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

This practice test contains 29 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 An engineer is constructing a device that turns electrical energy into mechanical energy. The engineer notices that some of the electrical energy also turns into thermal energy.

Which of the following describes how the device can reach maximum efficiency?

Ⓐ The device must minimize electrical energy while maximizing thermal energy.

Ⓑ The device must minimize mechanical energy while maximizing thermal energy.

Ⓒ The device must minimize thermal energy while maximizing mechanical energy.

Ⓓ The device must minimize mechanical energy while maximizing electrical energy.

2 Newton's universal law of gravitation and Coulomb's law have similar mathematical relationships, as shown.

Newton's universal law of gravitation: $F_g = G \frac{m_1 m_2}{d^2}$

Coulomb's law: $F_e = k \frac{q_1 q_2}{d^2}$

Which of the following tables correctly identifies whether the force described applies to only Newton's universal law of gravitation, only Coulomb's law, or both laws?

Ⓐ

Force Description	Law or Laws Description Applies To
The force can be repulsive.	only Coulomb's law
The force can be attractive.	both laws
The force increases if the mass of both objects increases.	only Newton's universal law of gravitation
The force decreases if the distance between the objects increases.	both laws

Ⓑ

Force Description	Law or Laws Description Applies To
The force can be repulsive.	only Newton's universal law of gravitation
The force can be attractive.	only Newton's universal law of gravitation
The force increases if the mass of both objects increases.	both laws
The force decreases if the distance between the objects increases.	both laws

Ⓒ

Force Description	Law or Laws Description Applies To
The force can be repulsive.	only Newton's universal law of gravitation
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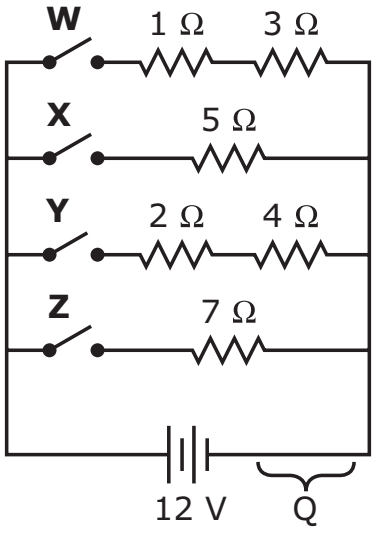
The force increases if the mass of both objects increases.	only Newton's universal law of gravitation
The force decreases if the distance between the objects increases.	only Coulomb's law

Ⓓ

Force Description	Law or Laws Description Applies To
The force can be repulsive.	only Coulomb's law
The force can be attractive.	only Newton's universal law of gravitation
The force increases if the mass of both objects increases.	both laws
The force decreases if the distance between the objects increases.	only Coulomb's law

3 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.

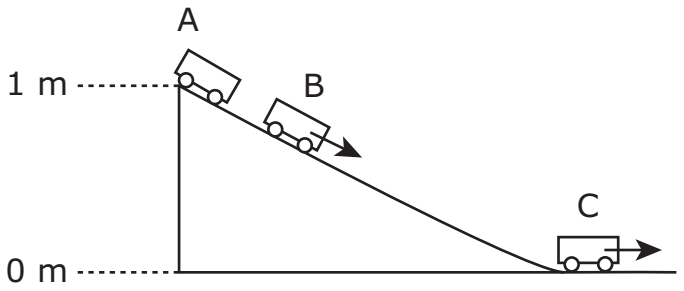
Ⓐ W

Ⓑ X

Ⓒ Y

Ⓓ Z

4 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

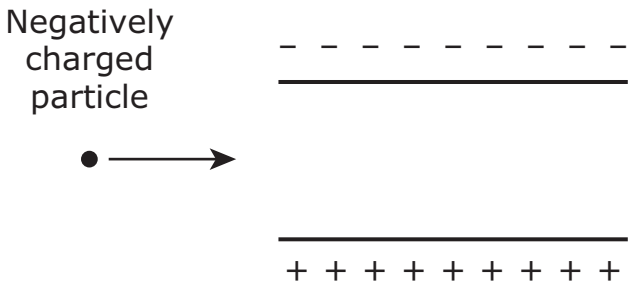
Ⓒ

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

5 The diagram shows a negatively charged particle traveling toward two parallel charged plates.



What will most likely happen to the negatively charged particle when it travels between the charged plates?

Ⓐ It will accelerate as it travels in a straight line.

