MASSACHUSETTS
Department of Elementary
and Secondary Education

Release of Spring 2026 MCAS Test Items from the High School Introductory Physics Paper-Based Test

Spring 2026
Massachusetts Department of
Elementary and Secondary Education

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and Secondary Education

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Overview of High School Introductory Physics Test

The spring 2026 high school Introductory Physics test was administered in two formats: a computer-based version and a paper-based version. Most students took the computer-based test. The paper-based test was offered as an accommodation for eligible students who were unable to use a computer. More information can be found on the MCAS Test Administration Resources page at www.doe.mass.edu/mcas/admin.html.

Most of the operational items on the high school Introductory Physics test were the same, regardless of whether a student took the computer-based version or the paper-based version. In places where a technology-enhanced item was used on the computer-based test, an adapted version of the item was created for use on the paper test. These adapted paper items were multiple-choice or multiple-select items that tested the same Science content and assessed the same standard as the technology-enhanced item.

This document displays released items from the paper-based test. Released items from the computer-based test are available on the MCAS Resource Center website at mcas.onlinehelp.cognia.org/released-items.

Test Sessions and Content Overview

The high school Introductory Physics test was made up of two separate test sessions. Each session included selected-response questions and constructed-response questions. On the paper-based test, the selected-response questions were multiple-choice items and multiple-select items, in which students select the correct answer(s) from among several answer options.

Standards and Reporting Categories

The high school Introductory Physics test was based on learning standards in the 2016 *Massachusetts Science and Technology/Engineering Curriculum Framework*. The Framework is available on the Department website at www.doe.mass.edu/frameworks/current.html.

The introductory physics standards are grouped under the three content reporting categories listed below. Note that standard HS.PHY.1.8 is included in the Energy reporting category.

- Motion, Forces, and Interactions
- Energy
- Waves

Most items on the high school Introductory Physics test are also reported as aligning to one of three MCAS Science Practice Categories. The three practice categories are listed below.

- Practice Category A: Investigations and Questioning
- Practice Category B: Mathematics and Data
- Practice Category C: Evidence, Reasoning, and Modeling

More information about the practice categories is available on the Department website at www.doe.mass.edu/mcas/tdd/practice-categories.html.

The table at the conclusion of this document provides the following information about each released operational item: reporting category, standard covered, science practice category covered (if any), item type, and item description. The correct answers for released selected-response questions are also displayed in the table.

Reference Materials

Each student taking the paper-based version of the high school Introductory Physics test was provided with an Introductory Physics Reference Sheet. A copy of the reference sheet follows the final question in this document. Each student was also provided with a calculator.

During both high school Introductory Physics test sessions, the use of authorized bilingual word-to-word dictionaries and glossaries was allowed for students who are currently or were ever reported as English learners. No other reference tools or materials were allowed.

High School Introductory Physics
SESSION 1

This session contains 20 questions.

You may use your reference sheet in this session.

Directions

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

For some questions, you will mark your answers by filling in the circles in your Test & Answer 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.

1 A motorcycle has an initial velocity of 12 m/s. It then accelerates at 3 m/s^2 for 2 s.

What is the final velocity of the motorcycle after the 2 s time period?

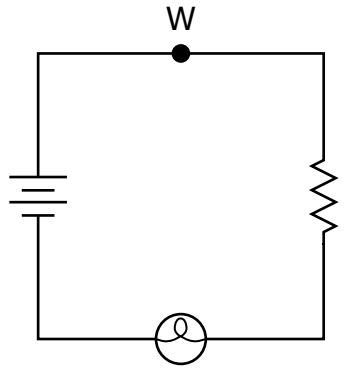
Ⓐ 7 m/s

Ⓑ 12 m/s

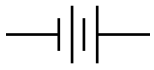
Ⓒ 18 m/s

Ⓓ 24 m/s

2 The diagram shows a simple circuit.

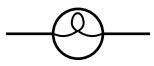


Which of the following could be added at point W to increase the brightness of the light bulb in the circuit?

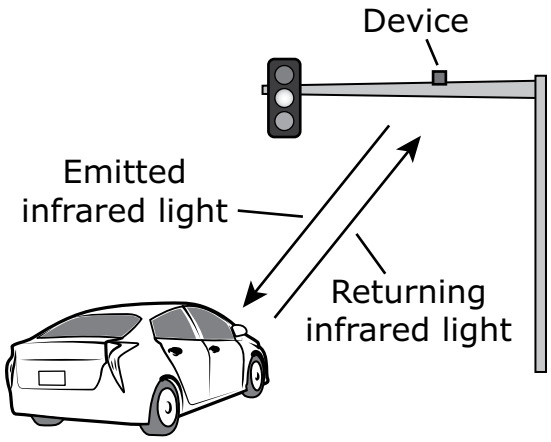
Ⓐ 

Ⓑ 

Ⓒ 

Ⓓ 

3 A device is used to detect cars that are stopped at a traffic light. The device emits infrared light and then detects returning infrared light, as shown.



Which of the following best describes how this device works?

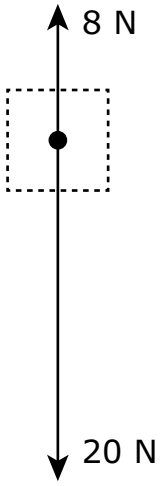
Ⓐ It emits mechanical waves that reflect off a car.

Ⓑ It emits mechanical waves that resonate with a car.

Ⓒ It emits electromagnetic waves that reflect off a car.

Ⓓ It emits electromagnetic waves that resonate with a car.

4 A free-body force diagram for a 2 kg object is shown.



What is the magnitude of the object's acceleration?

Ⓐ 4 m/s^2

Ⓑ 6 m/s^2

Ⓒ 14 m/s^2

Ⓓ 20 m/s^2

5 Two negatively charged objects have electrostatic and gravitational forces between them. Which of the following explains one way the electrostatic and gravitational forces are similar?

Ⓐ Both types of forces are always attractive.

Ⓑ Both types of forces occur only if the objects are in contact with each other.

Ⓒ Both types of forces would increase in strength if the masses of the objects decreased.

Ⓓ Both types of forces would decrease in strength if the distance between the objects increased.

6 An airplane is traveling at a velocity of 80 m/s when it lands on the ground. As soon as the airplane touches the ground, it undergoes a constant acceleration of $-5.0\ m/s^2$ and its velocity decreases to 10 m/s in 14 s.

Which of the following equations can be used to determine the distance the airplane travels as it slows from 80 m/s to 10 m/s?

Ⓐ $\Delta x = 0 + \frac{1}{2}(-5.0\ m/s^2)(14\ s)^2$

Ⓑ $\Delta x = (80\ m/s)(-5.0\ m/s^2)(14\ s)$

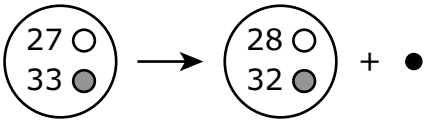
Ⓒ $\Delta x = 80\ m/s + (-5.0\ m/s^2)(14\ s)$

Ⓓ $\Delta x = (80\ m/s)(14\ s) + \frac{1}{2}(-5.0\ m/s^2)(14\ s)^2$

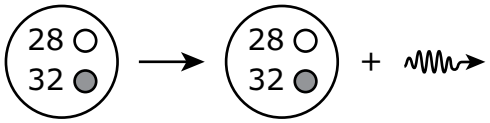
This question has two parts.

