XX. Introductory Physics, High School

High School Introductory Physics Test

The spring 2019 high school Introductory Physics test was based on overlapping learning standards in the October 2006 and April 2016 versions of the *Massachusetts Science and Technology/Engineering Curriculum Framework*. The 2006 and 2016 versions of the framework are available on the Department website at www.doe.mass.edu/frameworks/.

Introductory Physics test results are reported under the following four legacy MCAS reporting categories:

- Motion and Forces
- Heat and Heat Transfer
- Waves and Radiation
- Electromagnetism

The table at the conclusion of this chapter indicates each item's reporting category and the 2006 and 2016 framework learning standards each item assesses. The correct answers for multiple-choice questions are also displayed in the table.

Test Sessions

The high school Introductory Physics test included two separate test sessions, which were administered on consecutive days. Each session included multiple-choice and open-response questions.

Reference Materials and Tools

Each student taking the high school Introductory Physics test was provided with an Introductory Physics Reference Sheet. A copy of this reference sheet follows the final question in this chapter.

Each student also had sole access to a calculator with at least four functions and a square-root key.

During both Introductory Physics test sessions, the use of bilingual word-to-word dictionaries was allowed for current and former English learner students only. No other reference tools or materials were allowed.

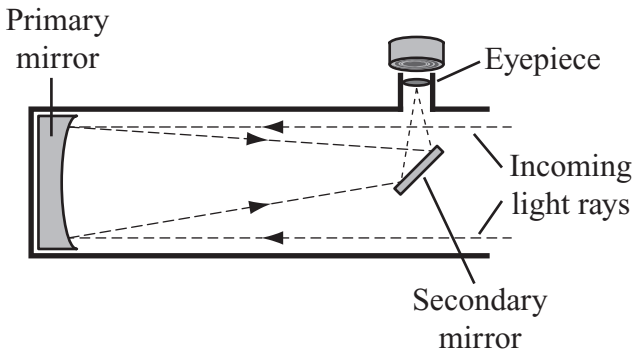
Introductory Physics

Session 1

DIRECTIONS

This session contains twenty-one multiple-choice questions and two open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

1 The diagram represents how light travels inside one type of telescope.



Which of the following determines how the secondary mirror is positioned in this telescope?

A. The energy of a light wave is proportional to its frequency.

B. The frequency of a light wave is inversely proportional to its wavelength.

C. When a light wave is refracted, the change in speed depends on its wavelength.

D. When a light wave is reflected, the angle of incidence and the angle of reflection are equal.

2 Which of the following changes to the resistance and the voltage will always increase the current in a circuit?

A. a decrease in both the resistance and the voltage

B. an increase in both the resistance and the voltage

C. a decrease in the resistance and an increase in the voltage

D. an increase in the resistance and a decrease in the voltage

3 Which of the following statements describes how energy changes as water vapor cools from 120°C to 110°C?

A. The kinetic energy of the water molecules decreases as energy is released into the environment.

B. The potential energy of the water molecules increases as energy is released into the environment.

C. The kinetic energy of the water molecules increases as energy is absorbed from the environment.

D. The potential energy of the water molecules decreases as energy is absorbed from the environment.

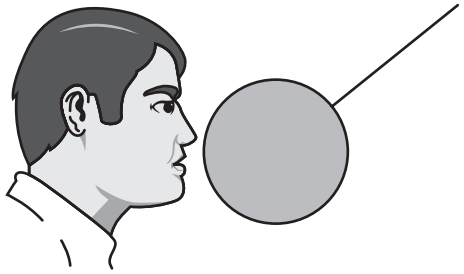
4 The table below shows the mass and the velocity of three vehicles.

Vehicle	Mass (kg)	Velocity (m/s)
truck	1500	10
car	500	25
sport-utility	1000	20

Which of the following lists the vehicles in order of their momentum, from greatest to least?

A. sport-utility, truck, car
B. car, sport-utility, truck
C. truck, car, sport-utility
D. truck, sport-utility, car

5 The illustration below represents a physics teacher doing a classroom demonstration. He pulls a pendulum made with a bowling ball toward his face until it touches his nose. Then he lets go of the ball.



