

## **Computer-Based Released Items High School Introductory Physics MCAS Spring 2023**

The spring 2023 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.

The Department of Elementary and Secondary Education is releasing items from both versions of the test to provide information about the knowledge and skills that students are expected to demonstrate.

- Released items from the **computer-based test** are available online at [mcas.pearsonsupport.com/released-items](https://mcas.pearsonsupport.com/released-items). The computer-based released items are collected in a “mini test” called an ePAT (electronic practice assessment tool). Items in the ePAT are displayed in TestNav 8, the testing platform for the computer-based tests.
- Released items from the **paper-based test** are available in PDF format on the Department’s website at [www.doe.mass.edu/mcas/release.html](http://www.doe.mass.edu/mcas/release.html).

This document provides information about each released item from the *computer-based test*, including the following: reporting category, standard covered, science practice category covered (if any), item type, and item description. Answers are provided for selected-response items only. Sample student responses and scoring guides for constructed-response items will be posted at [www.doe.mass.edu/mcas/student/](http://www.doe.mass.edu/mcas/student/).

### **A Note about Testing Mode**

Most of the operational items on the 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 STE content and assessed the same standard as the technology-enhanced item.

**High School Introductory Physics**  
**Spring 2023 Computer-Based Released Operational Items**

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description	Correct Answer (SR)**
1	Motion, Forces, and Interactions	HS.PHY.2.2	B. Mathematics and Data	SR	Determine which object has the greatest momentum.	D
2	Motion, Forces, and Interactions	HS.PHY.2.4	C. Evidence, Reasoning, and Modeling	SR	Compare the forces between pairs of charged particles.	<i>see page 5</i>
3	Motion, Forces, and Interactions	HS.PHY.2.5	C. Evidence, Reasoning, and Modeling	SR	Explain why a compass needle moves when it is placed near a current-carrying wire.	C
4	Energy	HS.PHY.3.1	C. Evidence, Reasoning, and Modeling	SR	Interpret a model to identify where a car has the most gravitational potential energy and where the car has the most kinetic energy.	<i>see page 5</i>
5	Motion, Forces, and Interactions	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR	Determine that an object is accelerating upward based on its free-body force diagram.	A
6	Energy	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR 2 pt.	Describe how a test charge will move when placed next to a charge that is fixed in position, and describe how the distance and forces between the two charges will change.	<i>see page 5</i>
7	Motion, Forces, and Interactions	HS.PHY.2.9	B. Mathematics and Data	SR	Determine the values of resistors in a series circuit.	<i>see page 5</i>
8	Motion, Forces, and Interactions	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR	Interpret a velocity vs. time graph to determine when a vehicle has the greatest acceleration.	C
9	Motion, Forces, and Interactions	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR	Describe the velocity and forces acting on an object based on a position vs. time graph.	<i>see page 6</i>
10	Energy	HS.PHY.3.1	B. Mathematics and Data	SR	Determine over which time interval the most work was done on an object.	A
11	Energy	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Interpret a temperature vs. thermal energy added graph to determine when a substance changed from a liquid to a gas.	C
12	Waves	HS.PHY.4.1	None	SR	Recognize that both mechanical and electromagnetic waves carry energy.	A
13	Waves	HS.PHY.4.1	None	SR	Recognize that the amount of time it takes a wave to complete one cycle can be found from the frequency of the wave.	B
14	Waves	HS.PHY.4.1	B. Mathematics and Data	SR	Calculate the wavelength of the light emitted from a laser.	B
15	Waves	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR 2 pt.	Describe how waves diffract as they pass through an opening and then constructively interfere.	<i>see page 6</i>
16	Waves	HS.PHY.4.1	B. Mathematics and Data	CR 3 pt.	Calculate the velocity of a wave, interpret a model to compare the wavelengths of the wave in different situations, and explain how the velocity of the wave is changed as a result of the wavelength changing.	

