**Computer-Based Released Items**
**High School Introductory Physics MCAS**
**Spring 2024**

The spring 2024 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. 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.

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/.

## 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 science content and assessed the same standard as the technology-enhanced item.

## High School Introductory Physics
## Spring 2024 Computer-Based Released Operational Items

| CBT Item No. | Reporting Category | Standard | Science Practice Category | Item Type* | Item Description | Correct Answer (SR)** |
|---|---|---|---|---|---|---|
| 1 | Energy | HS.PHY.3.5 | None | SR | Describe how changing the distance between two charged particles affects the forces between the particles. | C |
| 2 | Energy | HS.PHY.3.2 | C. Evidence, Reasoning, and Modeling | SR | Complete a model to show how the molecular motion of a substance changes as it is heated. | *see page 5* |
| 3 | Waves | HS.PHY.4.1 | B. Mathematics and Data | SR | Compare the wavelength of a sound wave in air and water. | D |
| 4 | Motion, Forces, and Interactions | HS.PHY.2.9 | B. Mathematics and Data | SR | Calculate the current flowing through a series circuit. | A |
| 5 | Motion, Forces, and Interactions | HS.PHY.2.2 | B. Mathematics and Data | SR | Determine the object with the greatest momentum. | C |
| 6 | Energy | HS.PHY.1.8 | C. Evidence, Reasoning, and Modeling | SR | Interpret a model to describe a nuclear process. | *see page 5* |
| 7 | Waves | HS.PHY.4.5 | C. Evidence, Reasoning, and Modeling | SR 2 pt. | Interpret a diagram to determine the wave behavior shown, and describe how the speed and wavelength of light changes as it passes from air into another medium. | Part A: A Part B: *see page 5* |
| 8 | Waves | HS.PHY.4.3 | None | SR | Identify an example of light behaving like a particle. | A |
| 9 | Motion, Forces, and Interactions | HS.PHY.2.1 | B. Mathematics and Data | SR | Calculate the net force on an object. | D |
| 10 | Motion, Forces, and Interactions | HS.PHY.2.5 | A. Investigations and Questioning | SR 2 pt. | Explain that current flowing through a wire produces a magnetic field that can apply a force, and determine the question that was being answered by an investigation. | Part A: *see page 5* Part B: C |
| 11 | Energy | HS.PHY.3.4 | C. Evidence, Reasoning, and Modeling | SR | Determine which temperature vs. time graph represents two objects in thermal contact. | B |
| 12 | Motion, Forces, and Interactions | HS.PHY.2.9 | B. Mathematics and Data | SR | Analyze a series circuit to determine the voltage drop across each resistor and the total voltage drop across the circuit. | B |
| 13 | Waves | HS.PHY.4.1 | C. Evidence, Reasoning, and Modeling | SR | Compare the speed and wavelength of radio waves and infrared radiation in a vacuum, given that radio waves have a lower frequency than infrared radiation. | *see page 5* |
| 14 | Motion, Forces, and Interactions | HS.PHY.2.10 | B. Mathematics and Data | SR | Calculate the average speed of an object. | C |
| 15 | Motion, Forces, and Interactions | HS.PHY.2.10 | B. Mathematics and Data | SR | Interpret a distance vs. time graph to describe the motion of an object and the magnitude of the net force on the object. | *see page 6* |
| 16 | Motion, Forces, and Interactions | HS.PHY.2.10 | C. Evidence, Reasoning, and Modeling | SR | Identify the free-body force diagram for an object falling with negligible air resistance. | B |