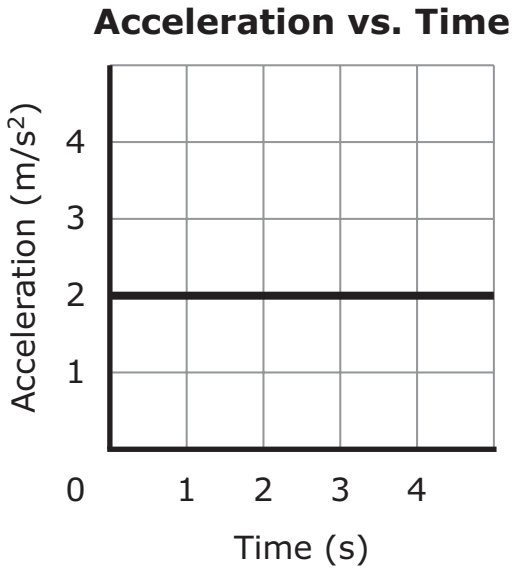
Ⓑ It will maintain its original speed as it travels in a straight line.

Ⓒ Its path will bend upward toward the negatively charged plate.

Ⓓ Its path will bend downward toward the positively charged plate.

This question has two parts.

6 The graph shows the acceleration of a 5 kg object over time.



Part A

What is the net force acting on the object?

Ⓐ 0.4 N

Ⓑ 2.0 N

Ⓒ 2.5 N

Ⓓ 10.0 N

Part B

The mass of the object increases from 5 kg to 6 kg and the net force on the object remains the same. Which of the following describes what will happen to the acceleration of the object when its mass is increased?

Ⓐ The acceleration of the object will increase.

Ⓑ The acceleration of the object will decrease.

Ⓒ The acceleration of the object will stay the same.

7 The behavior of light can be described by both a wave model and a particle model, but certain observations support one model more than the other.

Two observations are described.

- Observation 1: A pattern of bright and dark spots is seen when light passes through two slits.
- Observation 2: The higher the frequency of the light shined on a metal surface, the greater the kinetic energy of the electrons that are knocked off the surface.

Which of the following best describes the observations?

Ⓐ Observations 1 and 2 both support the wave model.

Ⓑ Observations 1 and 2 both support the particle model.

Ⓒ Observation 1 supports the wave model and observation 2 supports the particle model.

Ⓓ Observation 1 supports the particle model and observation 2 supports the wave model.

8 The table shows the mass and specific heat of three samples.

Sample	Mass (g)	Specific Heat $\left(\frac{J}{g \bullet °C}\right)$
W	5	0.9
X	8	0.4
Y	6	0.8

Each sample was heated to an initial temperature of 50°C and then cooled to a final temperature of 20°C.

Which of the following correctly orders the samples from the least to the greatest amount of heat they released while cooling?

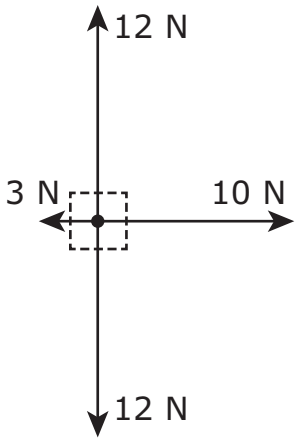
Ⓐ $W \rightarrow Y \rightarrow X$

Ⓑ $X \rightarrow W \rightarrow Y$

Ⓒ $X \rightarrow Y \rightarrow W$

Ⓓ $Y \rightarrow X \rightarrow W$

9 A student pushes a 12 N book to the right with a force of 10 N. The book experiences a frictional force of 3 N. The free-body force diagram shown represents the forces acting on the book.



What is the magnitude of the net force acting on the book?

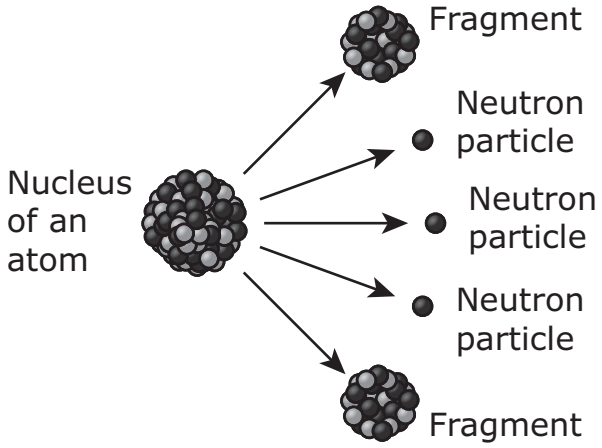
Ⓐ 7 N

Ⓑ 11 N

Ⓒ 13 N

Ⓓ 37 N

10 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.

11 The table shows wavelengths and frequencies for some waves.

Type of Wave	Frequency (Hz)	Wavelength (m)
gamma ray	3.0×10^{20}	1×10^{-12}
infrared	3.0×10^{13}	1×10^{-5}
ultraviolet	7.5×10^{15}	4×10^{-8}

Which of the following claims is supported by the data in the table?

Ⓐ All the waves have the same period.

Ⓑ All the waves are traveling in a solid.

Ⓒ All the waves have the same amplitude.

Ⓓ All the waves are traveling at the same speed.