7 Cobalt-60 is a radioactive isotope that undergoes two processes, process 1 and process 2, when it decays. The diagrams show the processes.

Process 1



Process 2



Key	
○	Proton
●	Neutron
•	Electron
⇝	Photon

Part A

Which of the following best describes the energy involved in process 1?

Ⓐ The nucleus absorbs kinetic energy.

Ⓑ The emitted electron has kinetic energy.

Ⓒ The nucleus absorbs electromagnetic energy.

Ⓓ The emitted electron has chemical potential energy.

Part B

Which of the following best explains why a photon is emitted during process 2?

Ⓐ to reduce the nucleus size

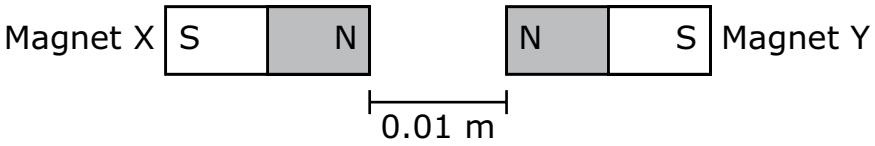
Ⓑ to change the type of nucleus

Ⓒ to make the nucleus more stable

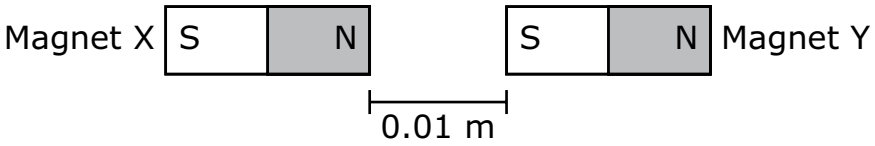
Ⓓ to increase the temperature of the nucleus

8 Two bar magnets, X and Y, are initially placed 0.01 m apart with their north poles facing each other. Magnet Y is then rotated so its south pole faces the north pole of magnet X. The diagrams show the initial setup and the final setup, after magnet Y is rotated.

Initial Setup



Final Setup



Which of the following best describes how the force exerted on magnet X is affected when magnet Y is rotated?

Ⓐ The magnitude of the force decreases and the direction of the force reverses.

Ⓑ The magnitude of the force stays the same and the direction of the force reverses.

Ⓒ The magnitude of the force increases and the direction of the force stays the same.

Ⓓ The magnitude of the force stays the same and the direction of the force stays the same.

9 Two beams of light, X and Y, shine on a metal surface and eject electrons from the surface. Light X ejects electrons that have a greater amount of energy than the electrons light Y ejects.

Which of the following best compares light X and light Y?

Ⓐ Light X's speed is less than light Y's.

Ⓑ Light X's speed is greater than light Y's.

Ⓒ Light X's frequency is less than light Y's.

Ⓓ Light X's frequency is greater than light Y's.

10 Which of the following questions would be **most** useful to ask to determine whether a wave is transverse or longitudinal?

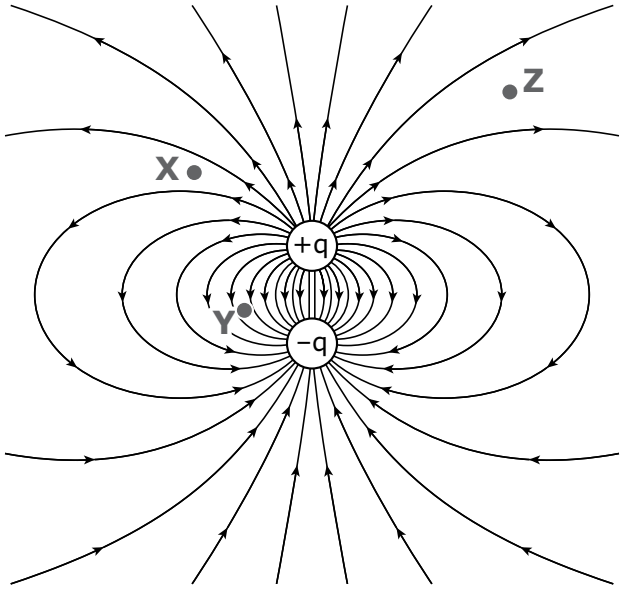
Ⓐ Can the wave travel through solids?

Ⓑ Does the wave have a measurable frequency?

Ⓒ In what direction do particles move relative to the direction the wave moves?

Ⓓ Is the wave generated by electromagnetic radiation or by a mechanical force?

11 A positively charged particle and a negatively charged particle that are surrounded by an electric field are shown in the diagram. Three locations in the electric field are labeled X, Y, and Z.



Which of the following best describes the strength of the electric field for two locations?

Ⓐ Location X has the weakest electric field, and location Z has the strongest electric field.

Ⓑ Location Y has the weakest electric field, and location Z has the strongest electric field.

Ⓒ Location Y has the weakest electric field, and location X has the strongest electric field.

Ⓓ Location Z has the weakest electric field, and location Y has the strongest electric field.

12 A generator converts

Ⓐ mechanical energy into electrical energy.

Ⓑ electrical energy into mechanical energy.

The generator converts energy by using the forces that act on charges as a result of a changing

Ⓐ gravitational field.

Ⓑ magnetic field.

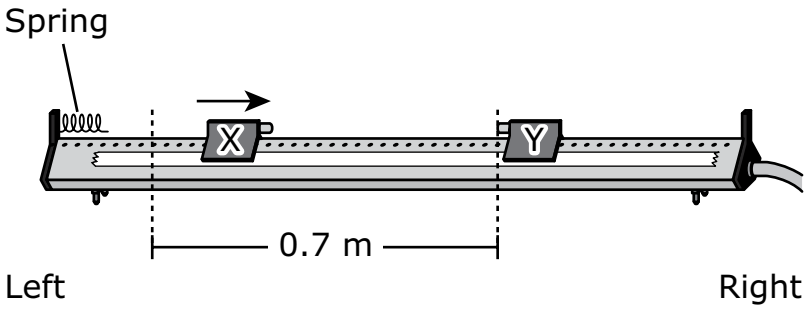
The following section focuses on an investigation about collisions.

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

A group of students conducted an investigation to learn about collisions. The students used an air track and two gliders, X and Y. Friction was negligible on the air track. The investigation had the following steps:

- The spring pushed glider X.
- Glider X moved a distance of 0.7 m to the right at a constant velocity.
- Glider X collided with glider Y.

The diagram shows glider X moving toward glider Y after glider X was pushed by the spring.



The students recorded the data from three trials of the investigation. A negative velocity indicates that the glider moved to the left, and a positive velocity indicates that the glider moved to the right. The data are shown in the table. No velocity data were recorded for glider Y after the collisions.

Trial	Mass of Gliders (kg)		Velocity before Collision (m/s)		Velocity after Collision (m/s)	
	X	Y	X	Y	X	Y
1	0.2	0.4	0.60	0	–0.20	?
2	0.8	0.2	0.30	0	0.18	?
3	0.8	0.8	0.30	0	0.00	?

13 In trial 1, which of the following best explains what happened to the kinetic energy of glider X after it collided with glider Y?