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| 17 | Energy | HS.PHY.3.2 | C. Evidence, Reasoning, and Modeling | CR 3 pt. | Interpret a graph of the gravitational potential energy (GPE) and kinetic energy (KE) of a falling object to identify the object's height and explain the reasoning, create a graph of the object's GPE and KE, and describe how the object's GPE and KE would have been affected by air resistance acting on the object. | |
| 18 | Motion, Forces, and Interactions | HS.PHY.2.10 | C. Evidence, Reasoning, and Modeling | SR | Interpret motion graphs to determine which graph represents constant, positive acceleration. | B |
| 19 | Motion, Forces, and Interactions | HS.PHY.2.4 | C. Evidence, Reasoning, and Modeling | SR | Interpret a diagram to compare the charges on two objects and to describe how changing the magnitudes of the charges would affect the system. | *see page 6* |
| 20 | Waves | HS.PHY.4.1 | None | CR 4 pt. | Identify sound waves as a type of mechanical wave, describe how one type of electromagnetic wave can be used, explain why electromagnetic waves must be used in space, and describe a difference between mechanical and electromagnetic waves. | |
| 21 | Motion, Forces, and Interactions | HS.PHY.2.3 | A. Investigations and Questioning | CR 4 pt. | Calculate the change in momentum of a ball during a collision and the net force applied to the ball, explain how to reduce the average net force on the ball, and analyze an investigation to determine which factors change and which factors must be kept constant. | |
| 22 | Waves | HS.PHY.4.5 | C. Evidence, Reasoning, and Modeling | SR | Interpret a diagram to determine the wave behavior used by a device. | *see page 6* |
| 23 | Motion, Forces, and Interactions | HS.PHY.2.5 | C. Evidence, Reasoning, and Modeling | SR | Describe what an investigation demonstrates when a magnet is passed through a coil of wire. | B |
| 24 | Motion, Forces, and Interactions | HS.PHY.2.1 | B. Mathematics and Data | SR | Interpret position vs. time graphs to determine which graph represents an object with a net force acting on it. | D |
| 25 | Motion, Forces, and Interactions | HS.PHY.2.2 | B. Mathematics and Data | SR 2 pt. | Calculate the total momentum of a system and the velocity of an object just after a collision. | Part A: B<br>Part B: *see page 6* |
| 26 | Energy | HS.PHY.3.4 | None | SR | Determine which water sample has the least average kinetic energy based on the temperatures of the samples. | C |
| 27 | Motion, Forces, and Interactions | HS.PHY.2.4 | B. Mathematics and Data | SR | Determine which change would cause the greatest increase in gravitational attraction between two objects. | D |
| 28 | Motion, Forces, and Interactions | HS.PHY.2.10 | C. Evidence, Reasoning, and Modeling | SR | Analyze a velocity vs. time graph to determine when the direction of the net force on an object is opposite the object's motion. | B |
| 29 | Motion, Forces, and Interactions | HS.PHY.2.9 | B. Mathematics and Data | SR | Describe how adding another resistor in series affects the current in a circuit. | A |
| 30 | Energy | HS.PHY.3.4 | B. Mathematics and Data | SR | Identify the information required to calculate the energy absorbed by an object. | D |

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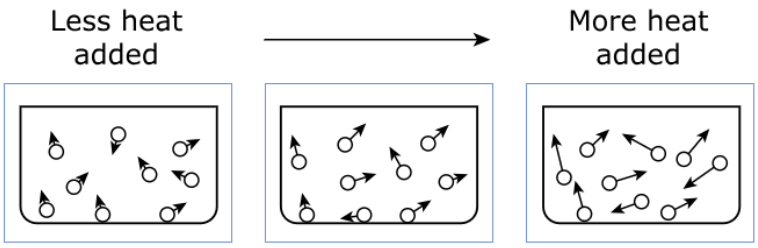
|---|---|---|---|---|---|---|
| 31 | Energy | HS.PHY.3.1 | C. Evidence, Reasoning, and Modeling | SR<br>2 pt. | Calculate the initial gravitational potential energy of an object, and describe how the object's gravitational potential energy and kinetic energy changed as the object's height decreased. | Part A: D<br>Part B:<br>*see page 6* |
| 32 | Motion, Forces, and Interactions | HS.PHY.2.2 | B. Mathematics and Data | SR | Calculate the speed of two railroad cars after the cars collide, connect, and move together. | B |
| 33 | Energy | HS.PHY.3.3 | C. Evidence, Reasoning, and Modeling | SR | Calculate the percent efficiency of a device that converts kinetic energy to gravitational potential energy. | C |
| 34 | Motion, Forces, and Interactions | HS.PHY.2.9 | C. Evidence, Reasoning, and Modeling | SR | Compare the voltage drop across and current through two resistors in a circuit. | *see page 7* |
| 35 | Energy | HS.PHY.3.1 | C. Evidence, Reasoning, and Modeling | SR | Order the gravitational potential energy of an object at three heights from least to greatest. | *see page 7* |
| 36 | Motion, Forces, and Interactions | HS.PHY.2.3 | C. Evidence, Reasoning, and Modeling | SR | Compare the collision time and the force on an object for two collisions with different surfaces. | *see page 7* |
| 37 | Motion, Forces, and Interactions | HS.PHY.2.1 | B. Mathematics and Data | SR | Interpret data to determine when there was zero net force on a moving object. | D |
| 38 | Motion, Forces, and Interactions | HS.PHY.2.10 | B. Mathematics and Data | CR<br>3 pt. | Analyze a velocity vs. time graph to explain when an object has the greatest acceleration during a time interval, calculate the average acceleration of the object over a given amount of time, and compare the net forces on the object for two different time intervals and explain the reasoning. | |
| 39 | Motion, Forces, and Interactions | HS.PHY.2.3 | A. Investigations and Questioning | SR | Determine a variable that should be controlled in an investigation about reducing the forces from a collision. | A |
| 40 | Energy | HS.PHY.3.1 | B. Mathematics and Data | SR | Calculate an object's change in mechanical energy. | C |
| 41 | Waves | HS.PHY.4.5 | None | SR | Explain why light bends when traveling from one medium to another. | A |
| 42 | Waves | HS.PHY.4.1 | C. Evidence, Reasoning, and Modeling | SR | Identify the diagram that has the wavelength and amplitude of a wave correctly labeled. | B |
| 43 | Energy | HS.PHY.3.5 | C. Evidence, Reasoning, and Modeling | CR<br>4 pt. | Analyze a diagram to compare the magnitude of the electrostatic forces acting on two objects, explain why the electrostatic forces have certain directions, and explain how releasing the objects changes the magnitude of the force acting on one of the objects and the kinetic energies of the objects. | |

