MASSACHUSETTS
Department of Elementary
and Secondary Education

Release of February 2024 MCAS Biology and Introductory Physics Test Information

March 2024
Massachusetts Department of Elementary and Secondary Education

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and Secondary Education

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Russell D. Johnston
Acting Commissioner

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I. Document Purpose and Structure

Document Purpose and Structure

Purpose

The purpose of this document is to share with educators and the public information regarding the February 2024 MCAS Biology and Introductory Physics tests, including the reporting category and standard associated with each item. The Department does not currently release items from the February Biology and Introductory Physics tests. All items continue to be released for the spring Biology and Introductory Physics tests.

Structure

Chapters II and III of this document contain, respectively, information for the February 2024 Biology and Introductory Physics tests. Each of these chapters has two sections.

The **first section** provides a brief overview of the test, including test format and item types. The Introductory Physics Reference Sheet used by students during MCAS Introductory Physics test sessions appears at the end of the first section of the Introductory Physics chapter.

The **second section** of each chapter are tables that cross-reference each item on the computer-based test and the paper-based test with its MCAS reporting category and with the *Framework* standard it assesses. The tables show how the items on the test assess standards in the 2016 *Massachusetts Science and Technology/ Engineering Curriculum Framework*.

II. February 2024 Biology Test

February 2024 High School Biology Test

The February 2024 high school Biology test was a next-generation assessment that 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 Biology 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 content and assessed the same standard as the technology-enhanced item.

Test Sessions

The high school Biology 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 February 2024 high school MCAS Biology 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 biology standards are grouped under the four content reporting categories listed below.

- Molecules to Organisms
- Heredity
- Evolution
- Ecosystems

Most items on the high school Biology 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 tables at the conclusion of this chapter provides the following information about each released operational item: reporting category, standard covered, science practice category covered (if any), item type, and item description.

Spanish-Language Edition

Since approximately 55% of English learner students in Massachusetts public schools are native Spanish speakers, a Spanish-language edition of the February Biology test was made available to eligible Spanish-speaking students. The computer-based version of the Spanish-language edition presented the Spanish translation above the English text for each item. The booklets for the paper-based version of the Spanish-language edition were issued in side-by-side English/Spanish format: pages on the left side of each booklet presented items in Spanish; pages on the right side presented the same items in English.

Reference Materials and Tools

Each student taking the high school Biology test had access to a calculator.

During both Biology 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.

February 2024 Biology
Computer-Based Operational Items

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
1	*Molecules to Organisms*	HS.LS.1.4	C. Evidence, Reasoning, and Modeling	SR	Describe a missing step in a model of cell division.
2	*Evolution*	HS.LS.4.4	None	SR	Explain how bacteria become resistant to antibiotics over time.
3	*Evolution*	HS.LS.4.5	B. Mathematics and Data	SR	Analyze information to determine shifts in populations due to natural selection.
4	*Ecology*	HS.LS.2.5	None	SR	Identify a process bacteria perform while breaking down plant matter.
5	*Heredity*	HS.LS.3.3	B. Mathematics and Data	SR	Determine the expected offspring that will inherit a certain trait from a cross.
6	*Heredity*	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Determine a body cell's chromosome number when given a gamete's chromosome number, and evaluate a claim about the number of chromosomes an offspring receives from its parents.
7	*Heredity*	HS.LS.3.3	C. Evidence, Reasoning, and Modeling	SR	Use evidence from the results of crosses to determine the inheritance pattern of a trait.
8	*Heredity*	HS.LS.3.4	C. Evidence, Reasoning, and Modeling	SR	Analyze data to determine which phenotype and genotype were most affected by an environmental factor.
9	*Molecules to Organisms*	HS.LS.1.2	C. Evidence, Reasoning, and Modeling	SR	Determine the sequence of several events to show the flow of signals in the nervous system.
10	*Evolution*	HS.LS.4.1	C. Evidence, Reasoning, and Modeling	SR	Use evidence from a cladogram to support a claim about the relatedness among groups of organisms.
11	*Molecules to Organisms*	HS.LS.1.1	B. Mathematics and Data	SR	Analyze data about enzyme activity to determine expected results of an investigation based on the function of the enzyme.
12	*Molecules to Organisms*	HS.LS.1.6	None	SR	Identify sugars as carbohydrates.
13	*Heredity*	HS.LS.3.2	None	SR	Describe the expected alleles in the gametes of a heterozygous female for a given gene.
14	*Ecology*	HS.LS.2.1	None	SR	Explain why one species of bacteria is more common than other species of bacteria in a certain environment.
15	*Heredity*	HS.LS.3.3	B. Mathematics and Data	SR	Use information to determine parents' genotypes and calculate the probability that their offspring will inherit a particular trait.
16	*Molecules to Organisms*	HS.LS.1.1	C. Evidence, Reasoning, and Modeling	CR	Determine the mRNA and amino acid sequences for two alleles when given the DNA sequences, and explain whether the resulting proteins would be the same for each allele.
17	*Ecology*	HS.LS.2.1	C. Evidence, Reasoning, and Modeling	SR	Analyze a food web to determine how a decrease in one population would affect other populations in the ecosystem.
18	*Evolution*	HS.LS.4.2	A. Investigations and Questioning	SR	Identify a question scientists could ask to determine how an inherited trait gives an organism a survival advantage.
19	*Molecules to Organisms*	HS.LS.1.5	A. Investigations and Questioning	SR	Determine a measurement that could be made in an investigation to estimate the rate of photosynthesis.

