observer saw. The solid lines represent the actual path of light.



Part A

Which of the following explains why the light traveled from the candle to the observer in the path shown?

Ⓐ The light refracted as it entered and exited the magnifying glass.

Ⓑ The light diffracted as it entered and exited the magnifying glass.

Ⓒ The light reflected off the surface of the magnifying glass instead of passing through the magnifying glass.

Ⓓ The light traveled as a particle through the magnifying glass instead of traveling as a wave through the magnifying glass.

Part B

The path of the light from the candle appeared to bend as it traveled to the observer.

As the light from the candle entered the magnifying glass, the light

Ⓐ sped up.

Ⓑ slowed down.

Because the frequency of the light did not change, the wavelength of the light

Ⓐ increased.

Ⓑ decreased.

8 A student will drop water balloons into four containers to determine which container best minimizes the collision force on the water balloons so that they do not break.

Select **two** variables that the student must keep constant during testing to determine which container best minimizes the collision force on the water balloons.

Ⓐ the mass of each water balloon

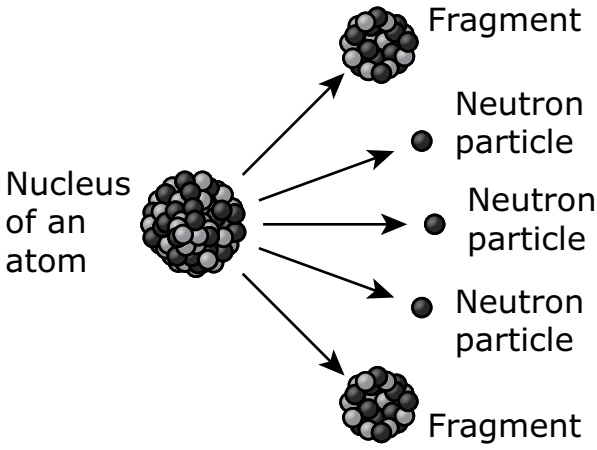
Ⓑ the temperature of each water balloon

Ⓒ the frequency of dropping water balloons

Ⓓ the height from which water balloons are dropped

Ⓔ the time between dropping one water balloon and the next

9 Some atomic nuclei can be split apart into fragments and other particles, such as neutrons. Once a nucleus is split, fragments move away from each other very quickly. The fragments then slow down as they interact with the surrounding medium. An example of this process is shown in the diagram.



What type of nuclear process occurs when an atomic nucleus splits into fragments?

Ⓐ fission

Ⓑ fusion

Which of the following describes the energy during this nuclear process?

Ⓐ The fragments initially have kinetic energy, which is transferred to the surrounding medium as mass.

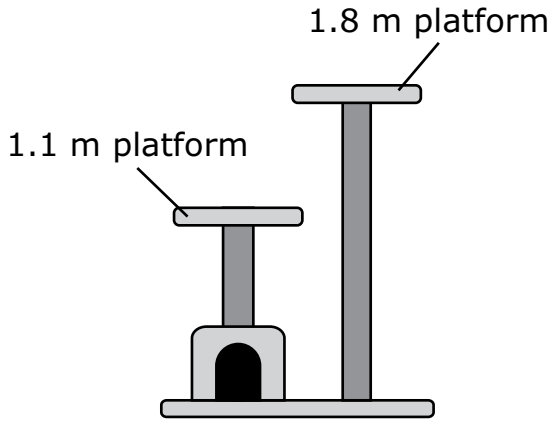
Ⓑ The fragments initially have gravitational energy, which is transferred to the surrounding medium as mass.

Ⓒ The fragments initially have kinetic energy, which is transferred to the surrounding medium as thermal energy.

Ⓓ The fragments initially have gravitational energy, which is transferred to the surrounding medium as thermal energy.

This question has two parts.

10 Cats play and sleep on cat towers. A cat tower with two platforms is shown. One platform is 1.8 m above the ground, and the second platform is 1.1 m above the ground.



Part A

A 1.5 kg cat sat on the 1.8 m platform. What was the gravitational potential energy of the cat relative to the ground?

Ⓐ 2.4 J

Ⓑ 10.5 J

Ⓒ 18 J

Ⓓ 27 J

Part B

The cat jumped from the 1.8 m platform to the 1.1 m platform. Which of the following best describes the gravitational potential energy (GPE) and the kinetic energy (KE) of the cat as it was moving to the 1.1 m platform?

Ⓐ The cat's GPE and KE increased.

Ⓑ The cat's GPE and KE decreased.

Ⓒ The cat's GPE decreased and its KE increased.

Ⓓ The cat's GPE increased and its KE decreased.

11 Four students took turns pushing a box. The table shows the forces they exerted on the box, the distances they pushed it, and the amount of time they pushed it.

Student	Force (N)	Distance (m)	Time (s)
W	10	4	5
X	5	8	8
Y	5	12	10
Z	1	14	8

Which two students did the same amount of work?

Ⓐ students W and X

Ⓑ students X and Y

Ⓒ students Y and Z

Ⓓ students Z and W

12 A 60 Ω resistor is connected to a 1.5 V battery. If the internal resistance of the battery is ignored, what current will flow through the resistor?

Ⓐ 0.025 A

Ⓑ 0.040 A

Ⓒ 0.084 A

Ⓓ 0.090 A

13 Newton's universal law of gravitation and Coulomb's law have mathematical formulas that look similar. Which of the following is a difference between the forces described by these two laws?

Ⓐ The force due to gravity requires two objects, but the force due to electric charge requires only one object.

Ⓑ The force due to gravity is only attractive, but the force due to electric charge can be attractive or repulsive.

Ⓒ The force due to gravity varies inversely with the square of the distance, but the force due to electric charge does not.

Ⓓ The force due to gravity increases as distance decreases, but the force due to electric charge decreases as distance decreases.

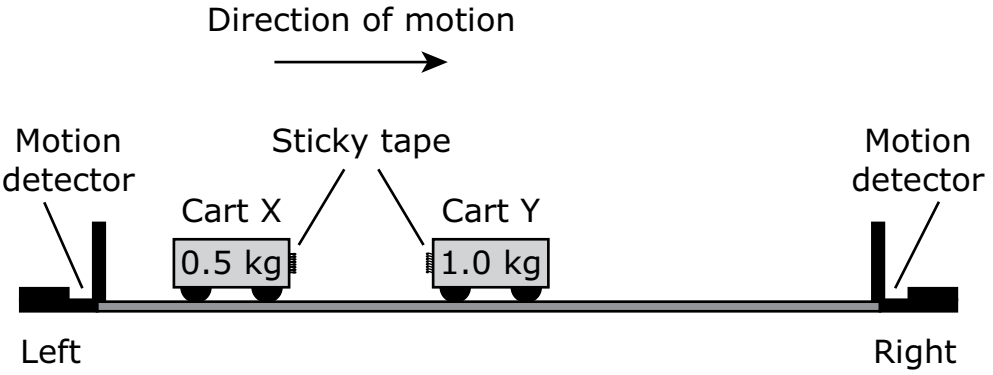
The following section focuses on collisions between two carts.