* Science 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/.

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




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

Carbon-14 changes to nitrogen-14 through [beta] decay, in which [a neutron changes into a proton] and an electron.

**Correct Answer for CBT Item #7 Part B: Technology-Enhanced Item**

The path of the light from the candle appeared to bend as it traveled to the observer. As the light from the candle entered the magnifying glass, the light [slowed down] . Because the frequency of the light did not change, the wavelength of the light [decreased.]

**Correct Answer for CBT Item #10 Part A: Technology-Enhanced Item**

The upward force that acted on the paper clips was from [a magnetic] field that was generated by the [current flowing through] the wire.

**Correct Answer for CBT Item #13: Technology-Enhanced Item**

In a vacuum, radio waves and infrared radiation have the same [speed,] but radio waves have a lower frequency than infrared radiation. Therefore, radio waves have a [longer wavelength] than infrared radiation.

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

The graph indicates that the marble was [accelerating] and the magnitude of the net force acting on the marble was [greater than] zero.

**Correct Answer for CBT Item #19: Technology-Enhanced Item**

The pith balls have [the same charge.]

If the student increases the magnitude of the charge on each pith ball, the distance between the pith balls will [increase.]

**Correct Answer for CBT Item #22: Technology-Enhanced Item**

To produce a detailed image of the bottom of the ocean, a sound wave emitted by a device on the ship must be [reflected] by the bottom of the ocean.

**Correct Answer for CBT Item #25 Part B: Technology-Enhanced Item**

| Time (s) | Car R Velocity (m/s) | Car S Velocity (m/s) |
|---|---|---|
| 1 | 5 | -5 |
| 2 | 5 | -5 |
| 3 | -7 | 3 |

**Correct Answer for CBT Item #31 Part B: Technology-Enhanced Item**

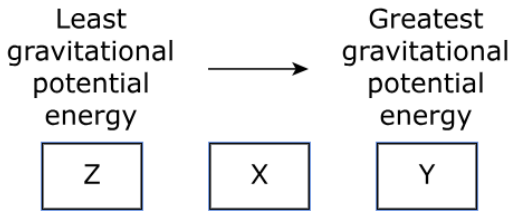
As the cat was moving to the 1.1 m platform, the gravitational potential energy of the cat [decreased] and the kinetic energy of the cat [increased.]

**Correct Answer for CBT Item #34: Technology-Enhanced Item**

The voltage drop across the 10 Ω resistor is [less than] the voltage drop across the 90 Ω resistor.

The current through the 10 Ω resistor is [equal to] the current through the 90 Ω resistor.

**Correct Answer for CBT Item #35: Technology-Enhanced Item**




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

Compared with landing on the ground, landing on the foam pad increased the [time of the collision,] which caused the [force on the athlete] to be reduced.