Which of the following **best** explains why the bowling ball does not touch the teacher again as it swings?

A. A small amount of energy is lost due to gravity.
B. Some kinetic energy is lost due to air resistance and friction.
C. The pendulum's inertia acts in opposition to its potential energy.
D. The pendulum's kinetic energy gradually turns to potential energy.

6 Which of the following is the **best** example of conduction?

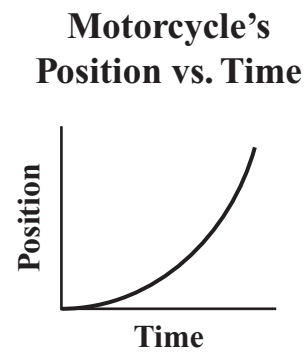
A. The glass roof of a greenhouse reflects energy.

B. Warm air rises above cool air in the atmosphere.

C. Sunlight transfers energy to a concrete sidewalk.

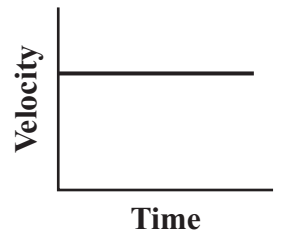
D. The handle of a pan on a hot stove becomes warm.

7 The graph represents how a motorcycle's position changes over time.

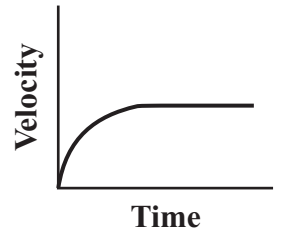


Which of the following graphs **best** represents the motorcycle's velocity over time?

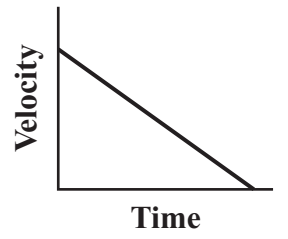
A.



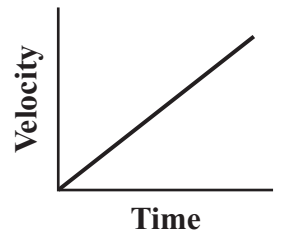
B.



C.



D.



8 A 6 V battery is connected to a 24 Ω resistor to create a circuit. The 6 V battery is then replaced with a 12 V battery.

How does the current change in the circuit when the 12 V battery is used instead of the 6 V battery?

A. The current is reduced by one-fourth.
B. The current is reduced by one-half.
C. The current is doubled.
D. The current is tripled.

9 A laser beam travels from a telescope on Earth to a reflector on the Moon and then back to the telescope in 2.56 seconds. Based on this information, how far is the Moon from Earth?

A. 58,600,000 m
B. 117,000,000 m
C. 384,000,000 m
D. 1,536,000,000 m

10 Which of the following actions can produce an electric current in a loop of wire?

A. spinning the wire near a battery
B. placing a resistor at the end of the wire
C. heating a switch and placing it on the wire
D. moving a magnet up and down near the wire

11 A cyclist and bicycle have a combined mass of 90 kg. Starting from rest, the cyclist rides down a 10 m high hill and up a 7 m high hill without pedaling the bicycle.

What is the potential energy of the cyclist and bicycle at the top of the 7 m hill with respect to the bottom of the 7 m hill?

A. 900 J
B. 2700 J
C. 6300 J
D. 9000 J

Question 12 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 12 in the space provided in your Student Answer Booklet.

12 The diagram below represents one type of wave created on a guitar string when the string is plucked. The string has a length of 0.65 m and vibrates at a frequency of 880 Hz.

a. In your Student Answer Booklet, copy the wave diagram and label the wavelength of the wave.

b. Calculate the velocity of this wave on the string. Show your calculations and include units in your answer.

The wave on the guitar string also creates sound waves in the air. The speed of the sound waves is 340 m/s in air. The pitch created by the guitar string matches the pitch heard by an observer.