Read the information below and use it to answer the selected-response questions and constructed-response question that follow.

A group of students conducted two trials to investigate collisions between two carts, X and Y, on a straight, level track. Cart X has a mass of 0.5 kg and cart Y has a mass of 1.0 kg. The students used motion detectors to determine the velocities of the carts as they moved along the track. Assume friction was negligible.

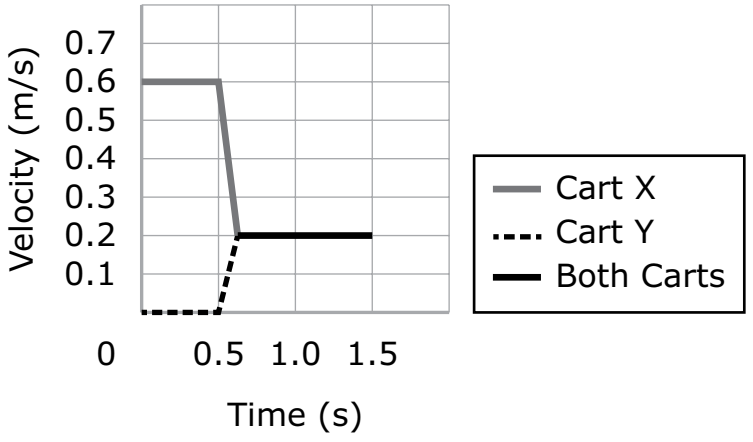
Trial 1

The students attached sticky tape on one end of each cart, as shown in the diagram, so that the carts would stay together after the collision.



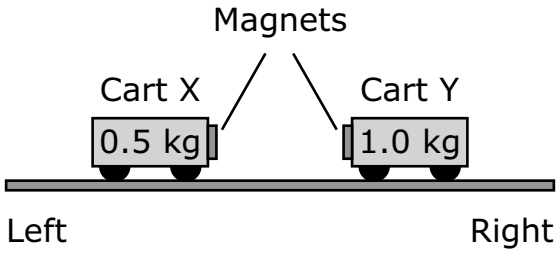
A student pushed cart X toward cart Y and let go of the cart. Cart X then collided with cart Y. The graph shows the velocity of each cart before, during, and after the collision.

Trial 1: Velocity vs. Time



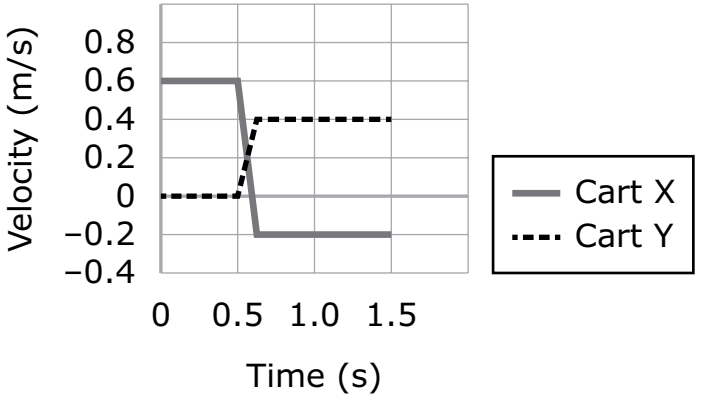
Trial 2

The students removed the sticky tape and attached a small, strong magnet on the front of each cart, as shown. The north ends of the magnets were facing each other.



The student again pushed cart X toward cart Y and let go of the cart. Cart X collided with cart Y. The graph shows the velocity of each cart before, during, and after the collision.