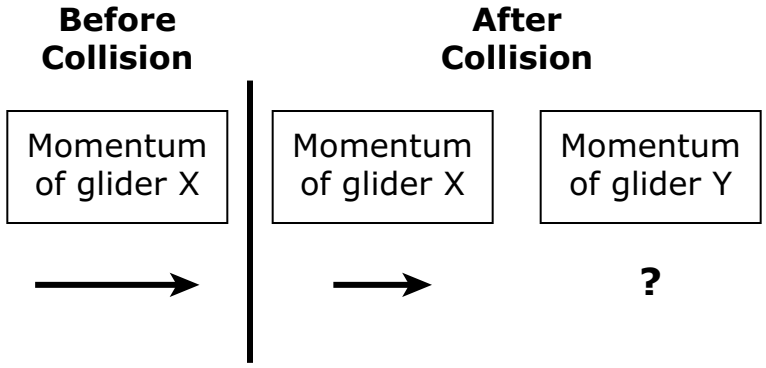
Ⓐ The kinetic energy of glider X decreased because some kinetic energy was transferred to glider Y.

Ⓑ The kinetic energy of glider X decreased to zero because all of the kinetic energy was transferred to glider Y.

Ⓒ The kinetic energy of glider X increased because some kinetic energy was transferred from glider Y to glider X.

Ⓓ The kinetic energy of glider X remained the same because no kinetic energy was transferred between the gliders.

14 The students made an incomplete model of the momentum of each glider before and after the collision in trial 2. In the model, the length of each arrow represents the magnitude of the momentum.



Which of the following arrows best completes the model?

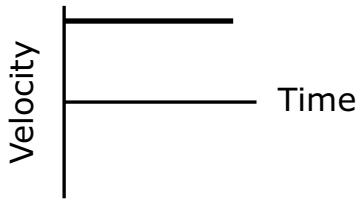
Ⓐ →

Ⓑ ⟶

Ⓒ ←

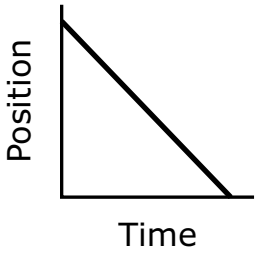
Ⓓ ⟵

15 The graph shows the velocity of glider X as it moved 0.7 m toward glider Y.

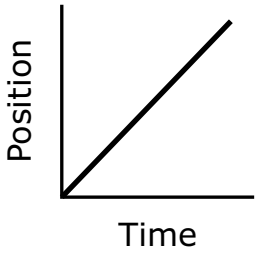


Which of the following graphs shows the position of glider X as it moved the 0.7 m toward glider Y?

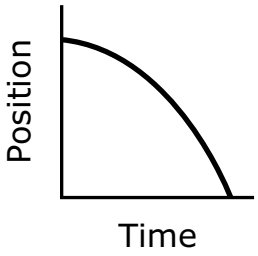
Ⓐ



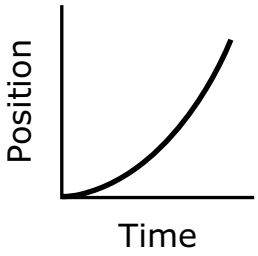
Ⓑ



Ⓒ



Ⓓ



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

16 During trial 1, glider X was moving to the right before the collision with glider Y, and then moved to the left after the collision with glider Y.

A. Based on the data table, calculate the momentum of glider X before the collision in trial 1. Show your calculations and include units in your answer.

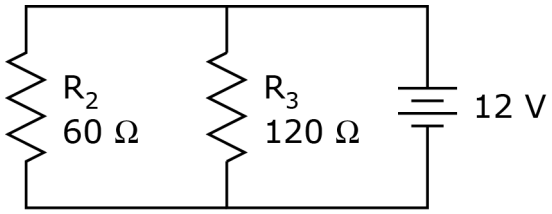
B. Calculate the change in momentum of glider X that resulted from the collision in trial 1. Show your calculations and include units in your answer.

C. In trial 1, the collision between glider X and glider Y occurred over 0.01 s.

Calculate the average force applied to glider X during the collision. Show your calculations and include units in your answer.

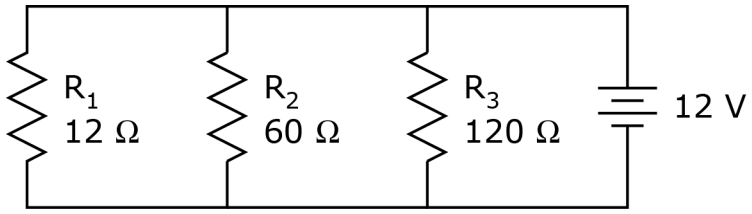
16

17 The circuit shown has a total current of 0.3 A.

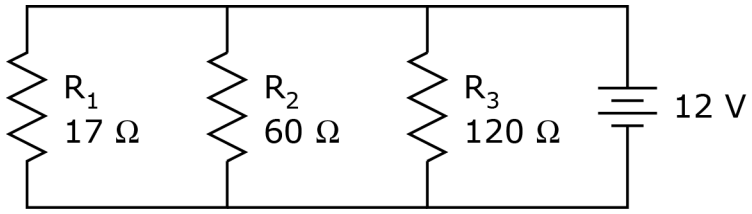


A resistor is added to the circuit so that the total current in the circuit is 0.7 A. Which diagram shows the new circuit with a total current of 0.7 A?

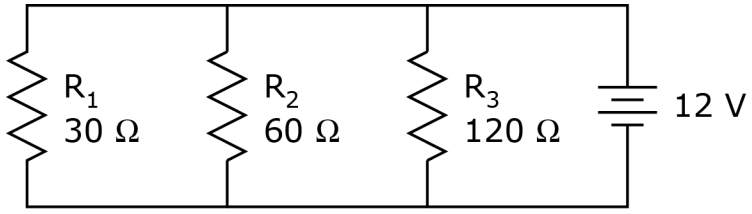
Ⓐ



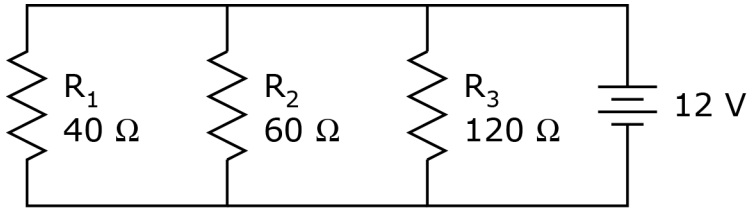
Ⓑ



Ⓒ



Ⓓ



18 The efficiencies of two devices, device X and device Y, are shown in the table.

Device	Efficiency
X	0.42
Y	0.30

If 95.0 J of energy is added to each device, what will be the difference in the output energies from the devices?

Ⓐ The output energy of device X will be 11.4 J less than the output energy of device Y.

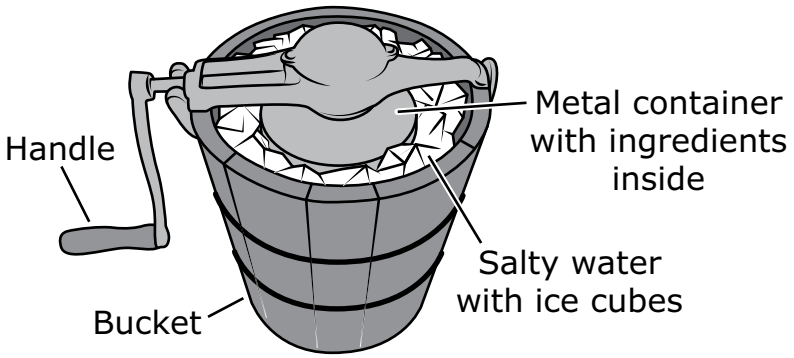
Ⓑ The output energy of device X will be 90.5 J less than the output energy of device Y.