12 Three students each built a device to protect an egg when it was dropped to the ground from a height of 11.5 m. To keep the egg from breaking, each device needed to reduce the force applied to the egg to less than 25 N. The students dropped the devices with the eggs inside and recorded some data for each device, as shown in the table.

Device	Mass of Egg (kg)	Velocity of Egg before Impact (m/s)	Time to Stop Egg (s)
1	0.05	14	0.01
2	0.05	14	0.05
3	0.05	14	0.10

Which of the following tables correctly identifies whether the egg inside each device broke when the device hit the ground?

Ⓐ

Device	Result
1	egg broke
2	egg broke
3	egg broke

Ⓑ

Device	Result
1	egg broke
2	egg broke
3	egg did not break

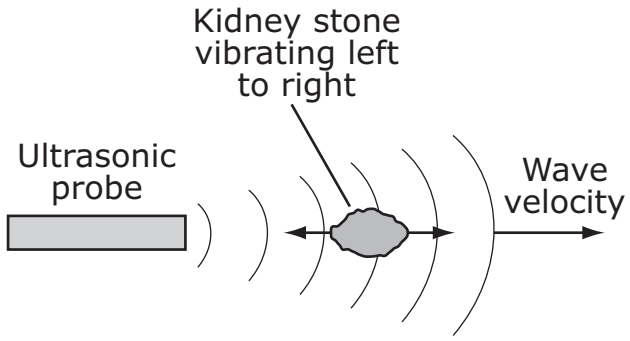
Ⓒ

Device	Result
1	egg broke
2	egg did not break
3	egg did not break

Ⓓ

Device	Result
1	egg did not break
2	egg did not break
3	egg broke

13 Kidney stones are deposits of calcium that can build up in the body and cause discomfort. Ultrasonic probes can be used to send out waves that cause the kidney stones to break apart, as shown in the diagram.



Based on this information, which conclusion can be made about the waves created by the ultrasonic probe?

Ⓐ The waves are transverse.

Ⓑ The waves are longitudinal.

Ⓒ The waves have low frequencies.

Ⓓ The waves have long wavelengths.

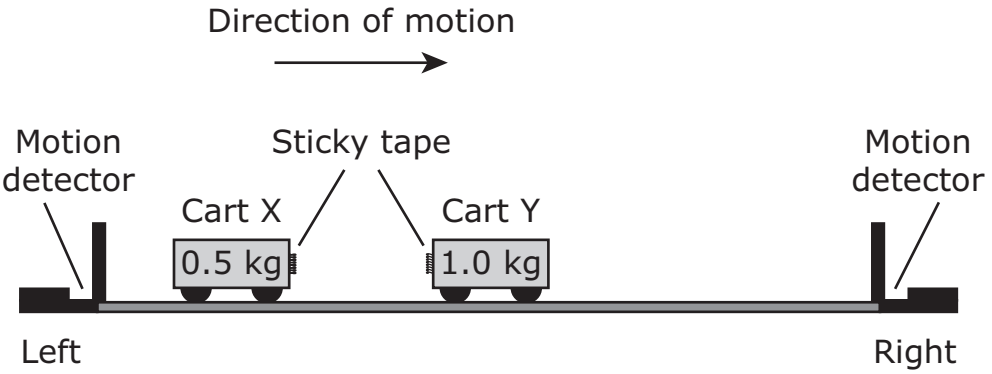
The following section focuses on collisions between two carts.

Read the information below and use it to answer the four selected-response questions and one 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.

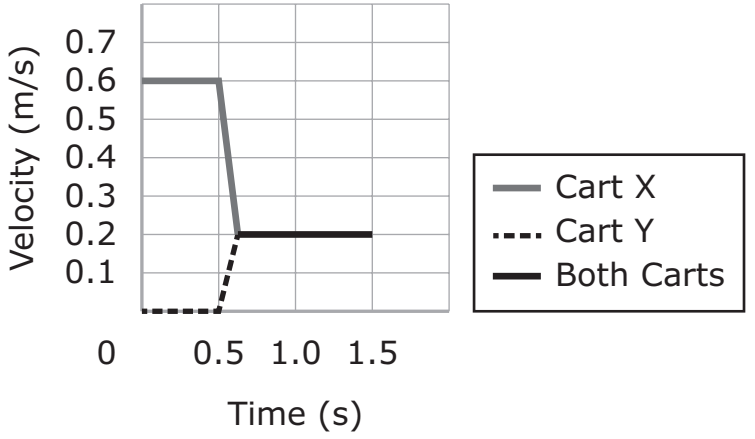
Trial 1

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.