Trial 2: Velocity vs. Time



14 What was the momentum of cart X **before** the collision in trial 1?

Ⓐ 0.2 kg · m/s

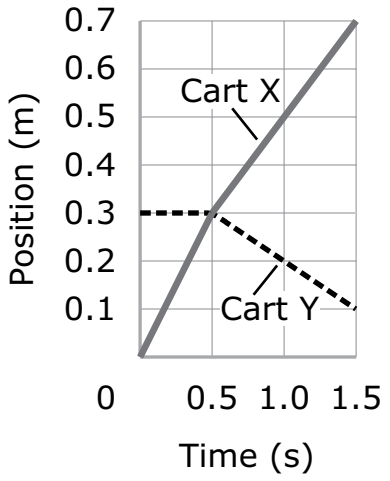
Ⓑ 0.3 kg · m/s

Ⓒ 0.6 kg · m/s

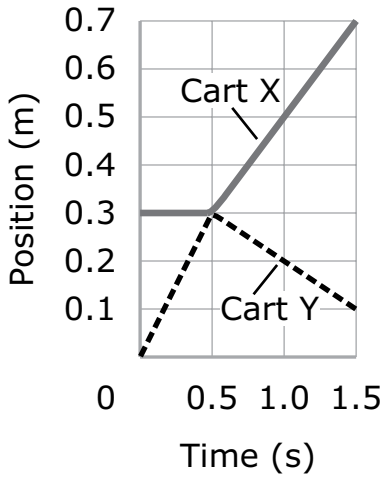
Ⓓ 0.8 kg · m/s

15 Which of the following graphs represents the data from trial 2?

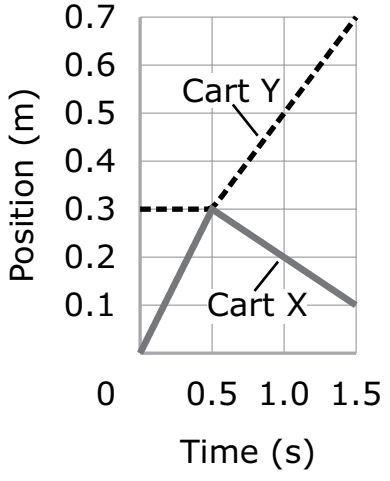
Ⓐ



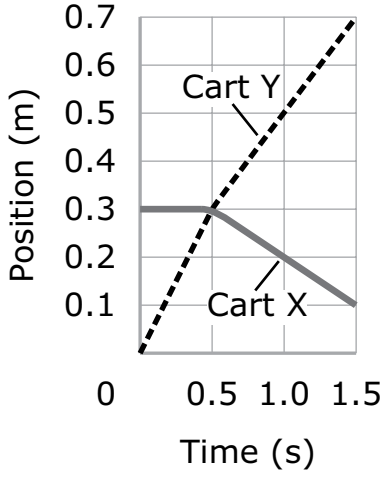
Ⓑ



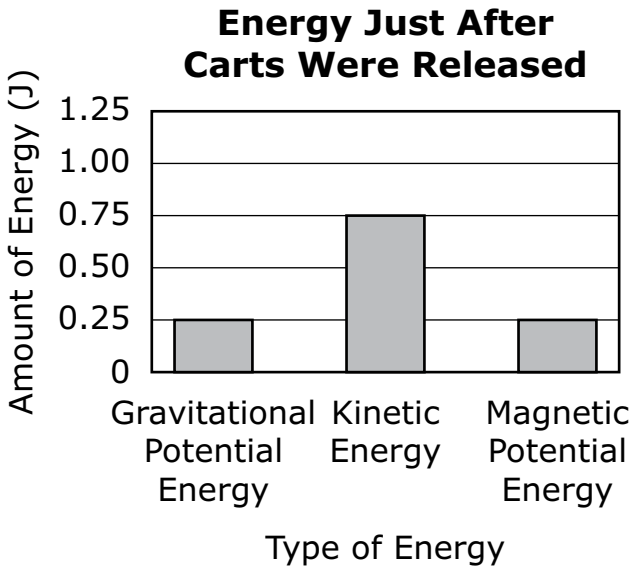
Ⓒ



Ⓓ



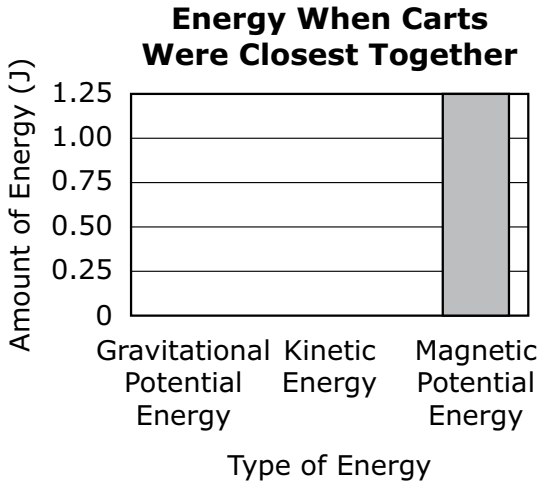
16 The students conducted another trial with magnets. The new trial was similar to trial 2, except they pushed both carts toward each other at the same time and then released each cart. The bar graph shows the total energy in the system just after the students released the carts.



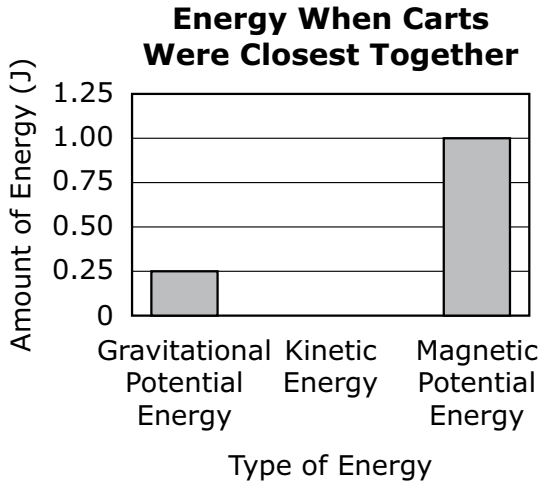
The carts came to a brief stop when they were closest together.

Which of the following bar graphs represents the amount of each type of energy in the system when the carts were closest together?

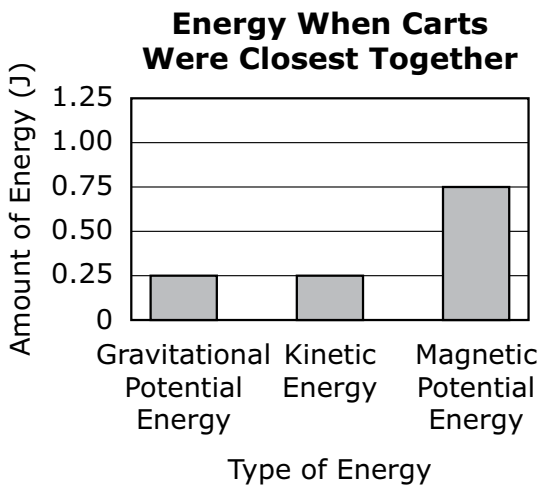
Ⓐ



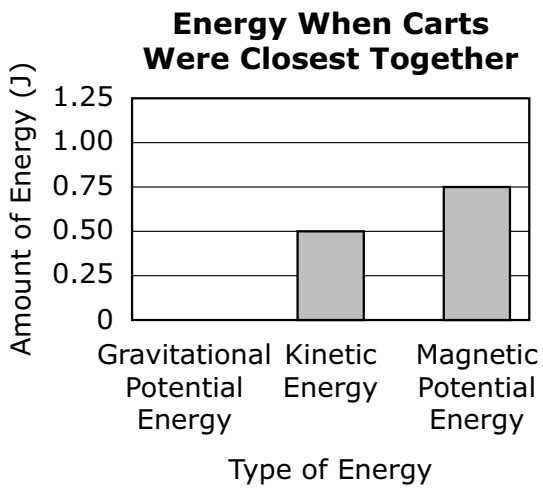
Ⓑ



Ⓒ



Ⓓ



This question has three parts. Write your response on the next page. Be sure to label each part of your response.

17 In trial 1, cart X and cart Y collided and attached to each other. During the collision, each cart exerted a force on the other cart.

A. Compare the magnitudes of the forces that cart X and cart Y exerted on each other during the collision. Explain your reasoning.

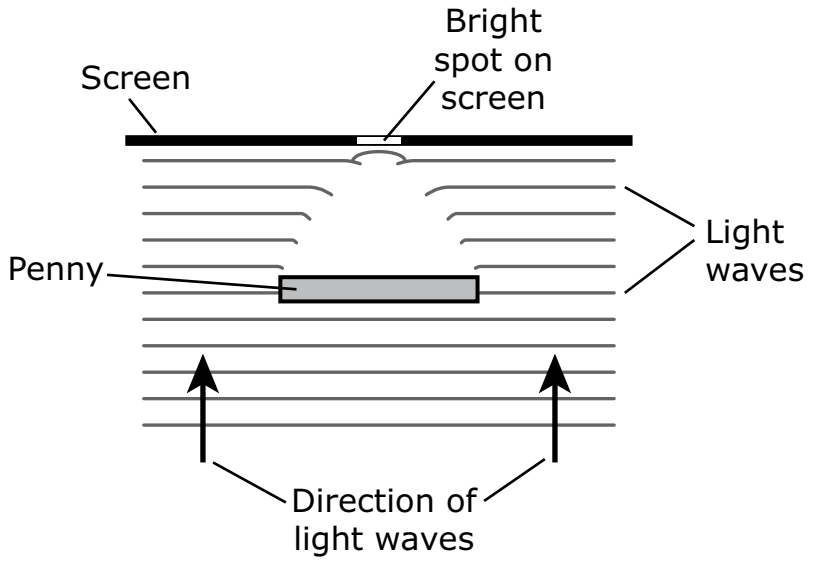
B. The collision between cart X and cart Y occurred from 0.5 s to 0.6 s.