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
20	*Heredity*	HS.LS.3.4	B. Mathematics and Data	CR	Use heritability data to identify and explain which trait is most affected by environmental factors and to explain why a certain cross will be more successful; describe two environmental factors that could affect an organism's growth.
21	*Molecules to Organisms*	HS.LS.1.3	C. Evidence, Reasoning, and Modeling	CR	Complete a feedback loop, describe how the feedback loop represents homeostasis, and describe how body systems respond to a change in the body.
22	*Molecules to Organisms*	HS.LS.1.5	C. Evidence, Reasoning, and Modeling	SR	Describe how an environmental factor can affect photosynthesis in plants.
23	*Heredity*	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Use a model to describe how meiosis contributes to genetic diversity.
24	*Ecology*	HS.LS.2.2	C. Evidence, Reasoning, and Modeling	SR	Determine whether different situations would most likely increase or reduce the genetic diversity of a population.
25	*Evolution*	HS.LS.4.1	C. Evidence, Reasoning, and Modeling	SR	Use a cladogram to determine evolutionary relationships among species and describe the best evidence used to build the cladogram.
26	*Molecules to Organisms*	HS.LS.1.6	A. Investigations and Questioning	SR	Identify a question that scientists could answer to determine that a substance is an enzyme.
27	*Ecology*	HS.LS.2.7	B. Mathematics and Data	SR	Analyze graphs to draw conclusions about how climate change affects the number of plant species in an ecosystem.
28	*Heredity*	HS.LS.3.2	None	SR	Identify processes that increase the genetic diversity of a population.
29	*Evolution*	HS.LS.4.4	None	SR	Explain how viruses can adapt to infect different hosts.
30	*Molecules to Organisms*	HS.LS.1.3	None	SR	Determine the process that allows oxygen levels to be maintained at a certain level in the body.
31	*Evolution*	HS.LS.4.5	A. Investigations and Questioning	SR	Analyze information about the distribution of subgroups of a population to support a claim about speciation.
32	*Molecules to Organisms*	HS.LS.1.6	None	SR	Identify the elements that make up a particular macromolecule.
33	*Molecules to Organisms*	HS.LS.1.2	None	SR	Determine the body system that allows an organism to obtain nutrients from a food source.
34	*Ecology*	HS.LS.2.5	None	SR	Describe the role of decomposers in the carbon cycle.
35	*Ecology*	HS.LS.2.1	None	SR	Determine abiotic factors that could reduce an ecosystem's carrying capacity for a population.
36	*Ecology*	HS.LS.2.4	B. Mathematics and Data	SR	Use a food web to determine an organism from the trophic level that has the most available energy and to calculate the amount of energy available to a trophic level in the ecosystem.
37	*Ecology*	HS.LS.2.6	C. Evidence, Reasoning, and Modeling	CR	Analyze a food web and explain how the removal of a population affected the size and biodiversity of other populations in the ecosystem, and explain how reintroducing that population could affect the size of other populations in the ecosystem.
38	*Molecules to Organisms*	HS.LS.1.1	None	SR	Determine the cellular process carried out by bacterial cells' ribosomes.
39	*Heredity*	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Describe homologous chromosomes in a diagram.