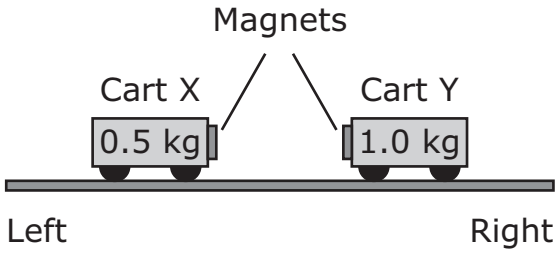
A student pushed cart X toward cart Y and let go of the cart. Cart X then collided with cart Y. The graph shows the velocity of each cart before, during, and after the collision.

Trial 1: Velocity vs. Time



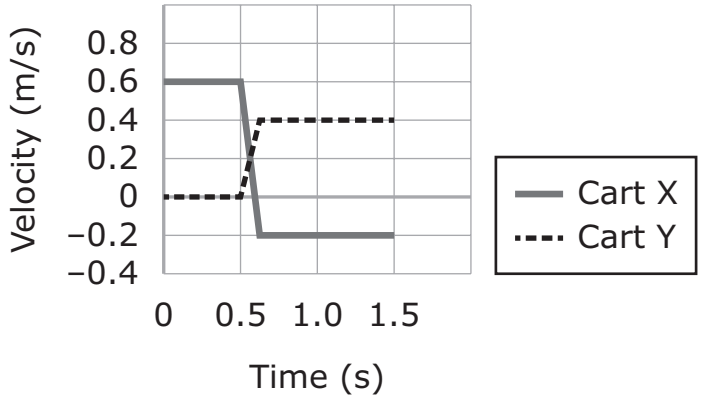
Trial 2

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

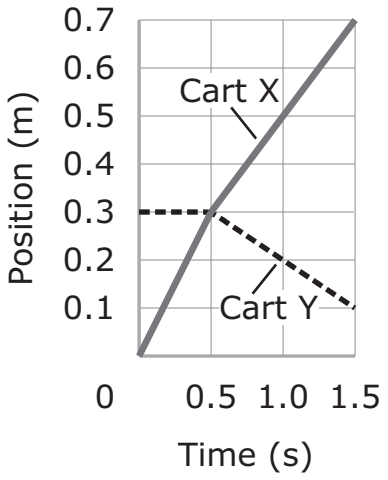
Ⓑ 0.3 kg • m/s

Ⓒ 0.6 kg • m/s

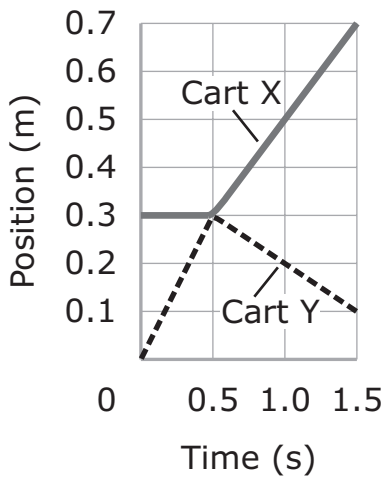
Ⓓ 0.8 kg • m/s

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

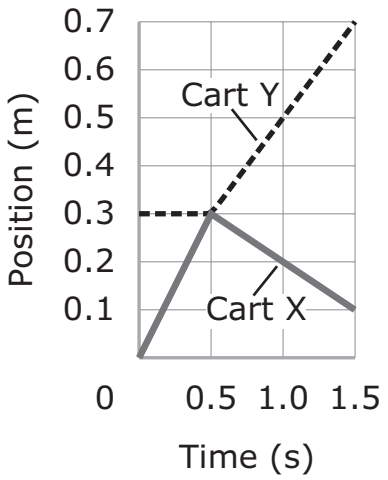
Ⓐ



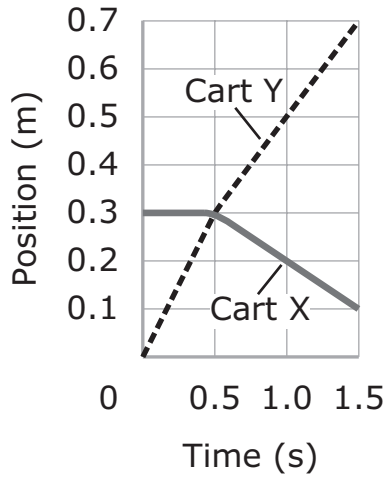
Ⓑ



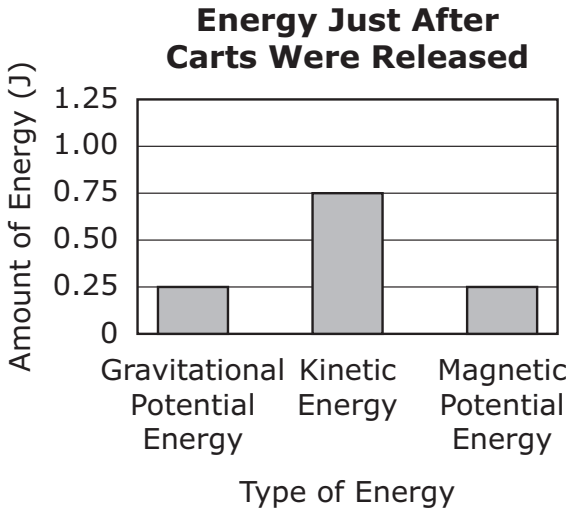
Ⓒ



Ⓓ



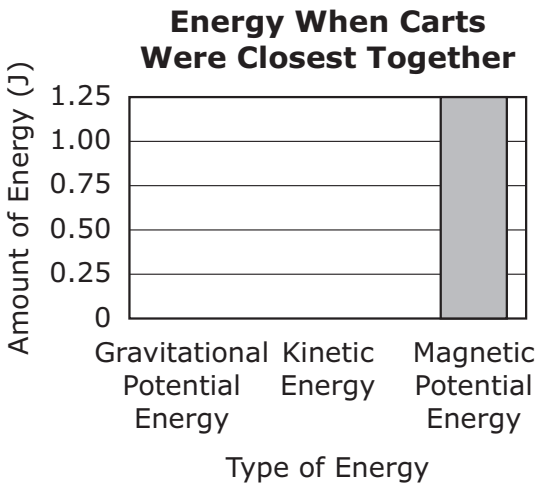
16 The students conducted another trial with magnets. The new trial was similar to trial 2, except they pushed both carts toward each other at the same time and then released each cart. The bar graph shows the total energy in the system just after the students released the carts.