Calculate the acceleration of cart X during the collision. Show your calculations and include units in your answer.

C. Calculate the magnitude of the force exerted on cart X by cart Y during the collision. Show your calculations and include units in your answer.

17

18 Some students set up a demonstration that involved shining light on a penny and a screen behind the penny. Based on their observations, the students made the model shown.



The students claim that the model shows light acting like a wave.

Select the **two** pieces of evidence that support the students' claim.

Ⓐ Light reflected around the penny.

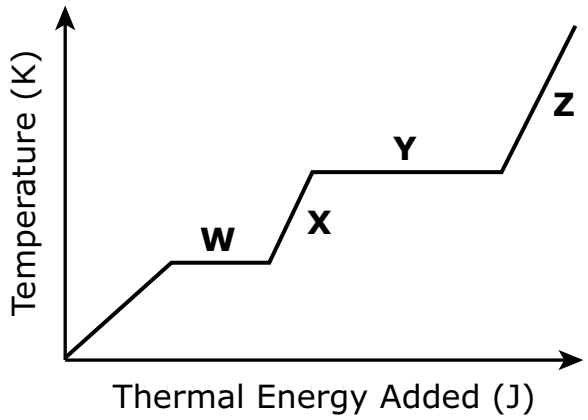
Ⓑ Light diffracted around the penny.

Ⓒ A bright spot appeared on the screen because of constructive interference.

Ⓓ Photoelectrons were released from the penny because the light became excited.

19 The graph shows the change in temperature of a substance as thermal energy is added. Four sections of the graph are labeled.

Heating Curve for a Substance



In which section of the graph is the substance changing phase from a liquid to a gas?

Ⓐ section W

Ⓑ section X

Ⓒ section Y

Ⓓ section Z

This question has three parts. Write your response on the next page. Be sure to label each part of your response.

20 A person at a baseball game is seated 200 m away from a batter. The person sees the batter hit a ball, and then hears the sound of the ball being hit 0.58 s later.

A. Calculate the speed of the sound wave created when the bat hits the ball. Show your calculations and include units in your answer.

B. Besides the difference in speed of the two types of waves, describe **two** additional differences between the visible light waves and the sound waves produced when the ball is hit.

C. The game is also broadcast over the radio for people who cannot attend the game. Radio waves carry the broadcast signal.

One way that visible light waves differ from radio waves is that they can be seen by humans, while radio waves cannot. Describe a second difference between the two types of waves.

20

This question has three parts. Write your response on the next page. Be sure to label each part of your response.

21 Two students push a bookcase at a constant speed to the right across a floor.

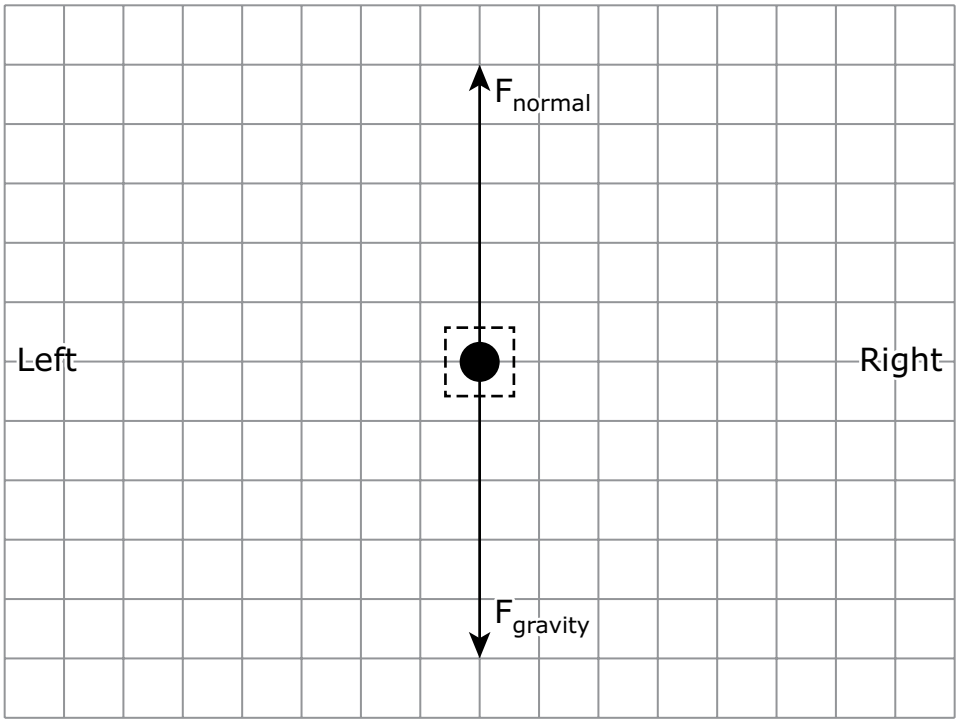
A. Complete the free-body force diagram for the bookcase moving at a constant speed. Draw and label **two** arrows to represent the horizontal forces.

- Draw each arrow on the free-body force diagram.
- The length of an arrow represents the magnitude of the force.
- Label one arrow $F_{friction}$ and the other arrow F_{push} to identify the force that each arrow represents.

B. Identify one change to the floor that would affect the amount of force required to move the bookcase at a constant speed. Explain how the change affects the amount of force required to move the bookcase.

C. Identify another change, this time to the bookcase, that would affect the amount of force required to move the bookcase at a constant speed. Explain how the change affects the amount of force required to move the bookcase.

21 A.



STOP!

High School Introductory Physics

PRACTICE TEST

SESSION 2

This practice session contains 22 questions.

Directions

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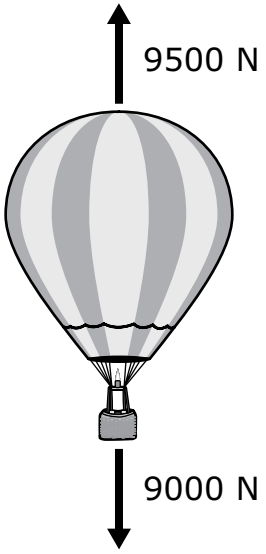
22 The diagram shows a 900 kg hot air balloon. Only two forces are acting on the balloon, a 9000 N gravitational force and a 9500 N lift force.



What is the acceleration of the balloon?