Ⓒ The output energy of device X will be 11.4 J more than the output energy of device Y.

Ⓓ The output energy of device X will be 90.5 J more than the output energy of device Y.

This question has four parts. Write your response on page 22. Be sure to label each part of your response.

19 Homemade ice cream can be made using a metal container in a bucket. The metal container is filled with the ice cream ingredients (cream, sugar, and flavoring). The bucket is filled with salty water and ice cubes. The ice cream ingredients are stirred using a handle. The diagram shows the ice cream maker.



A. The parts of the ice cream maker system have different initial temperatures.

- The metal container and the ingredients both have an initial temperature of 10°C.
- The salty water with ice cubes has an initial temperature of −15°C.

The temperature of the air surrounding the bucket is 20°C.

On page 22, draw an arrow pointing left or right in **each** box to show how heat flows through the system.

B. The ingredients for vanilla ice cream have a specific heat of 3.22 J/g • °C and a freezing point of −5.6°C.

Calculate the amount of thermal energy transfer required to reduce the temperature of 1500 g of vanilla ice cream ingredients from 10°C to −5.6°C. Show your calculations and include units in your answer.

Continued

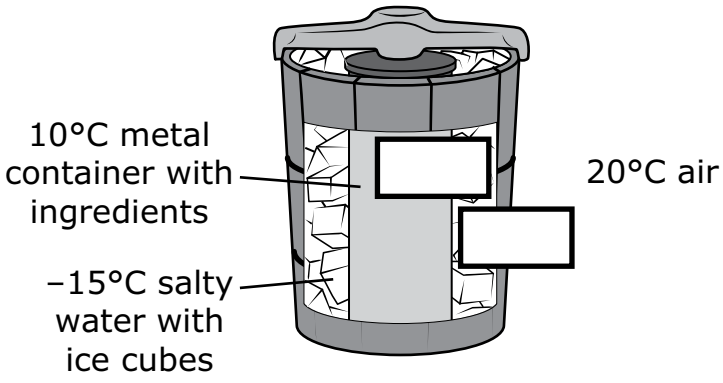
C. The ingredients for chocolate ice cream have a specific heat of 3.11 J/g • °C and a freezing point of –5.6°C.

Identify whether reducing the temperature of 1500 g of chocolate ice cream ingredients from 10°C to –5.6°C will require more, less, or the same amount of thermal energy transfer as is required to reduce 1500 g of vanilla ice cream ingredients from 10°C to –5.6°C. Explain your reasoning.

D. As the ice cream is being made, the temperature of the salty water with ice cubes is constant.

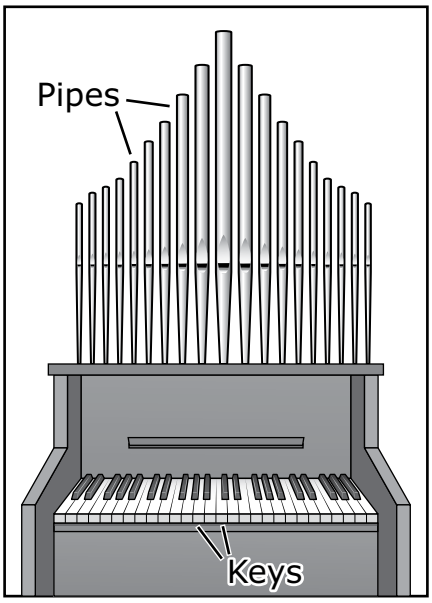
Explain how there can be thermal energy transfer between the metal container and the salty water without the temperature of the salty water changing.

19 A.


10°C metal container with ingredients
–15°C salty water with ice cubes
20°C air

This question has four parts. Write your response on page 25. Be sure to label each part of your response.

20 Pipe organs are musical instruments that produce sound waves using pipes. Each pipe is designed to produce a sound wave with a specific frequency when a key is pressed. A pipe organ is shown.



A. A sound wave reaches the end of an organ pipe, is reflected, and then constructively interferes with another sound wave.

Which of the following best describes what happens in the resulting wave when the sound waves constructively interfere?

Mark your answer by filling in the appropriate circle on page 25.

A The amplitude is less than that of the original waves.

B The amplitude is greater than that of the original waves.

C The wavelength is less than that of the original waves.

D The wavelength is greater than that of the original waves.

B. An organ pipe produces a sound wave with a frequency of 20 Hz.

Calculate the period of the sound wave. Show your calculations and include units in your answer.

C. The 20 Hz sound wave travels through the air at a speed of 343 m/s.

Calculate the wavelength of the sound wave. Show your calculations and include units in your answer.

D. A different pipe from the same organ produces a sound wave with a frequency of 32 Hz.

Identify whether the wavelength of the 32 Hz sound wave is longer than, shorter than, or equal to the wavelength of the 20 Hz sound wave. Explain your reasoning.

20 A. Ⓐ The amplitude is less than that of the original waves.

Ⓑ The amplitude is greater than that of the original waves.

Ⓒ The wavelength is less than that of the original waves.

Ⓓ The wavelength is greater than that of the original waves.

High School Introductory Physics
SESSION 2

This session contains 22 questions.

You may use your reference sheet in this session.

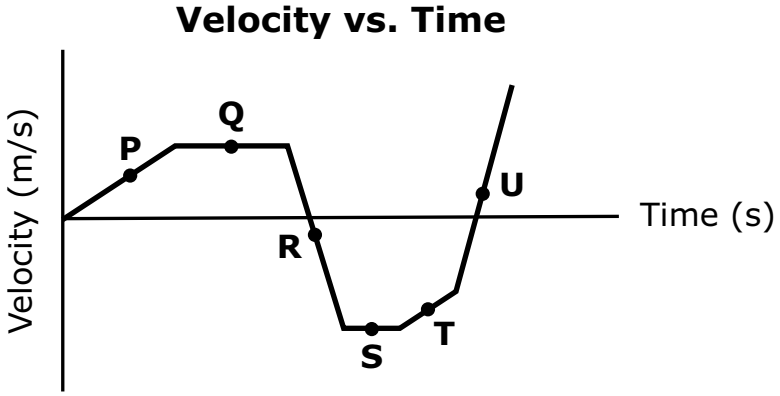
Directions

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

For some questions, you will mark your answers by filling in the circles in your Test & Answer 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.

21 The graph shows the velocity of an object over time. Six points on the graph are labeled P, Q, R, S, T, and U.



At which two points is the net force acting on the object zero?

Ⓐ point P and point T

Ⓑ point Q and point S

Ⓒ point R and point U

Ⓓ point S and point T

22 Air in the atmosphere has different densities at different heights above Earth's surface. Scientists are investigating the relationship between air density and the net force on a metal ball falling toward Earth's surface.

Measuring which of the following variables would **most** help the scientists determine the relationship between air density and net force on the ball as it falls toward Earth?