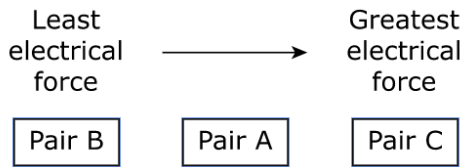
17	Energy	HS.PHY.1.8	C. Evidence, Reasoning, and Modeling	SR	Interpret models of radioactive decay to determine which models represent alpha decay, beta decay, and gamma decay.	<i>see page 6</i>
18	Motion, Forces, and Interactions	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the velocity of a rocket after a certain time period when given the initial velocity and constant acceleration.	B
19	Motion, Forces, and Interactions	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Determine the speed vs. time graph that best matches a given situation.	C
20	Motion, Forces, and Interactions	HS.PHY.2.4	B. Mathematics and Data	CR 4 pt.	Identify the attractive force between objects, compare the magnitude of the force between different pairs of objects, and determine how the force would change if the mass of one object were reduced.	
21	Energy	HS.PHY.3.4	B. Mathematics and Data	CR 4 pt.	Determine the direction of heat flow between marbles and water in an investigation, calculate the amount of thermal energy transferred and the specific heat of the marbles, and describe whether changing the number of marbles would affect their specific heat.	
22	Motion, Forces, and Interactions	HS.PHY.2.3	A. Investigations and Questioning	SR	Determine two variables that must be kept constant while testing how well a device minimizes the collision force on an object.	A,D
23	Motion, Forces, and Interactions	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Describe the velocity of an object based on its free-body force diagram and explain how increasing the applied force should be represented in the object's free-body force diagram.	<i>see page 6</i>
24	Energy	HS.PHY.3.2	B. Mathematics and Data	SR	Calculate the change in gravitational potential energy of a system of two objects.	C
25	Waves	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	SR 2 pt.	Recognize that two wave pulses interfere when they overlap and determine the amplitude of the resulting wave pulse.	B;B
26	Motion, Forces, and Interactions	HS.PHY.2.9	B. Mathematics and Data	SR	Calculate the current through a resistor.	A
27	Energy	HS.PHY.3.2	B. Mathematics and Data	SR	Calculate the acceleration of an object due to gravity on Mars.	C
28	Motion, Forces, and Interactions	HS.PHY.2.4	None	SR	Identify a difference between the forces described by Newton's law of gravitation and Coulomb's law.	B
29	Motion, Forces, and Interactions	HS.PHY.2.2	B. Mathematics and Data	SR	Analyze a collision using momentum conservation and model the velocity of one of the objects before and after the collision.	B
30	Waves	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR	Determine two pieces of evidence from a model that support the claim that light acts like a wave.	B,C
31	Energy	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR	Describe how to increase the potential energy between two magnets.	B
32	Motion, Forces, and Interactions	HS.PHY.2.3	B. Mathematics and Data	SR	Compare the change in momentum and the change in velocity of two objects.	<i>see page 7</i>

33	Motion, Forces, and Interactions	HS.PHY.2.9	C. Evidence, Reasoning, and Modeling	SR	Interpret circuit diagrams to determine the circuit with the brightest light bulb.	C
34	Energy	HS.PHY.3.1	B. Mathematics and Data	SR	Calculate the amount of work gravity did on an object.	B
35	Energy	HS.PHY.3.3	C. Evidence, Reasoning, and Modeling	SR	Describe how a setup can be changed to reduce how far an object rolls off a table.	A
36	Energy	HS.PHY.3.3	B. Mathematics and Data	SR 2 pt.	Describe how energy changes in a system and determine the efficiency of part of the system.	Part A: <i>see page 7</i> Part B: B
37	Motion, Forces, and Interactions	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	CR 3 pt.	Analyze a model of two objects that are at rest and connected by a pulley to compare the net force on and mass of each object, and describe how mass being added to an object would affect the direction of the net force on the object.	
38	Motion, Forces, and Interactions	HS.PHY.2.2	B. Mathematics and Data	SR	Compare the momentum of vehicles with different masses and velocities.	<i>see page 7</i>
39	Waves	HS.PHY.4.1	None	SR	Describe a difference between an electromagnetic wave and a mechanical wave.	C
40	Energy	HS.PHY.3.4	A. Investigations and Questioning	SR	Determine which measurements a student must make to calculate the specific heat of a metal sample.	A,D,F
41	Motion, Forces, and Interactions	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR 2 pt.	Determine which free-body force diagram represents the forces on an object and calculate the acceleration of the object.	C;B
42	Motion, Forces, and Interactions	HS.PHY.2.5	None	CR 4 pt.	Explain why a light bulb turns on in a given setup, describe two changes to the setup that would increase the brightness of the bulb, and describe how the relationship between electricity and motion in the setup is different than in an electric motor.	