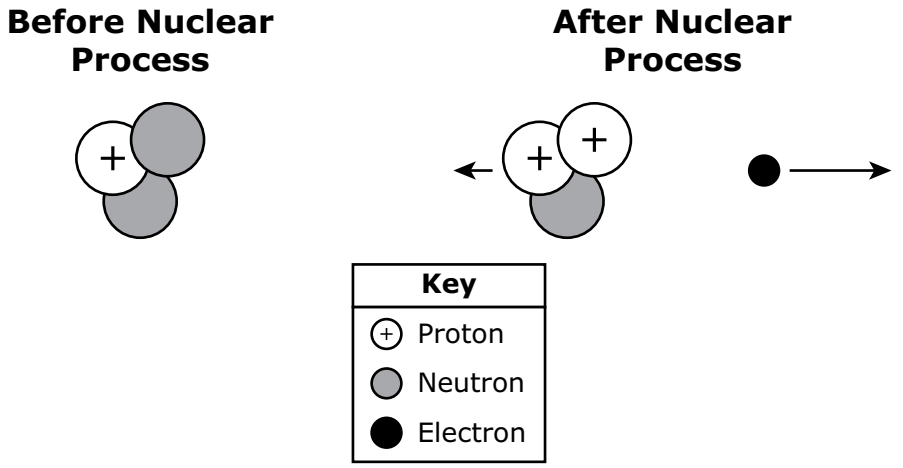
Ⓐ 0.21 m/s^2 upward

Ⓑ 0.21 m/s^2 downward

Ⓒ 0.56 m/s^2 upward

Ⓓ 0.56 m/s^2 downward

23 Tritium is a form of hydrogen. The diagram shows a model of a tritium nucleus before and after it undergoes a nuclear process. The tritium nucleus is at rest before the nuclear process. The arrows represent the magnitude and direction of the velocity of the particles after the nuclear process.



Which of the following best describes the nuclear process shown in the model?

Ⓐ The nuclear process is fusion, and energy is released.

Ⓑ The nuclear process is fusion, and energy is absorbed.

Ⓒ The nuclear process is beta decay, and energy is released.

Ⓓ The nuclear process is beta decay, and energy is absorbed.

24 Two rubber balls roll along a straight track toward each other at the same speed. The balls are the same size but have different masses. The two balls collide.

Which of the following best describes how the total momentum of the rubber balls is affected by the collision?

Ⓐ The total momentum stays the same, because the total momentum is conserved.

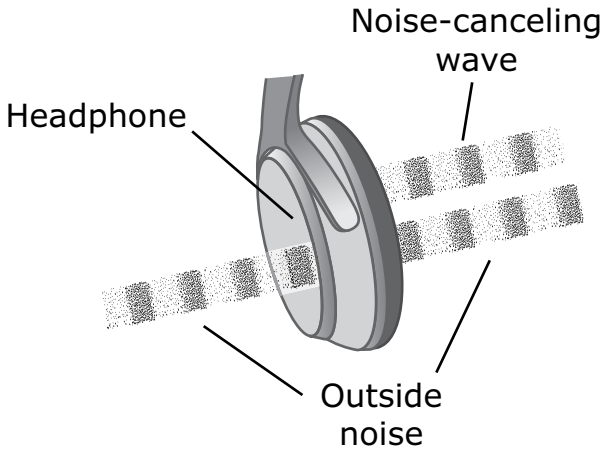
Ⓑ The total momentum is doubled, because each ball gains the other ball's momentum.

Ⓒ The total momentum is reduced by half, because each ball loses half of its momentum.

Ⓓ The total momentum becomes zero, because the momentum of each ball is equal and opposite.

This question has two parts.

25 A student listening to music uses noise-canceling headphones to reduce outside noise. The headphones create an inverted sound wave that interacts with the outside noise. The diagram represents how the headphones work.



Part A

Which wave behavior is used by the noise-canceling headphones to reduce outside noise for the student?

Ⓐ constructive interference

Ⓑ destructive interference

Ⓒ reflection

Ⓓ refraction

Part B

The student then uses the noise-canceling headphones in a location where the outside noise is louder and has a higher pitch. How would the noise-canceling wave produced by the headphones need to change for the headphones to be equally effective when the outside noise is louder and has a higher pitch?

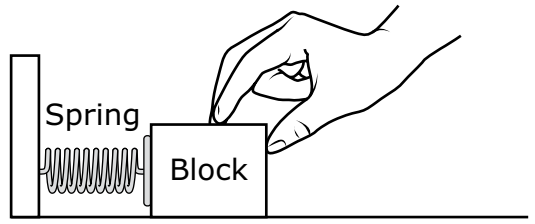
Ⓐ The wave's velocity and wavelength would need to increase.

Ⓑ The wave's velocity and wavelength would need to decrease.

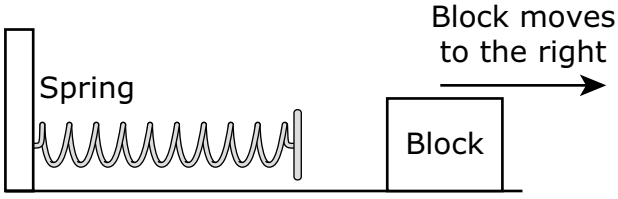
Ⓒ The wave's frequency and amplitude would need to increase.

Ⓓ The wave's frequency and amplitude would need to decrease.

26 A student compresses a spring with a block, as shown in the diagram.



When the student lets go of the block, the block moves to the right, as shown in the diagram below.



Which of the following describes a change in energy that occurs when the student lets go of the block?

Ⓐ The total energy of the system increases as the moving block creates kinetic energy.

Ⓑ The total energy of the system decreases as kinetic energy changes into potential energy.

Ⓒ The potential energy of the block increases as the kinetic energy of the spring decreases.

Ⓓ The potential energy of the spring decreases as the kinetic energy of the block increases.

27 A rocket with a constant acceleration of 25 m/s^2 has an initial velocity of 200 m/s in the same direction as the acceleration. What is the magnitude of the rocket's velocity 10 s later?

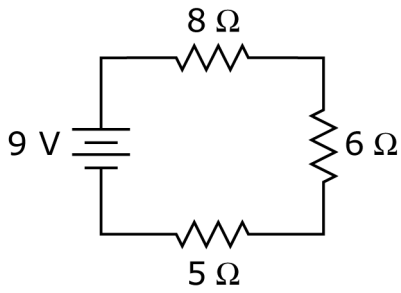
Ⓐ 250 m/s

Ⓑ 450 m/s

Ⓒ 1250 m/s

Ⓓ 1450 m/s

28 A circuit includes a battery and three resistors, as shown.



What is the total resistance of the circuit?

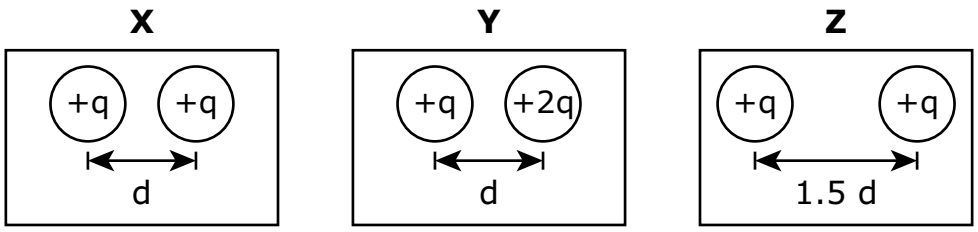
Ⓐ 2 Ω

Ⓑ 19 Ω

Ⓒ 28 Ω

Ⓓ 240 Ω

29 Three pairs of charges, X, Y, and Z, are shown.



Which of the following correctly orders the pairs of charges by the magnitude of the forces between the charges in each pair?