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
40	*Molecules to Organisms*	HS.LS.1.7	A. Investigations and Questioning	SR	Describe a measurement a scientist could make to determine the rate of cellular respiration in an organism.
41	*Molecules to Organisms*	HS.LS.1.4	C. Evidence, Reasoning, and Modeling	SR	Use a model to determine the process that ensures replicated DNA is identical to the original DNA, and explain why DNA replication must occur before mitosis.
42	*Evolution*	HS.LS.4.2	C. Evidence, Reasoning, and Modeling	CR	Analyze information to determine the type of natural selection that occurred, describe an advantage of a certain trait and explain how natural selection caused the trait to become more common, and describe evidence that can be used to show that two organisms are the same species.

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

February 2024 Biology
Paper-Based Operational Items

PBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
1	*Molecules to Organisms*	HS.LS.1.4	C. Evidence, Reasoning, and Modeling	SR	Describe a missing step in a model of cell division.
2	*Evolution*	HS.LS.4.4	None	SR	Explain how bacteria become resistant to antibiotics over time.
3	*Evolution*	HS.LS.4.5	B. Mathematics and Data	SR	Analyze information to determine shifts in populations due to natural selection.
4	*Ecology*	HS.LS.2.5	None	SR	Identify a process bacteria perform while breaking down plant matter.
5	*Heredity*	HS.LS.3.3	B. Mathematics and Data	SR	Determine the expected offspring that will inherit a certain trait from a cross.
6	*Heredity*	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Calculate the number of chromosomes in an animal's body cells and determine the accuracy of a claim about the number of chromosomes an offspring receives from its parents.
7	*Heredity*	HS.LS.3.3	C. Evidence, Reasoning, and Modeling	SR	Use evidence from the results of crosses to determine the inheritance pattern of a trait.
8	*Heredity*	HS.LS.3.4	C. Evidence, Reasoning, and Modeling	SR	Analyze data to determine which phenotype and genotype were most affected by an environmental factor.
9	*Molecules to Organisms*	HS.LS.1.2	C. Evidence, Reasoning, and Modeling	SR	Determine the sequence of several events to show the flow of signals in the nervous system.
10	*Evolution*	HS.LS.4.1	C. Evidence, Reasoning, and Modeling	SR	Use evidence from a cladogram to support a claim about the relatedness among groups of organisms.
11	*Molecules to Organisms*	HS.LS.1.1	B. Mathematics and Data	SR	Analyze data about enzyme activity to determine expected results of an investigation based on the function of the enzyme.
12	*Molecules to Organisms*	HS.LS.1.6	None	SR	Identify sugars as carbohydrates.
13	*Heredity*	HS.LS.3.2	None	SR	Describe the expected alleles in the gametes of a heterozygous female for a given gene.
14	*Ecology*	HS.LS.2.1	None	SR	Explain why one species of bacteria is more common than other species of bacteria in a certain environment.
15	*Heredity*	HS.LS.3.3	B. Mathematics and Data	SR	Use information to determine parents' genotypes and calculate the probability that their offspring will inherit a particular trait.
16	*Molecules to Organisms*	HS.LS.1.1	C. Evidence, Reasoning, and Modeling	CR	Determine the mRNA and amino acid sequences for two alleles when given the DNA sequences, and explain whether the resulting proteins would be the same for each allele.
17	*Ecology*	HS.LS.2.1	C. Evidence, Reasoning, and Modeling	SR	Analyze a food web to determine how a decrease in one population would affect other populations in the ecosystem.
18	*Evolution*	HS.LS.4.2	A. Investigations and Questioning	SR	Identify a question scientists could ask to determine how an inherited trait gives an organism a survival advantage.
19	*Molecules to Organisms*	HS.LS.1.5	A. Investigations and Questioning	SR	Determine a measurement that could be made in an investigation to estimate the rate of photosynthesis.

PBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
20	*Heredity*	HS.LS.3.4	B. Mathematics and Data	CR	Use heritability data to identify and explain which trait is most affected by environmental factors and to explain why a certain cross will be more successful; describe two environmental factors that could affect an organism's growth.
21	*Molecules to Organisms*	HS.LS.1.3	C. Evidence, Reasoning, and Modeling	CR	Complete a feedback loop, describe how the feedback loop represents homeostasis, and describe how body systems respond to a change in the body.
22	*Molecules to Organisms*	HS.LS.1.5	C. Evidence, Reasoning, and Modeling	SR	Describe how an environmental factor can affect photosynthesis in plants.
23	*Heredity*	HS.LS.3.1	C. Evidence, Reasoning, and Modeling	SR	Use a model to describe how meiosis contributes to genetic diversity.
24	*Ecology*	HS.LS.2.2	C. Evidence, Reasoning, and Modeling	SR	Determine whether different situations would most likely increase the genetic diversity of a population.
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26	*Molecules to Organisms*	HS.LS.1.6	A. Investigations and Questioning	SR	Identify a question that scientists could answer to determine that a substance is an enzyme.
27	*Ecology*	HS.LS.2.7	B. Mathematics and Data	SR	Analyze graphs to draw conclusions about how climate change affects the number of plant species in an ecosystem.
28	*Heredity*	HS.LS.3.2	None	SR	Identify processes that increase the genetic diversity of a population.
29	*Evolution*	HS.LS.4.4	None	SR	Explain how viruses can adapt to infect different hosts.
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35	*Ecology*	HS.LS.2.1	None	SR	Determine abiotic factors that could reduce an ecosystem's carrying capacity for a population.
36	*Ecology*	HS.LS.2.4	B. Mathematics and Data	SR	Use a food web to determine an organism from the trophic level that has the most available energy and to calculate the amount of energy available to a trophic level in the ecosystem.
37	*Ecology*	HS.LS.2.6	C. Evidence, Reasoning, and Modeling	CR	Analyze a food web and explain how the removal of a population affected the size and biodiversity of other populations in the ecosystem, and explain how reintroducing that population could affect the size of other populations in the ecosystem.
38	*Molecules to Organisms*	HS.LS.1.1	None	SR	Determine the cellular process carried out by bacterial cells' ribosomes.
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PBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
40	*Molecules to Organisms*	HS.LS.1.7	A. Investigations and Questioning	SR	Describe a measurement a scientist could make to determine the rate of cellular respiration in an organism.
41	*Molecules to Organisms*	HS.LS.1.4	C. Evidence, Reasoning, and Modeling	SR	Use a model to determine the process that ensures replicated DNA is identical to the original DNA, and explain why DNA replication must occur before mitosis.
42	*Evolution*	HS.LS.4.2	C. Evidence, Reasoning, and Modeling	CR	Analyze information to determine the type of natural selection that occurred, describe an advantage of a certain trait and explain how natural selection caused the trait to become more common, and describe evidence that can be used to show that two organisms are the same species.

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

III. February 2024 Introductory Physics Test

February 2024 High School Introductory Physics Test

The February 2024 high school Introductory Physics test was a next-generation assessment that 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 content and assessed the same standard as the technology-enhanced item.

Test Sessions

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 February 2024 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 tables at the conclusion of this chapter provides the following information about each released operational item: reporting category, standard covered, science practice category covered (if any), item type, and item description.

Spanish-Language Edition

Since approximately 55% of English learner students in Massachusetts public schools are native Spanish speakers, a Spanish-language edition of the February Introductory Physics test was made available to eligible Spanish-speaking students. The computer-based version of the Spanish-language edition presented the Spanish translation above the English text for each item. The booklets for the paper-based version of the Spanish-language edition were issued in side-by-side English/Spanish format: pages on the left side of each booklet presented items in Spanish; pages on the right side presented the same items in English.

Reference Materials

Each student taking the high school Introductory Physics test had access to the MCAS Introductory Physics Reference Sheet. A copy of the reference sheet is provided on the next page. Each student also had access to 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.