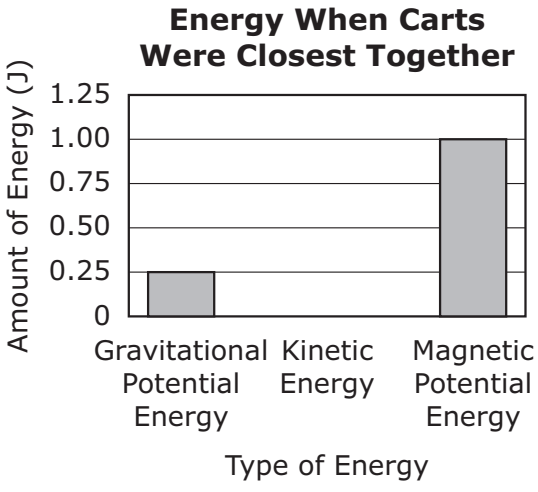
The carts came to a brief stop when they were closest together.

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

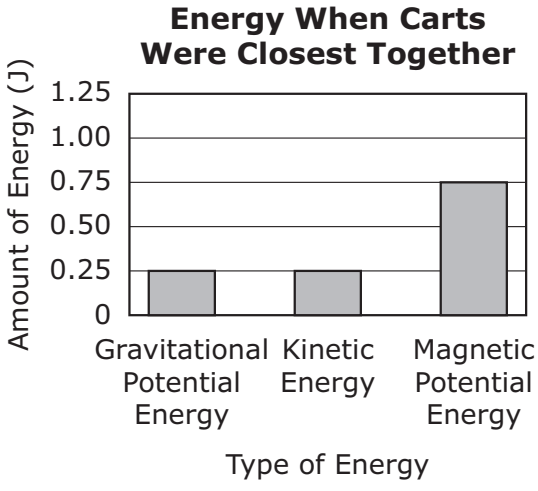
Ⓐ



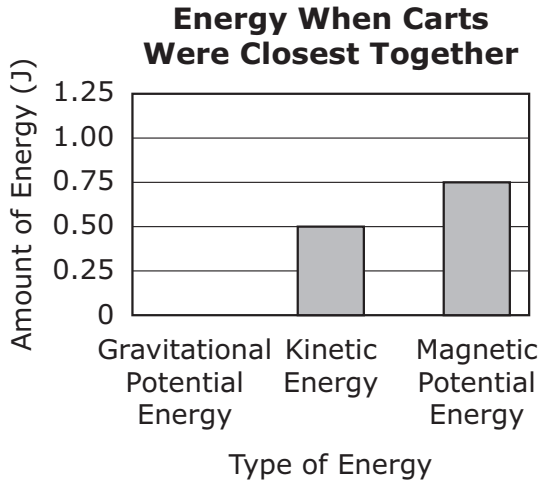
Ⓑ



Ⓒ



Ⓓ



This question has two parts.

17 The students calculated the kinetic energy (KE) of each cart before and after the collisions in trial 1 and trial 2. The table shows the calculated values for both collisions.

	Trial 1		Trial 2	
Cart	**KE before Collision (J)**	**KE after Collision (J)**	**KE before Collision (J)**	**KE after Collision (J)**
X	0.09	0.01	0.09	0.01
Y	0.00	0.02	0.00	0.08

Part A

Which of the following describes the momentum and kinetic energy of the system during the collision in trial 1?