Ⓐ

X		Y		Z
Least force	⟶			Greatest force

Ⓑ

X		Z		Y
Least force	⟶			Greatest force

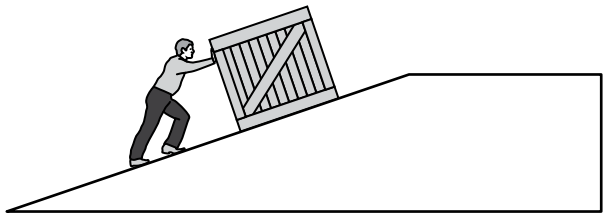
Ⓒ

Y		Z		X
Least force	⟶			Greatest force

Ⓓ

Z		X		Y
Least force	⟶			Greatest force

30 The diagram shows a worker pushing a crate from the bottom of a ramp to the top of the ramp.



The worker does 1900 J of work on the crate to push it to the top of the ramp. The crate has a gravitational potential energy of 1200 J at the top of the ramp.

What is the efficiency of the worker pushing the crate from the bottom to the top of the ramp?

Ⓐ 0.23

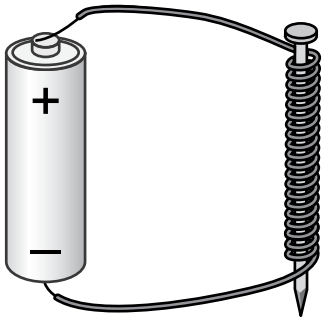
Ⓑ 0.37

Ⓒ 0.58

Ⓓ 0.63

This question has two parts.

31 In an investigation, students wrapped an insulated copper wire around an iron nail so that the nail had 20 loops around it. They connected the ends of the wire to a 1.5 V battery. The setup is shown.



A student held the nail with the wire above several metal paper clips. Some of the paper clips accelerated upward toward the nail.

Part A

The upward force that acted on the paper clips was from

Ⓐ an electric field.

Ⓑ a magnetic field.

Ⓒ a gravitational field.

The field was generated by the

Ⓐ heat generated in the wire.

Ⓑ stationary particles in the wire.

Ⓒ current flowing through the wire.

Part B

The students next investigated the number of paper clips that could be picked up when there were different numbers of loops of wire around the nail. The students made the table shown to record their data.

Number of Loops of Wire	Number of Paper Clips Picked Up
10	
20	
30	
40	

Which of the following questions were the students most likely trying to answer in their investigation?

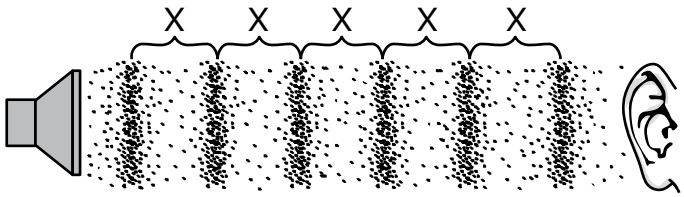
Ⓐ How does the number of paper clips picked up affect the electric field around the battery?

Ⓑ How does the number of paper clips picked up affect the gravitational field on the battery?

Ⓒ How does the number of loops of wire affect the strength of the magnetic field around the wire?

Ⓓ How does the number of loops of wire affect the electric field that moves through the paper clips?

32 The diagram shows a sound wave being produced by a speaker and the density of air molecules as the sound wave travels to a listener's ear. Each section labeled with an X shows an interval between dense regions of the air molecules.



What wave property does X represent?

Ⓐ amplitude

Ⓑ frequency

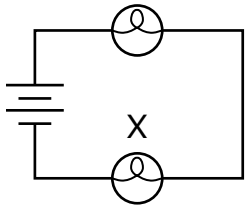
Ⓒ velocity

Ⓓ wavelength

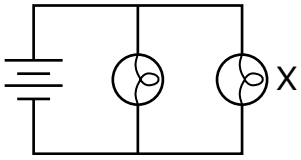
33 A student arranges light bulbs, wires, and a battery to create some circuits. All of the light bulbs have the same resistance, and each battery has the same voltage. One of the light bulbs in each circuit is labeled X.

In which circuit would the light bulb labeled X be brightest?

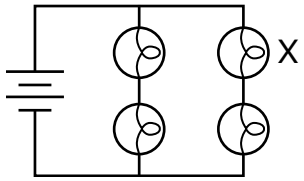
Ⓐ



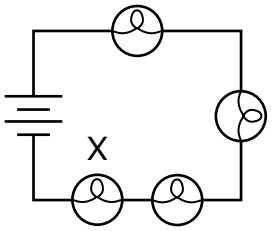
Ⓑ



Ⓒ



Ⓓ



34 Which of the following is an example of light behaving like a particle?

Ⓐ When violet light shines on a metal plate, electrons are ejected from the metal plate.

Ⓑ When light passes through slits and interferes, it forms a pattern of bright and dark regions on a wall.

Ⓒ When a light source is directed onto a soap bubble, reflections from the surface of the bubble produce colors.

Ⓓ When a laser beam shines on a round object, a circle with a bright spot in the center appears on a screen behind the object.

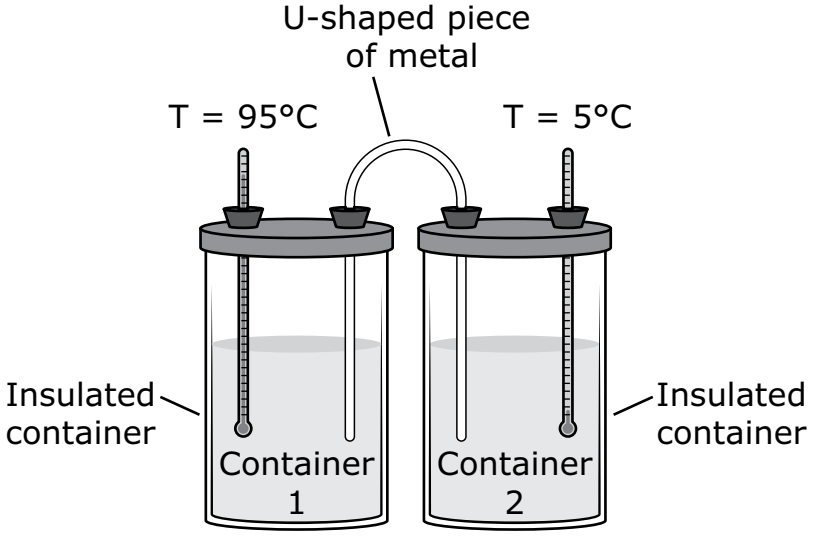
The following section focuses on heat and heat transfer.