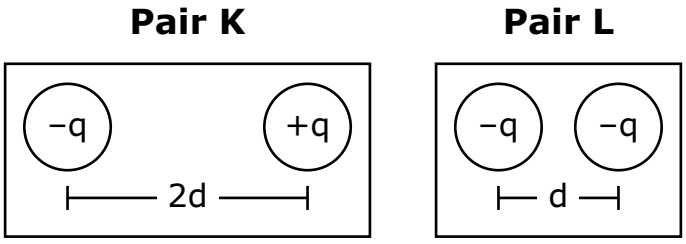
Ⓐ the ball's acceleration

Ⓑ the ball's temperature

Ⓒ the ball's specific heat

Ⓓ the ball's potential energy

23 The diagram shows two pairs of charged particles, pair K and pair L, held at different distances.



Energy is needed to move the particles closer together in

Ⓐ pair K.

Ⓑ pair L.

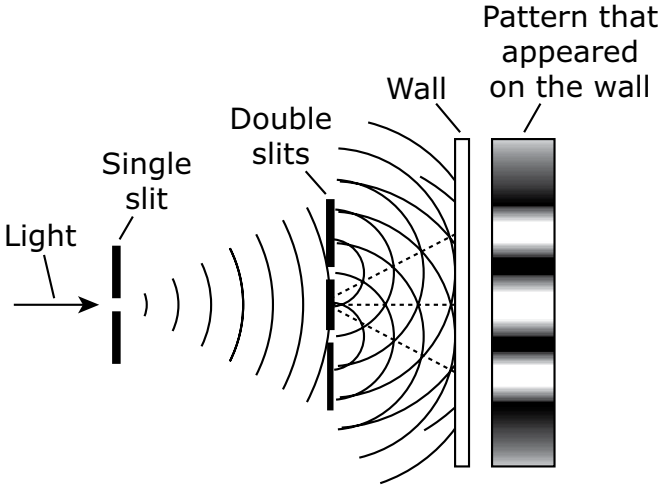
If all of the particles were released, the forces between them would increase in

Ⓐ pair K.

Ⓑ pair L.

This question has two parts.

24 The model shown represents the setup of a double-slit experiment.



Part A

During the experiment, as the light passed through the double slits it was

Ⓐ absorbed.

Ⓑ diffracted.

Ⓒ reflected.

Ⓓ refracted.

Part B

The pattern of light and dark regions on the wall was produced when light that passed through the double slits interacted because of

Ⓐ interference.

Ⓑ resonance.

Ⓒ the photoelectric effect.

25 A 1 kg object is dropped from rest and reaches the ground in 2 s. From what height was the object dropped?

Ⓐ 4 m

Ⓑ 10 m

Ⓒ 20 m

Ⓓ 40 m

26 A 100 g sample of water is heated from 30°C to 50°C. Which of the following changes to this procedure would require more heat energy?

Ⓐ using 50 g of water instead of 100 g

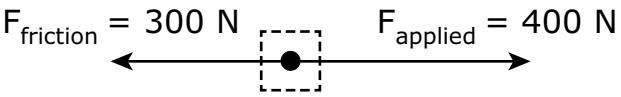
Ⓑ using 150 g of water instead of 100 g

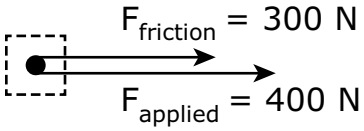
Ⓒ heating the water from 20°C to 40°C instead of from 30°C to 50°C

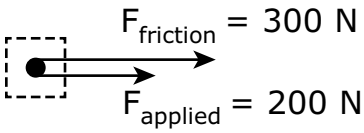
Ⓓ heating the water from 40°C to 60°C instead of from 30°C to 50°C

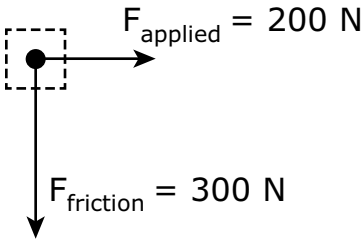
27 Two adults push a couch across a floor. Each adult applies a 200 N force to the couch in the same direction. There is a frictional force of 300 N acting on the moving couch.

Which of the following diagrams **best** represents the applied and frictional forces on the moving couch?

Ⓐ 

Ⓑ 

Ⓒ 

Ⓓ 

28 A box weighing 10 N is lifted from the floor to a height of 5 m. Which of the following describes the amount of work done to lift the box and the amount of energy transferred in the process?

Ⓐ No work is done, and the box loses 50 J of potential energy.

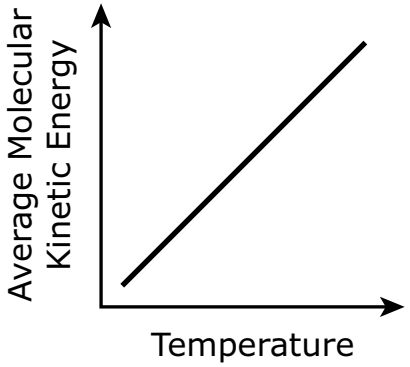
Ⓑ No work is done, and the box gains 50 J of potential energy.

Ⓒ The amount of work done is 50 J, and the box loses 50 J of potential energy.

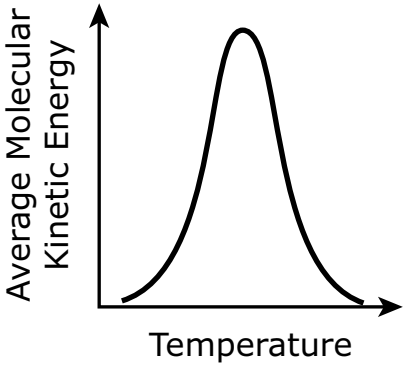
Ⓓ The amount of work done is 50 J, and the box gains 50 J of potential energy.

29 Which of the following graphs **best** represents how temperature is related to the average molecular kinetic energy of air?

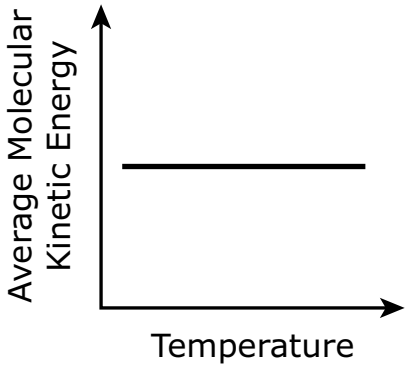
Ⓐ



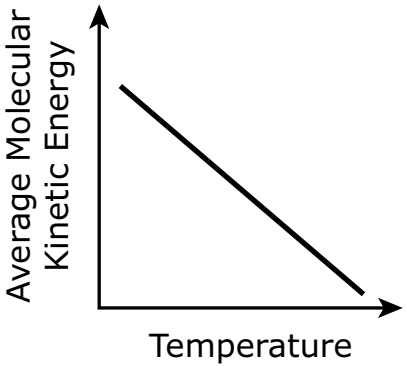
Ⓑ



Ⓒ



Ⓓ

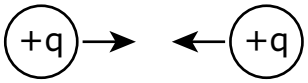


This question has two parts.

30 Two positively charged particles, each with a charge of +q, are placed near each other, as shown in the diagram.

Part A

Which of the following best represents the direction of the electrostatic force acting on each particle?

Ⓐ 

Ⓑ 

Ⓒ 

Ⓓ 

Part B

The two positively charged particles are moved so that the distance between them is half the original distance. Which of the following describes how this change affects the electrostatic force acting on each particle?