Ⓐ Momentum and kinetic energy were conserved.

Ⓑ Momentum and kinetic energy were not conserved.

Ⓒ Momentum was conserved and kinetic energy was not conserved.

Ⓓ Kinetic energy was conserved and momentum was not conserved.

Which of the following describes the momentum and the kinetic energy of the system during the collision in trial 2?

Ⓐ Momentum and kinetic energy were conserved.

Ⓑ Momentum and kinetic energy were not conserved.

Ⓒ Momentum was conserved and kinetic energy was not conserved.

Ⓓ Kinetic energy was conserved and momentum was not conserved.

Part B

Some of cart X's kinetic energy was transformed into different kinds of energy when cart X collided with cart Y in one of the trials.

Select the **two** types of energy that cart X's kinetic energy was transformed into.

Ⓐ electrical

Ⓑ gravitational potential

Ⓒ nuclear

Ⓓ sound

Ⓔ thermal

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

18 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 answer.

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

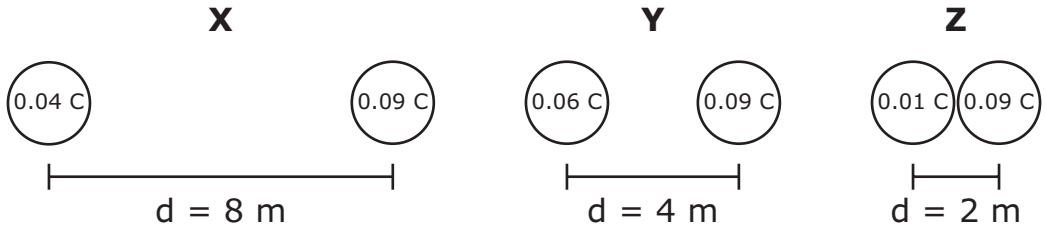
B. Calculate the acceleration of Cart X during the collision. Show your calculations and include units in your answer.

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.

18

Go On ➡

19 Three pairs of objects, X, Y, and Z, with different charges are shown. Each pair is separated by a different distance.



Which of the following correctly orders the pairs of objects from the least to the greatest amount of force between them?

Ⓐ $X \rightarrow Y \rightarrow Z$

Ⓑ $X \rightarrow Z \rightarrow Y$

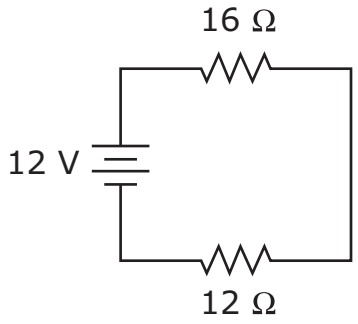
Ⓒ $Z \rightarrow X \rightarrow Y$

Ⓓ $Z \rightarrow Y \rightarrow X$

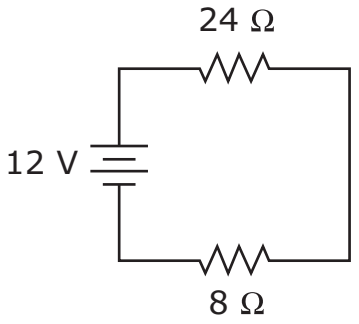
20 A circuit with two resistors and a 12 V battery has a current of 0.5 A.

Which of the following circuit diagrams could represent the circuit?

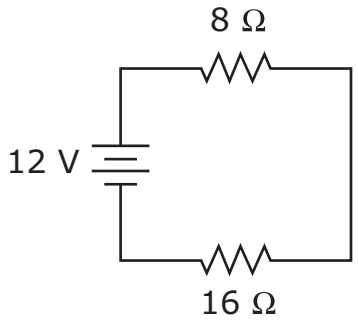
Ⓐ



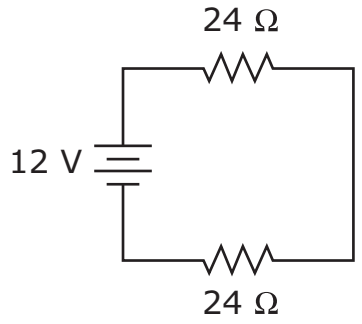
Ⓑ



Ⓒ



Ⓓ



21 Which of the following describes the molecules in a sample of water as the temperature of the water changes from 20°C to 30°C?

Ⓐ The molecules speed up and their average kinetic energy increases.

Ⓑ The molecules slow down and their average kinetic energy decreases.

Ⓒ The molecules speed up and their average kinetic energy stays the same.

Ⓓ The molecules slow down and their average kinetic energy stays the same.

This question has two parts.

22 Sound waves can travel through brick and air.

Part A

A 400 Hz sound wave travels through a brick. The sound wave moves through the brick with a speed of 4,176 m/s.

What is the wavelength of the sound wave?