Read the information below and use it to answer the selected-response questions and constructed-response question that follow.

A student conducted two investigations to learn about thermal energy transfer.

Investigation 1

During investigation 1, the student used two insulated containers, container 1 and container 2. The student added 500 g of 95°C water to container 1 and 500 g of 5°C water to container 2. The student closed the containers and placed a thermometer in each. The student then placed one end of a U-shaped piece of metal into the water in container 1 and the other end into the water in container 2, as shown.



Next, the student measured the water temperature in each container over time. The data are shown in Table 1.

Table 1: Temperature of Water over Time

Time (s)	Container 1 Temperature (°C)	Container 2 Temperature (°C)
0	95.0	5.0
100	77.3	22.7
200	66.6	33.4
300	60.0	40.0
400	56.1	43.9
500	53.7	46.3
600	52.2	47.8
700	50.0	50.0
800	50.0	50.0

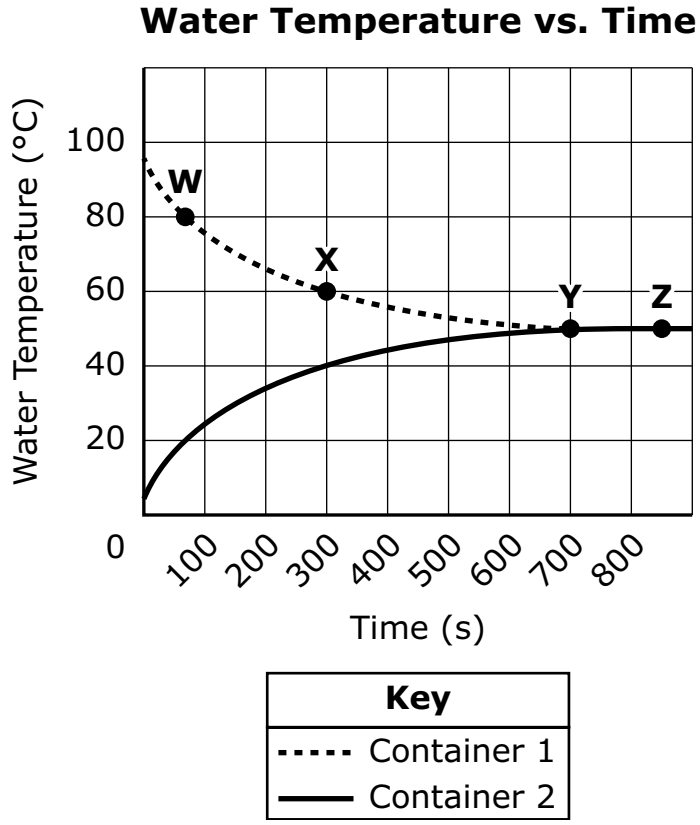
Investigation 2

The student investigated how the specific heat capacity of a substance affects the temperature change of the substance. During investigation 2, the student heated four liquids, W, X, Y, and Z. Each liquid had a mass of 200 g and was heated for the same amount of time using the same heat source. The specific heat capacities of the four liquids are shown in Table 2.

Table 2: Specific Heat Capacity of Liquids

Liquid	Specific Heat Capacity (J/g • °C)
W	4.18
X	1.97
Y	3.94
Z	3.67

35 The data from investigation 1 are represented in the graph. Four points on the graph are labeled W, X, Y, and Z.



At which point did container 1 and container 2 first reach thermal equilibrium?

Ⓐ point W

Ⓑ point X

Ⓒ point Y

Ⓓ point Z

36 Before beginning investigation 1, the student predicted that the direction of thermal energy transfer would be from container 1 to container 2.

Which of the following observations best supports the student's prediction?

Ⓐ The containers are good thermal insulators.

Ⓑ The U-shaped piece of metal is a good thermal conductor.

Ⓒ The water in container 1 is in thermal contact with the water in container 2.

Ⓓ The water in container 1 is at a higher temperature than the water in container 2.

37 In investigation 2, liquid Z had an initial temperature of 25°C before 54,316 J of thermal energy was added. What was the final temperature of liquid Z?

Ⓐ 49°C

Ⓑ 74°C

Ⓒ 99°C

Ⓓ 272°C

This question has three parts. Write your response on the next page. Be sure to label each part of your response.

38 The student analyzed the transfer of thermal energy that took place during investigation 1.

A. Identify whether the average molecular motion of the water molecules in container 1 **and** container 2 increased, decreased, or remained the same during the first 100 s in investigation 1. Be sure to label your answer for **each** container.

B. The student claimed that energy was conserved in the system during the transfer of thermal energy in investigation 1.

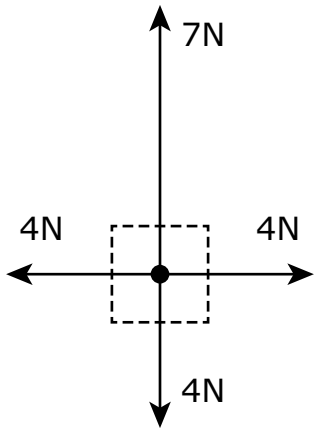
Describe how the student could use the data in Table 1 to support the claim.

C. Eventually thermal equilibrium was reached in investigation 1.

Compare the average molecular motion of the water molecules in both container 1 and container 2 after thermal equilibrium was reached. Explain your reasoning.

38

39 The free-body force diagram for an object is shown.



Based on the free-body force diagram, which of the following describes the motion of the object?

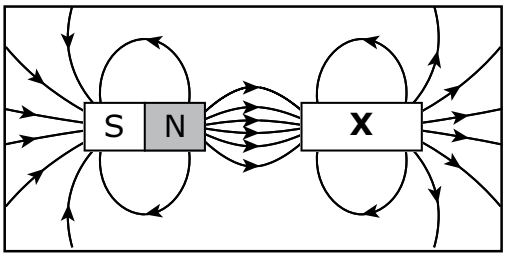
Ⓐ The object is accelerating upward.

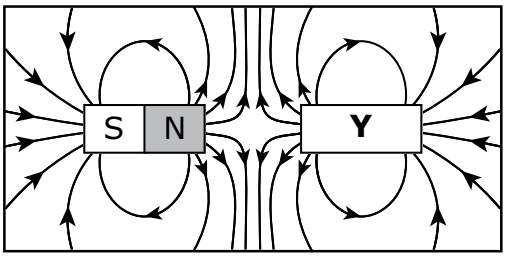
Ⓑ The object is accelerating to the right.