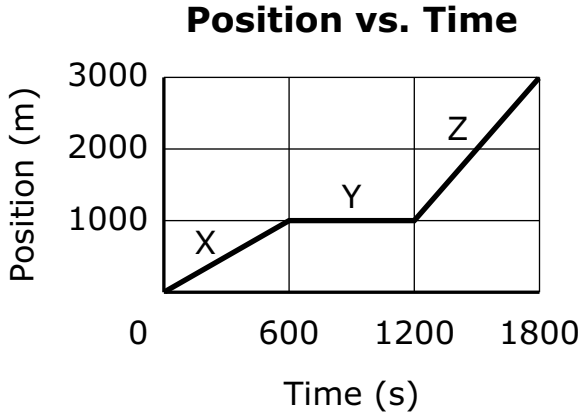
Ⓐ Each force is cut in half.

Ⓑ Each force does not change.

Ⓒ Each force doubles.

Ⓓ Each force is multiplied by four.

31 The graph shows how a runner's position changes over three time intervals, X, Y, and Z.



Based on the runner's speed during each time interval, which of the following orders the intervals from slowest speed to fastest speed?

Ⓐ Slowest interval → Fastest interval

X	Y	Z

Ⓑ Slowest interval → Fastest interval

Y	X	Z

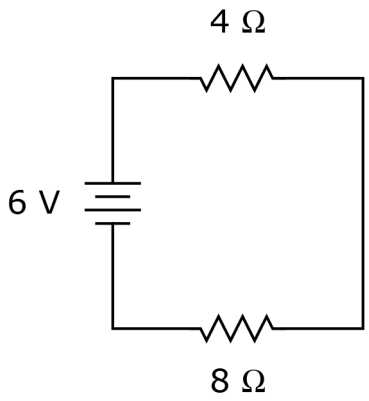
Ⓒ Slowest interval → Fastest interval

Y	Z	X

Ⓓ Slowest interval → Fastest interval

Z	X	Y

32 The diagram shows a circuit with two resistors and a battery.



Which of the following describes the voltage drop across the 4 Ω resistor?

Ⓐ It is one-half the voltage drop across the 8 Ω resistor.

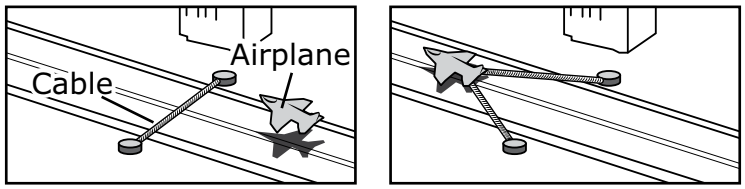
Ⓑ It is equal to the voltage drop across the 8 Ω resistor.

Ⓒ It is two times the voltage drop across the 8 Ω resistor.

Ⓓ It is four times the voltage drop across the 8 Ω resistor.

33 Airplanes can land on large ships called aircraft carriers. After an airplane lands on an aircraft carrier, a strong cable causes the airplane to slow down and stop. The diagrams show an airplane and the cable before and just after the plane lands on an aircraft carrier.

Before Landing **Just after Landing**



Which of the following describes a change that would reduce the force on the plane during landing?

Ⓐ The plane approaches the ship at a faster speed.

Ⓑ The plane approaches the ship at a slower speed.

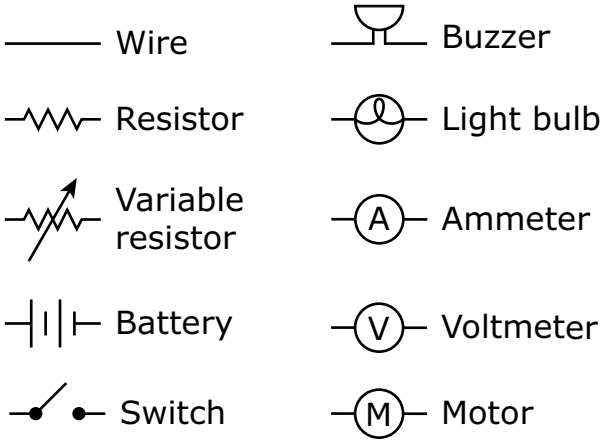
Ⓒ A shorter cable is used to stop the plane in less time.

Ⓓ A stronger cable is used to stop the plane in less time.

The following section focuses on investigating circuits.

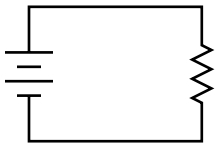
Read the information below and use it to answer the selected-response questions and constructed-response question that follow.

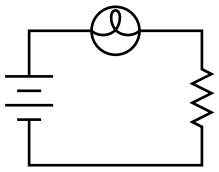
A group of students performed several investigations using components from a circuit kit. The schematic symbols for the different types of components in the kit are shown.

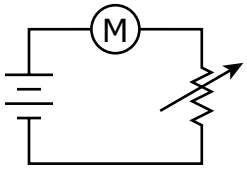


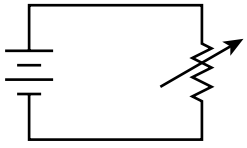
While performing the investigations, the students used the components to build a variety of circuits. They used an ammeter to measure the current through different circuit components and a voltmeter to measure the voltage drop across them.

34 Which of the following circuits that the students built converts electric energy into both thermal energy and mechanical energy?

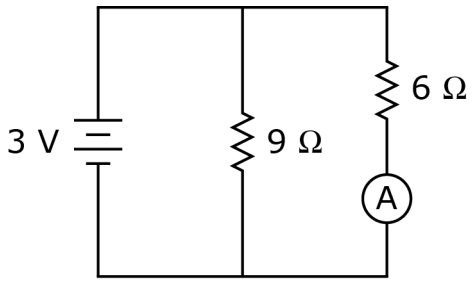
Ⓐ 

Ⓑ 

Ⓒ 

Ⓓ 

35 The students built a circuit with a battery, two resistors, and an ammeter, as shown.



What was the current through the ammeter in the circuit?

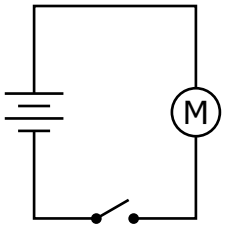
Ⓐ 0.2 A

Ⓑ 0.5 A

Ⓒ 15 A

Ⓓ 18 A

36 The students built a circuit with a battery, a switch, and a motor. The circuit is shown.



When the switch was closed, the motor began to spin. Which of the following best describes what caused the motor to spin?

Ⓐ Electric charges transferred momentum to the magnets in the motor.

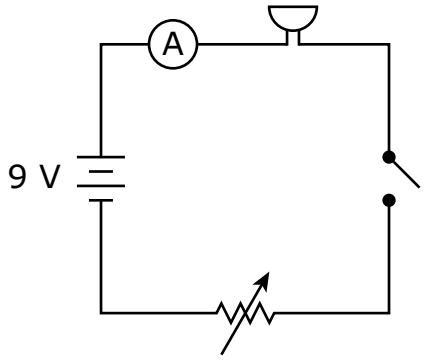
Ⓑ Electric charges repelled other charges on the magnets in the motor.

Ⓒ Electric current produced a magnetic field, which applied a force to the magnets in the motor.

Ⓓ Electric current added positive charges to the magnets in the motor, which created an electric field.

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

37 The students built a circuit that includes a buzzer, as shown. When the amount of current passing through the buzzer increases, the volume of the buzzer's sound also increases.



A. The students want to increase the volume of the sound coming from the buzzer.

Identify whether the students should increase or decrease the resistance in the variable resistor to increase the volume of the buzzer's sound. Explain your reasoning.