Ⓐ 0.096 m

Ⓑ 10.44 m

Ⓒ 750,000 m

Ⓓ 1,670,400 m

Part B

Another 400 Hz sound wave is traveling through air.

Which of the following correctly compares the speed of the sound wave traveling through air to the speed of the sound wave traveling through brick?

Ⓐ The speed of the sound wave traveling through air is faster.

Ⓑ The speed of the sound wave traveling through air is slower.

Ⓒ The speed of the sound wave traveling through air is the same.

Which of the following correctly compares the wavelengths of the 400 Hz sound wave traveling through air and the 400 Hz sound wave traveling through brick?

Ⓐ The 400 Hz sound wave traveling through air has a longer wavelength.

Ⓑ The 400 Hz sound wave traveling through air has a shorter wavelength.

23 A student released two objects at rest, W and X, from the same height above the ground. The table shows the masses of the objects and the height from which the student dropped them.

Object	Mass (kg)	Height (m)
W	7	4
X	5	4

Which of the following describes object W's kinetic energy just before both objects hit the ground?

Ⓐ Object W's kinetic energy was equal to object X's kinetic energy.

Ⓑ Object W's kinetic energy was less than object X's kinetic energy.

Ⓒ Object W's kinetic energy was greater than object X's kinetic energy.

Which of the following describes object W's velocity just before both objects hit the ground?

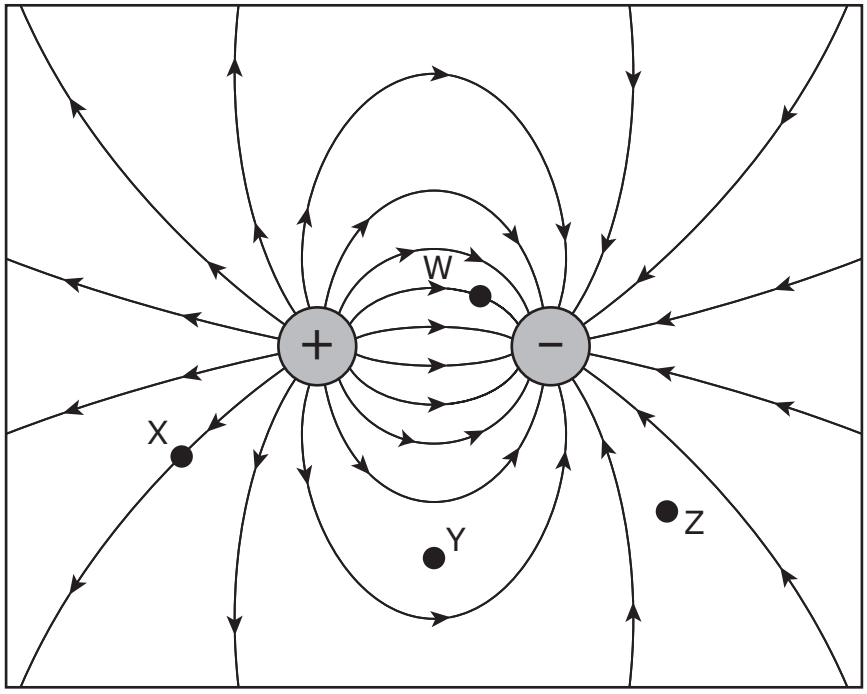
Ⓐ Object W's velocity was one-half of object X's velocity.

Ⓑ Object W's velocity was equal to object X's velocity.

Ⓒ Object W's velocity was two times object X's velocity.

Ⓓ Object W's velocity was four times object X's velocity.

24 The diagram represents the electric field around a positively charged object and a negatively charged object. Four locations, W, X, Y, and Z, are labeled in the diagram.



At which of the labeled locations would another positively charged object experience the greatest net force?

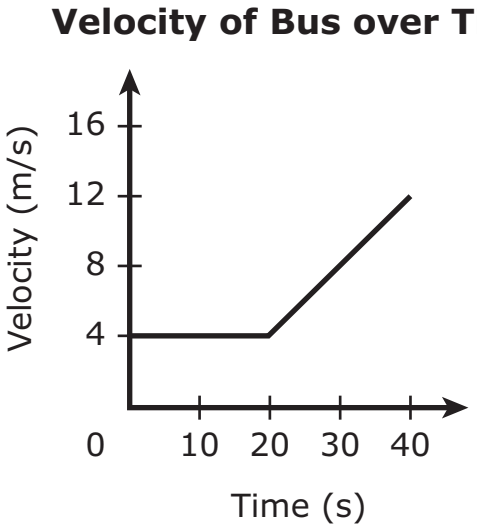
Ⓐ W

Ⓑ X

Ⓒ Y

Ⓓ Z

25 The velocity of a bus is represented in the graph shown.



Which of the following best describes how the bus moves over time?