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 ≈ 10 m/s² at Earth's surface

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

1 J = 1 N • m

February 2024 Introductory Physics
Computer-Based Operational Items

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
1	*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.
2	*Motion, Forces, and Interactions*	HS.PHY.2.1	B. Mathematics and Data	SR	Analyze a data table showing an object's velocity to determine the net force on the object.
3	*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.
4	*Motion, Forces, and Interactions*	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Analyze velocity vs. time graphs and force diagrams to determine which graphs and diagrams correspond to each other.
5	*Energy*	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Use a model to show the spacing of water molecules as thermal energy is added to the water.
6	*Waves*	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR	Interpret a model to describe how light behaves during a double-slit experiment.
7	*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.
8	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Compare the net forces on two vehicles by analyzing a velocity vs. time graph.
9	*Energy*	HS.PHY.1.8	C. Evidence, Reasoning, and Modeling	SR	Determine the number of protons and neutrons in a nucleus resulting from alpha decay.
10	*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.
11	*Waves*	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	SR	Determine the resulting wave when two waves constructively interfere.
12	*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.
13	*Motion, Forces, and Interactions*	HS.PHY.2.9	C. Evidence, Reasoning, and Modeling	SR	Analyze circuit diagrams to determine which ones have a greater total current.
14	*Motion, Forces, and Interactions*	HS.PHY.2.5	None	SR	Describe how electric current causes a motor to spin.
15	*Motion, Forces, and Interactions*	HS.PHY.2.9	B. Mathematics and Data	SR	Determine the arrangement of components in a circuit given conditions about the circuit, and calculate the current through a resistor in the circuit.
16	*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.
17	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the final velocity of an object after it accelerates.
18	*Energy*	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR	Determine the setup of a pair of magnets that results in one of the magnets experiencing the greatest force in a given direction.
19	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Interpret a free-body force diagram to determine the acceleration of an object.

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
20	*Motion, Forces, and Interactions*	HS.PHY.2.2	B. Mathematics and Data	CR	Calculate the momentum of two objects, describe how and explain why the momentum of each object changes as they collide, and calculate the momentum and velocity of one of the objects after the collision.
21	*Energy*	HS.PHY.3.3	B. Mathematics and Data	CR	Calculate the gravitational potential energy and kinetic energy of a component in a system, calculate the thermal energy gained by the system, and calculate the efficiency of the system.
22	*Motion, Forces, and Interactions*	HS.PHY.2.5	C. Evidence, Reasoning, and Modeling	SR	Describe the movement of a compass needle when current flows through a wire placed near the compass.
23	*Motion, Forces, and Interactions*	HS.PHY.2.3	B. Mathematics and Data	SR	Calculate the final velocity of an object that is pushed from rest.
24	*Motion, Forces, and Interactions*	HS.PHY.2.3	B. Mathematics and Data	SR	Calculate the average force it takes for a person in motion to come to a stop, when given their initial momentum and amount of time it takes for them to a stop.
25	*Energy*	HS.PHY.3.4	A. Investigations and Questioning	SR	Interpret a graph to determine the direction of heat flow in an investigation and when thermal equilibrium is reached; describe changes to the investigation that would result in a higher final temperature.
26	*Energy*	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Determine which model represents an electric field around a single charge.
27	*Motion, Forces, and Interactions*	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Analyze the setup of an investigation and a velocity vs. time graph to determine when forces were applied to an object.
28	*Motion, Forces, and Interactions*	HS.PHY.2.4	C. Evidence, Reasoning, and Modeling	SR	Describe how to increase the electrostatic force between two charged objects.
29	*Motion, Forces, and Interactions*	HS.PHY.2.2	B. Mathematics and Data	SR	Calculate the final velocity of two objects that collide and stick together.
30	*Motion, Forces, and Interactions*	HS.PHY.2.9	B. Mathematics and Data	SR	Determine the combination of resistors in a series circuit that will result in the brightest light bulb.
31	*Waves*	HS.PHY.4.1	B. Mathematics and Data	SR	Calculate the frequency of a sound wave.
32	*Energy*	HS.PHY.1.8	C. Evidence, Reasoning, and Modeling	SR	Identify the model that best represents fusion.
33	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the average velocity of an object when given different times and heights.
34	*Motion, Forces, and Interactions*	HS.PHY.2.10	C. Evidence, Reasoning, and Modeling	SR	Complete free-body force diagrams for two objects with different masses.
35	*Energy*	HS.PHY.3.2	B. Mathematics and Data	SR	Calculate the change in gravitational potential energy of an object as a result of a change in height.
36	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Interpret height vs. time data to compare the average speed and acceleration of an object during multiple trials of an investigation.
37	*Energy*	HS.PHY.3.1	C. Evidence, Reasoning, and Modeling	CR	Describe how an object's kinetic energy and gravitational potential energy changes as its height changes; compare the object's gravitational potential energy and velocity during different trials in an investigation and explain the reasoning.
38	*Motion, Forces, and Interactions*	HS.PHY.2.9	B. Mathematics and Data	SR	Describe a change to a circuit that reduces its total current.

CBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
39	*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.
40	*Waves*	HS.PHY.4.5	None	SR	Describe how the photoelectric effect converts energy from electromagnetic waves into electricity.
41	*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.
42	*Waves*	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	CR	Determine the amplitude of a resulting wave pulse when two wave pulses interfere and explain the reasoning; determine the amplitude, speed, and direction of each wave pulse after the pulses move past each other and explain the reasoning.

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

February 2024 Introductory Physics
Paper-Based Operational Items

PBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
1	*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.
2	*Motion, Forces, and Interactions*	HS.PHY.2.1	B. Mathematics and Data	SR	Analyze a data table showing an object's velocity to determine the net force on the object.
3	*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.
4	*Motion, Forces, and Interactions*	HS.PHY.2.1	C. Evidence, Reasoning, and Modeling	SR	Analyze velocity vs. time graphs and force diagrams to determine which graphs and diagrams correspond to each other.
5	*Energy*	HS.PHY.3.2	C. Evidence, Reasoning, and Modeling	SR	Use a model to show the spacing of water molecules as thermal energy is added to the water.
6	*Waves*	HS.PHY.4.3	C. Evidence, Reasoning, and Modeling	SR	Interpret a model to describe how light behaves during a double-slit experiment.
7	*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.
8	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Compare the net forces on two vehicles by analyzing a velocity vs. time graph.
9	*Energy*	HS.PHY.1.8	C. Evidence, Reasoning, and Modeling	SR	Determine the number of protons and neutrons in a nucleus resulting from alpha decay.
10	*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.
11	*Waves*	HS.PHY.4.5	C. Evidence, Reasoning, and Modeling	SR	Determine the resulting wave when two waves constructively interfere.
12	*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.
13	*Motion, Forces, and Interactions*	HS.PHY.2.9	C. Evidence, Reasoning, and Modeling	SR	Analyze circuit diagrams to determine which ones have a greater total current.
14	*Motion, Forces, and Interactions*	HS.PHY.2.5	None	SR	Describe how electric current causes a motor to spin.
15	*Motion, Forces, and Interactions*	HS.PHY.2.9	B. Mathematics and Data	SR	Determine the arrangement of components in a circuit given conditions about the circuit, and calculate the current through a resistor in the circuit.
16	*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.
17	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Calculate the final velocity of an object after it accelerates.
18	*Energy*	HS.PHY.3.5	C. Evidence, Reasoning, and Modeling	SR	Determine the setup of a pair of magnets that results in one of the magnets experiencing the greatest force in a given direction.
19	*Motion, Forces, and Interactions*	HS.PHY.2.10	B. Mathematics and Data	SR	Interpret a free-body force diagram to determine the acceleration of an object.

PBT Item No.	Reporting Category	Standard	Science Practice Category	Item Type*	Item Description
20	*Motion, Forces, and Interactions*	HS.PHY.2.2	B. Mathematics and Data	CR	Calculate the momentum of two objects, describe how and explain why the momentum of each object changes as they collide, and calculate the momentum and velocity of one of the objects after the collision.
21	*Energy*	HS.PHY.3.3	B. Mathematics and Data	CR	Calculate the gravitational potential energy and kinetic energy of a component in a system, calculate the thermal energy gained by the system, and calculate the efficiency of the system.
22	*Motion, Forces, and Interactions*	HS.PHY.2.5	C. Evidence, Reasoning, and Modeling	SR	Describe the movement of a compass needle when current flows through a wire placed near the compass.
23	*Motion, Forces, and Interactions*	HS.PHY.2.3	B. Mathematics and Data	SR	Calculate the final velocity of an object that is pushed from rest.
24	*Motion, Forces, and Interactions*	HS.PHY.2.3	B. Mathematics and Data	SR	Calculate the average force it takes for a person in motion to come to a stop, when given their initial momentum and amount of time it takes for them to a stop.
25	*Energy*	HS.PHY.3.4	A. Investigations and Questioning	SR	Interpret a graph to determine the direction of heat flow in an investigation and when thermal equilibrium is reached; describe changes to the investigation that would result in a higher final temperature.
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