B. When the students close the switch and set the variable resistor to 1950 Ω, the buzzer produces a sound with a constant frequency of 2900 Hz. Sound waves travel through air at a speed of 343 m/s.

Calculate the wavelength of the sound wave produced by the buzzer when the variable resistor is set to 1950 Ω. Show your calculations and include units in your answer.

C. The students place the circuit in a waterproof container and then put the container under water while the buzzer is making sound. The frequency of the buzzer's sound wave does not change as it moves from the air in the container into the water.

Compare the wavelength of the sound wave in air with the wavelength of the sound wave in water. Explain your reasoning.

37

38 A 1 kg bird is moving at 90 m/s as it catches its prey. The bird stops 0.8 s later.

What is the magnitude of the average acceleration of the bird from the time it catches its prey to the time it stops?

Ⓐ 10 m/s^2

Ⓑ 72 m/s^2

Ⓒ 90 m/s^2

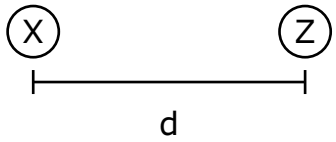
Ⓓ 113 m/s^2

39 In Diagram 1, objects X and Y are separated by distance d, as shown. Object Y's mass is twice the amount of object X's mass.

Diagram 1

In Diagram 2, object Y is replaced with object Z, as shown. Object Z's mass is the same as object X's mass.

Diagram 2



Which of the following best compares the gravitational force exerted on object X in Diagram 1 with the gravitational force exerted on object X in Diagram 2?

Ⓐ The force in Diagram 1 is one-fourth the force in Diagram 2.

Ⓑ The force in Diagram 1 is one-half the force in Diagram 2.

Ⓒ The force in Diagram 1 is two times the force in Diagram 2.

Ⓓ The force in Diagram 1 is four times the force in Diagram 2.

40 Engineers are testing the efficiency of four types of solar panels. The engineers plan to use each solar panel as the energy source in an electric circuit. They will measure the energy output from each solar panel.

To compare the efficiency of the solar panels, which of the following should the engineers keep constant?

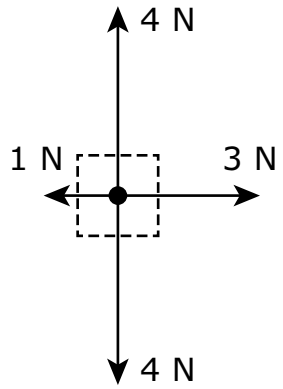
Ⓐ the thickness of each panel

Ⓑ the voltage produced by each panel

Ⓒ the amount of light reaching each panel

Ⓓ the total current flowing through each panel

41 A child pushes a toy block to the right. The free-body force diagram shows the forces acting on the block at one moment in time.



Select **two** statements that best describe the block at the moment in time shown in the diagram.

Ⓐ The block is accelerating.

Ⓑ The block is slowing down.

Ⓒ The net force on the block is 0 N.

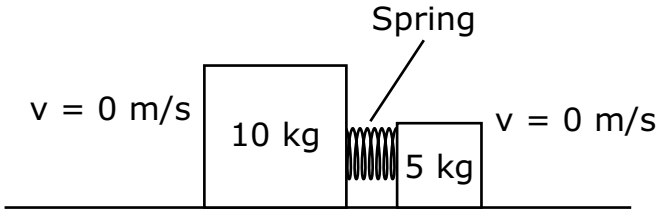
Ⓓ The net force on the block is 2 N.

Ⓔ The block is moving at a constant speed.

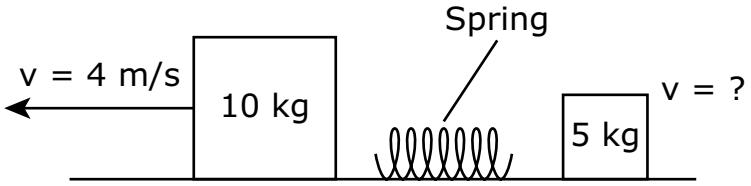
This question has four parts. Write your response on the next page. Be sure to label each part of your response.

42 A spring is compressed between a 10 kg block and a 5 kg block that are at rest on a frictionless surface. Then the spring is released. The diagrams show the two-block system before and after the spring is released.

Before Spring Is Released



After Spring Is Released



A. Determine the momentum of the system before **and** after the spring is released. Explain your reasoning using the law of conservation of momentum.

B. Calculate the momentum of the 10 kg block after the spring is released. Show your calculations and include units in your answer.

C. Calculate the magnitude of the velocity of the 5 kg block after the spring is released. Show your calculations and include units in your answer.

D. Energy is also conserved in this system.

Describe how energy is conserved when the spring is released. Be sure to discuss both potential **and** kinetic energy.

42

MASSACHUSETTS Department of Elementary and Secondary Education

Massachusetts Comprehensive Assessment System
Introductory Physics Reference Sheet

Formulas

$s_{average} = \frac{d}{\Delta t}$

$v_{average} = \frac{\Delta x}{\Delta t}$

$a_{average} = \frac{\Delta v}{\Delta t}$

$v_f = v_i + a\Delta t$

$\Delta x = v_i\Delta t + \frac{1}{2}a\Delta t^2$

$p = mv$

$F\Delta t = \Delta p$

$F_{net} = ma$

$F_g = mg$

$F_g = G\frac{m_1 m_2}{d^2}$

$F_e = k\frac{q_1 q_2}{d^2}$

$KE = \frac{1}{2}mv^2$

$\Delta PE = mg\Delta h$

$W = \Delta E = Fd$

$eff = \frac{E_{out}}{E_{in}}$

$Q = mc\Delta T$

$v = \lambda f$

$T = \frac{1}{f}$

$V = IR$

Variables

a = acceleration
c = specific heat
d = distance
E = energy
eff = efficiency
f = frequency
F = force
g = acceleration due to gravity
Δh = change in height
I = current
KE = kinetic energy
λ = wavelength
m = mass
p = momentum
ΔPE = change in gravitational potential energy
q = charge of particle
Q = heat added or removed
R = resistance
s = speed
Δt = change in time
T = period
ΔT = change in temperature
v = velocity
V = potential difference (voltage)
W = work
Δx = change in position (displacement)

Unit Symbols

ampere, A
coulomb, C
degree Celsius, °C
hertz, Hz
joule, J
kilogram, kg
meter, m
newton, N
ohm, Ω
second, s
volt, V