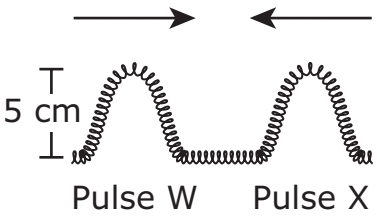
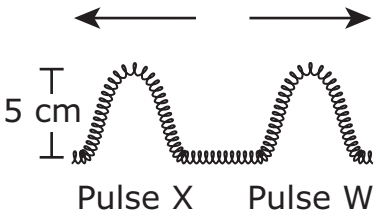
Ⓐ The bus stays in one place for 20 s and then travels at a constant speed.

Ⓑ The bus travels at a constant speed for 20 s and then accelerates at a constant rate.

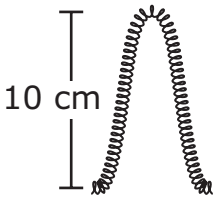
Ⓒ The bus accelerates at a constant rate for 20 s and then travels at a constant speed.

Ⓓ The bus accelerates at a constant rate for 20 s and then accelerates at an increasing rate.

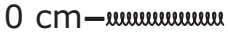
26 Two students created wave pulses, W and X, at the ends of a long flexible spring. The wave pulses moved toward each other, met in the middle of the spring, and then moved away from each other, as shown in the diagram.

First, the wave pulses moved toward each other.	Second, the wave pulses met in the middle.	Third, the wave pulses moved away from each other.
		

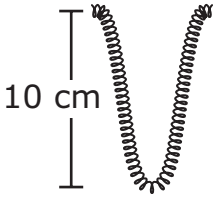
Which of the following figures shows how the spring appeared when the wave pulses met in the middle?

Ⓐ 

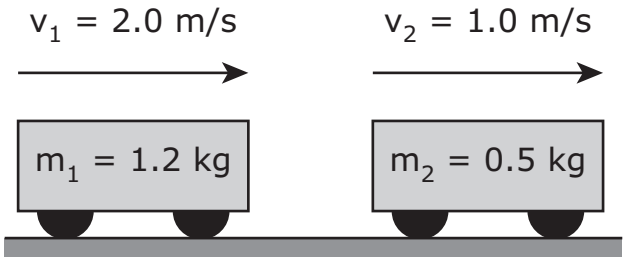
Ⓑ 

Ⓒ 

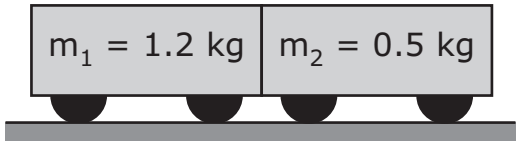
Ⓓ 

Ⓔ 

27 Two carts with different masses are both moving to the right. The mass and initial velocity of each cart are shown in the diagram.



The carts collide and then stick together, as shown below.



What is the speed and direction of the carts after the collision?

Ⓐ 1.5 m/s ←

Ⓑ 1.5 m/s →

Ⓒ 1.7 m/s ←

Ⓓ 1.7 m/s →

Ⓔ 3.0 m/s ←

Ⓕ 3.0 m/s →

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

28 A student heats a 200 g sample of water from 20°C to 80°C. The specific heat of water is 4.18 J/g • °C.

A. Calculate the thermal energy absorbed by the water. Show your calculations and include units in your answer.

The student then boils the water.

B. Describe what happens to the temperature of the water as it boils. Explain your answer.

The student repeats the experiment, this time placing a small block of iron into another 200 g sample of water. The specific heat of iron is 0.45 J/g • °C. Both the iron and the water are initially at 20°C and are heated to 80°C.

C. Compare the amount of thermal energy absorbed by the water in this experiment with your calculation in Part A. Explain your answer.

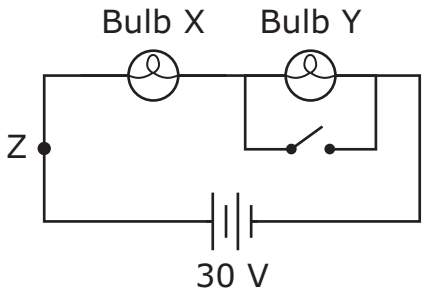
D. Describe how repeating the second experiment with a block made of a material with a greater specific heat will affect the amount of time it takes to heat the block. Assume the blocks have the same mass.

28

Go On ➡

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

29 A circuit diagram is shown below. Bulb X and bulb Y each have a resistance of 5 Ω.



A. Compare the brightness of bulb X to the brightness of bulb Y when the switch is open.

B. Describe what happens to bulb X and to bulb Y when the switch is closed.

Another bulb with a resistance of 5 Ω is added to the circuit at point Z. The switch is opened again.

C. Describe one way this circuit functions differently than the original circuit when the switch was open.

D. Calculate the current in this circuit with bulbs X, Y, and Z when the switch is open. Show your calculations and include units in your answer.

29

STOP!