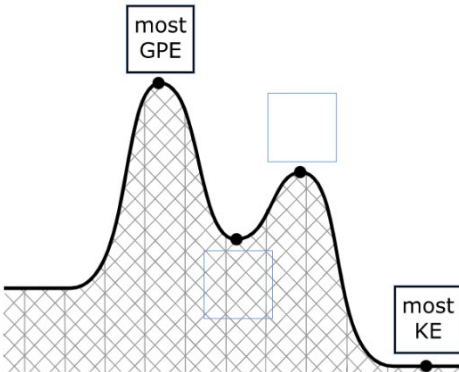
\* STE item types are selected-response (SR) and constructed-response (CR). All selected-response items are worth 1 point unless otherwise noted.

\*\*Answers are provided here for selected-response items only. Pages 5 through 7 of this document provide correct answers for technology-enhanced (TE) items. Sample student responses and scoring guides for constructed-response items will be posted at [www.doe.mass.edu/mcas/student/](http://www.doe.mass.edu/mcas/student/).

### Correct Answer for CBT Item #2: Technology-Enhanced Item



### Correct Answer for CBT Item #4: Technology-Enhanced Item



### Correct Answer for CBT Item #6: Technology-Enhanced Item

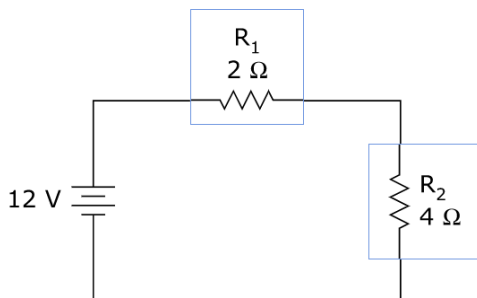
#### Part A:

The field of the fixed charge will cause the test charge to move   $\downarrow$

#### Part B:

As the test charge moves, the distance between the two charges will   $\downarrow$  making the forces between them   $\downarrow$

### Correct Answer for CBT Item #7: Technology-Enhanced Item



**Correct Answer for CBT Item #9: Technology-Enhanced Item**

The velocity of the object is  and the forces acting on the object are

**Correct Answer for CBT Item #15: Technology-Enhanced Item**

**Part A:**

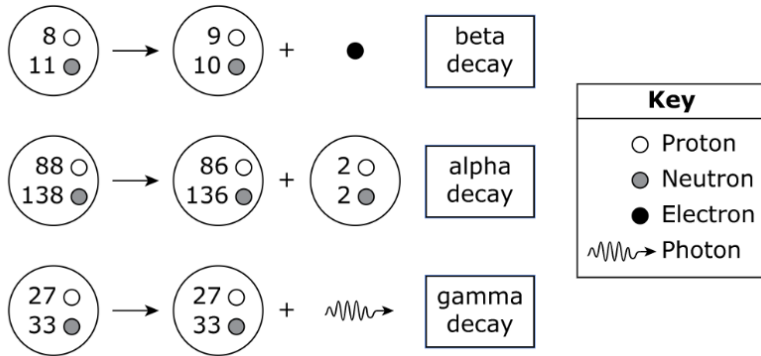
As waves passed through the gap, they

This wave phenomenon is called

**Part B:**

Constructive interference occurred where the crests of the waves passing through one gap met the  of the waves passing through the other gap.

**Correct Answer for CBT Item #17: Technology-Enhanced Item**



**Correct Answer for CBT Item #23: Technology-Enhanced Item**

Based on the free-body force diagram, the velocity of the refrigerator is  as it moves across the floor.

If the person applies a greater force to the refrigerator, the arrow representing the applied force should be  the arrow representing the friction force.

**Correct Answer for CBT Item #32: Technology-Enhanced Item**

The change in momentum of object X was  the change in momentum of object Y.

The change in velocity of object X was  the change in velocity of object Y.

**Correct Answer for CBT Item #36 Part A: Technology-Enhanced Item**

Before the spring was released, the marble was at rest and had

energy.

After the spring was released, some of the  energy stored in the spring was transferred to the marble, giving the marble

energy.

**Correct Answer for CBT Item #38: Technology-Enhanced Item**