Definitions

speed of electromagnetic waves in a vacuum = 3×10^8 m/s

G = Universal gravitational constant = $6.7 \times 10^{-11} \frac{N \cdot m^2}{kg^2}$

k = Coulomb's constant = $9 \times 10^9 \frac{N \cdot m^2}{C^2}$

$g \approx 10$ m/s^2 at Earth's surface

$1\ N = 1\frac{kg \cdot m}{s^2}$

1 J = 1 N • m

High School Introductory Physics
Spring 2026 Released Operational Items

PBT Item No.*	Page No.	Reporting Category	Standard	Science Practice Category	Item Type**	Item Description	Correct Answer (SR)***
1	4	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the final velocity of an object after it accelerates.	C
2	4	*Motion, Forces, and Interactions*	HS.PHY.2.9	None	SR	Determine which circuit element will increase the brightness of a light bulb in a circuit when it is added to the circuit.	A
3	5	*Waves*	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	SR	Explain how a device uses the principles of wave interactions with matter to detect an object.	C
4	6	*Motion, Forces, and Interactions*	HS.PHY.2.1	B. Mathematics and Data	SR	Interpret a free-body force diagram to determine the acceleration of an object.	B
5	7	*Motion, Forces, and Interactions*	HS.PHY.2.4	None	SR	Describe a similarity between electrostatic and gravitational forces.	D
6	7	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Determine which equation describes the distance traveled by an object undergoing constant acceleration.	D
7	8	*Energy*	HS.PHY.1.8	C. Evidence, Reasoning, and Modeling	SR	Interpret models of nuclear processes to determine the type of energy emitted and explain why energy is emitted.	B;C
8	9	*Energy*	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR	Describe how the magnetic force on a magnet is affected when a nearby magnet is rotated.	B
9	10	*Waves*	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR	Explain why a light source ejects electrons from a metal surface that have a greater amount of energy than the electrons ejected by another light source.	D
10	10	*Waves*	HS.PHY.4.1	A. Investigations and Questioning	SR	Identify which question would be most useful to determine whether a wave is transverse or longitudinal.	C
11	11	*Energy*	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Order the locations around a pair of charges by the strength of the electric field.	D
12	12	*Motion, Forces, and Interactions*	HS.PHY.2.5	None	SR	Describe how a generator uses a changing magnetic field to convert mechanical energy into electrical energy.	A;B
13	14	*Energy*	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Describe how the kinetic energy of an object changes as a result of a collision.	A

PBT Item No.*	Page No.	Reporting Category	Standard	Science Practice Category	Item Type**	Item Description	Correct Answer (SR)***
14	14	*Motion, Forces, and Interactions*	HS.PHY.2.2	C. Evidence, Reasoning, and Modeling	SR	Complete a model of the momentum of an object before and after a collision.	A
15	15	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Interpret a velocity vs. time graph to determine the position vs. time graph that represents the motion of an object.	B
16	16–17	*Motion, Forces, and Interactions*	HS.PHY.2.3	B. Mathematics and Data	CR	Calculate the momentum of an object just before a collision, the change in momentum of the object as a result of the collision, and the average force applied to the object during the collision.	
17	18	*Motion, Forces, and Interactions*	HS.PHY.2.9	C. Evidence, Reasoning, and Modeling	SR	Determine which parallel circuit has a given total current.	C
18	19	*Energy*	HS.PHY.3.3	B. Mathematics and Data	SR	Analyze how the efficiencies of two devices affect the output energies of the devices.	C
19	20–22	*Energy*	HS.PHY.3.4	B. Mathematics and Data	CR	Complete a model to show how heat flows through a system, calculate the amount of thermal energy required for a temperature change, explain why less thermal energy is required to change the temperature of a substance compared with another substance, and explain how the temperature of a substance can remain constant when thermal energy is transferred.	
20	23–25	*Waves*	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	CR	Describe how constructive interference affects the amplitude of a wave, calculate the period and wavelength of a wave, and explain why waves with different wavelengths have different frequencies.	
21	27	*Motion, Forces, and Interactions*	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Interpret a velocity vs. time graph to identify when the net force on an object is zero.	B
22	27	*Motion, Forces, and Interactions*	HS.PHY.2.1	A. Investigations and Questioning	SR	Identify which variable needs to be measured to determine the relationship between the net force on a falling object and air density.	A
23	28	*Energy*	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR	Determine when energy is needed to move two charged particles closer together and when the forces between two charged particles would increase if the particles were released.	B;A
24	29	*Waves*	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR	Interpret a model to describe how light behaves during a double-slit experiment.	B;A

PBT Item No.*	Page No.	Reporting Category	Standard	Science Practice Category	Item Type**	Item Description	Correct Answer (SR)***
25	30	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the height from which an object was dropped when given the amount of time it takes the object to reach the ground.	C
26	30	*Energy*	HS.PHY.3.4	None	SR	Describe how the procedure of an investigation about heating a liquid should be changed.	B
27	31	*Motion, Forces, and Interactions*	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR	Determine which diagram represents the applied and frictional forces acting on an object.	A
28	31	*Energy*	HS.PHY.3.1	B. Mathematics and Data	SR	Describe the amount of work done to lift a box and the amount of energy transferred in the process.	D
29	32	*Energy*	HS.PHY.3.2	None	SR	Determine which graph best represents the relationship between temperature and average molecular kinetic energy.	A
30	33	*Motion, Forces, and Interactions*	HS.PHY.2.4	C. Evidence, Reasoning, and Modeling	SR	Identify the model that represents the directions of the electrostatic forces acting on two charged particles and describe how moving the particles closer affects those forces.	B;D
31	34	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Interpret a position vs. time graph to order several time intervals by speed.	B
32	35	*Motion, Forces, and Interactions*	HS.PHY.2.9	C. Evidence, Reasoning, and Modeling	SR	Compare the voltage drop across two resistors in a series circuit.	A
33	36	*Motion, Forces, and Interactions*	HS.PHY.2.3	C. Evidence, Reasoning, and Modeling	SR	Determine that a slower-moving object will require a smaller force to stop it than a faster-moving object will.	B
34	37	*Energy*	HS.PHY.3.1	C. Evidence, Reasoning, and Modeling	SR	Interpret circuit diagrams to determine which circuit converts electric energy into thermal energy and mechanical energy.	C
35	38	*Motion, Forces, and Interactions*	HS.PHY.2.9	B. Mathematics and Data	SR	Calculate the current through a branch of a parallel circuit.	B
36	38	*Motion, Forces, and Interactions*	HS.PHY.2.5	None	SR	Describe how electric current causes a motor to spin.	C
37	39–40	*Waves*	HS.PHY.4.1	C. Evidence, Reasoning, and Modeling	CR	Explain whether the resistance in a circuit component should be increased or decreased for a given situation, calculate the wavelength of a sound wave produced by the circuit component, compare how the wavelength travels in air with how it travels in water, and explain the reasoning.	

PBT Item No.*	Page No.	Reporting Category	Standard	Science Practice Category	Item Type**	Item Description	Correct Answer (SR)***
38	41	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate average acceleration using time, initial velocity, and final velocity.	D
39	41	*Motion, Forces, and Interactions*	HS.PHY.2.4	C. Evidence, Reasoning, and Modeling	SR	Describe how the gravitational forces between two objects change when the mass of one object doubles.	C
40	42	*Energy*	HS.PHY.3.3	A. Investigations and Questioning	SR	Identify a variable that must be kept constant to compare the efficiency of multiple solar panels.	C
41	42	*Motion, Forces, and Interactions*	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Interpret a free-body force diagram to determine the net force on an object and whether the object is accelerating.	A,D
42	43–44	*Motion, Forces, and Interactions*	HS.PHY.2.2	B. Mathematics and Data	CR	Determine the momentum of a system and explain the reasoning, calculate the momentum and velocity of one of the blocks in the system, and describe how energy is conserved in the system.	

* The 2026 Introductory Physics test results were reported using 58 points instead of 60 points. DESE excluded one two-point question that students reported having technology difficulties with during test administration. This question did not count toward any student's score.

** Science item types are: selected-response (SR) and constructed-response (CR).

*** Answers are provided here for selected-response items only. Sample responses and scoring guidelines for constructed-response items will be posted to the Department's website later this year.