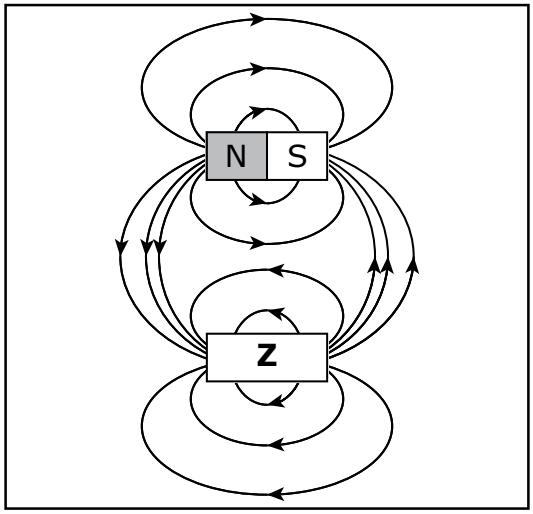
Ⓒ The object is moving upward with a constant speed.

Ⓓ The object is moving to the left at an increasing speed.

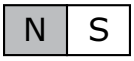
40 The magnetic fields between three pairs of magnets are shown. One magnet in each pair is labeled X, Y, or Z.

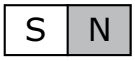




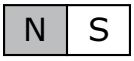


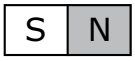
Which of the following shows the orientation of bar magnet **X**?

Ⓐ 

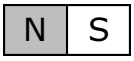
Ⓑ 

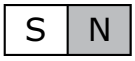
Which of the following shows the orientation of bar magnet **Y**?

Ⓐ 

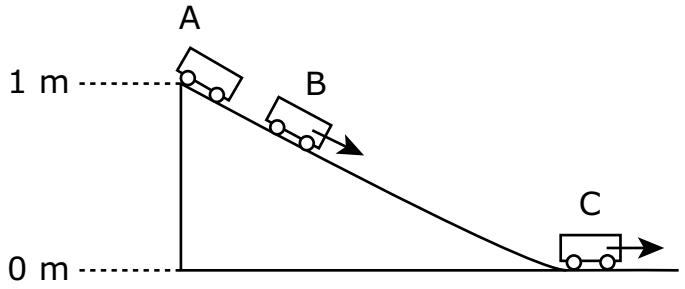
Ⓑ 

Which of the following shows the orientation of bar magnet **Z**?

Ⓐ 

Ⓑ 

41 A 2 kg cart is released from the top of a ramp that is 1 m high. Three positions of the cart are shown in the diagram. Assume friction is negligible.



Which of the following tables correctly shows the cart's gravitational potential energy and kinetic energy at positions A, B, and C?

Ⓐ

Position	Gravitational Potential Energy (J)	Kinetic Energy (J)
A	20	0
B	15	5
C	0	20

Ⓑ

Position	Gravitational Potential Energy (J)	Kinetic Energy (J)
A	0	0
B	5	5
C	20	20

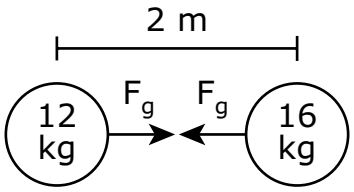
Ⓒ

Position	Gravitational Potential Energy (J)	Kinetic Energy (J)
A	15	0
B	15	10
C	15	15

Ⓓ

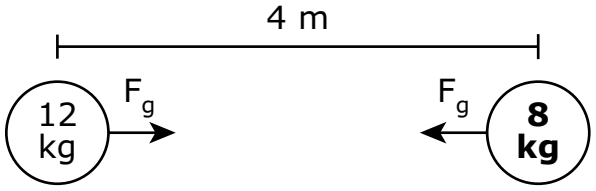
Position	Gravitational Potential Energy (J)	Kinetic Energy (J)
A	20	0
B	15	10
C	0	20

42 A 12 kg object and a 16 kg object are located 2 m apart. Each exerts a gravitational force, F_g, on the other, as shown in the diagram.

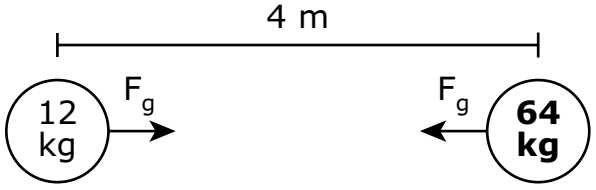


Which of the following pairs of objects placed 4 m apart will have these same gravitational forces?

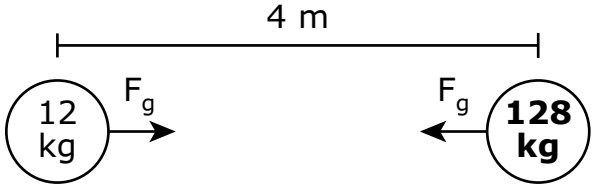
Ⓐ



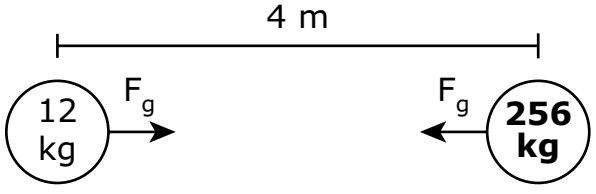
Ⓑ



Ⓒ

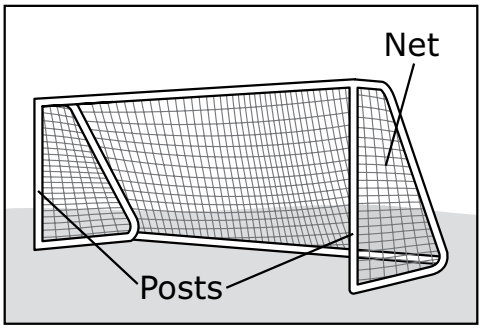


Ⓓ



This question has four parts. Write your response on page 54. Be sure to label each part of your response.

43 During a soccer game, players kick a ball into a goal to score a point. The goal is made of posts and a net, as shown.



A player kicked a 0.42 kg soccer ball into a goal. The ball was traveling 22 m/s when it collided with the net. The net stopped the ball.

A. Calculate the change in momentum of the ball during the collision with the net. Show your calculations and include units in your answer.

B. The collision between the ball and the soccer net lasted 0.25 s.

Calculate the average net force that the soccer net applied to the ball. Show your calculations and include units in your answer.

C. The ball is kicked into the soccer net again.

Identify one way to reduce the average net force on the ball as it is stopped by the soccer net. Explain your reasoning.

D. A group of students investigate how the magnitude of the force applied to a soccer ball as it is kicked affects the ball's velocity after it is kicked. The students will conduct their investigation on an indoor soccer field.

The students create a list of six factors in the investigation, as shown.

1. the ball's mass
2. the ball's velocity after being kicked
3. how hard the ball is kicked
4. the amount of light on the field
5. how inflated the ball is
6. the time of day the data are collected

From the students' list, identify each of the following:

- **two** factors that will change during the investigation
- **two** factors that must be kept constant (controlled)
- **two** factors that will not affect the outcome of the investigation

43

STOP!