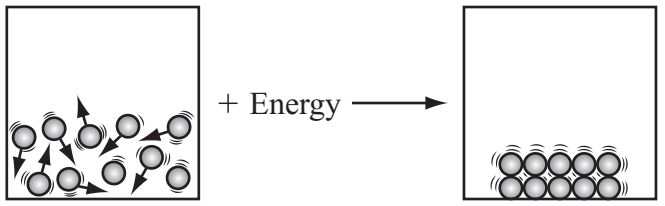
c. Compare the frequency **and** wavelength of the wave on the guitar string to the frequency and wavelength of the sound waves in the air.

Mark your answers to multiple-choice questions 13 through 22 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

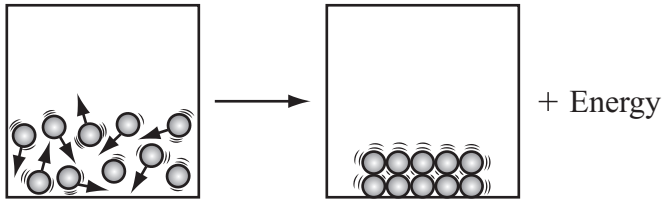
13 Liquid water in a sealed container is placed near a window. Over a few hours, the water in the container changes into water vapor.

Which diagram models the change in energy and particle movement of the water?

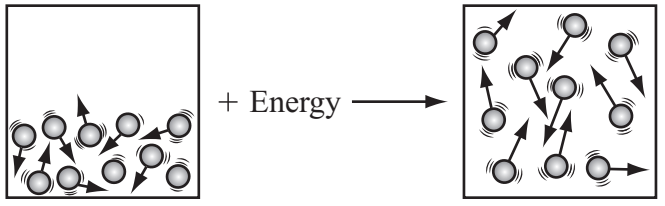
A. Liquid water Water vapor



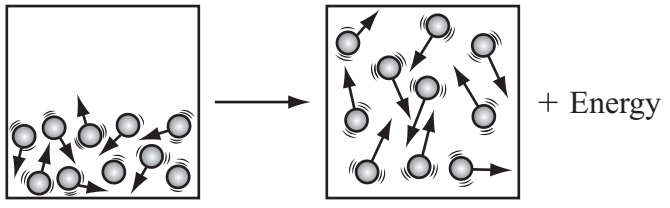
B. Liquid water Water vapor



C. Liquid water Water vapor



D. Liquid water Water vapor



14 Some insects can detect frequencies of light that are lower than the frequencies the human eye can detect. Based on this information, which of the following types of radiation do these insects detect?

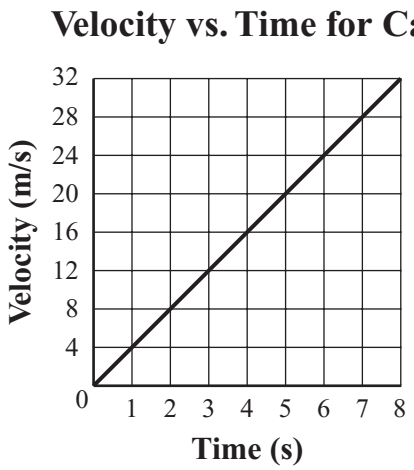
A. gamma rays

B. infrared radiation

C. ultraviolet radiation

D. x-rays

15 The graph shows how the velocity of a car changes over time.



What is the acceleration of the car?

A. 0.25 m/s^2

B. 4 m/s^2

C. 32 m/s^2

D. 256 m/s^2

16 Which of the following statements describes the motion of air particles as a sound wave moves across a room?

A. The air particles move in circles inside the sound wave.

B. The air particles move across the room with the sound wave.

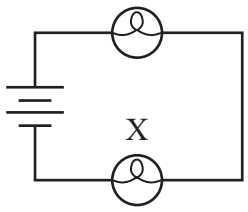
C. The air particles move back and forth, parallel to the direction of the sound wave.

D. The air particles move back and forth, perpendicular to the direction of the sound wave.

17 A student arranges light bulbs, wires, and a battery to create some circuits. All of the light bulbs have the same resistance, and each battery has the same voltage. One of the light bulbs in each circuit is labeled X.

In which circuit would the light bulb labeled X be brightest?

A.



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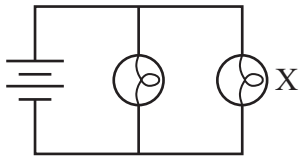
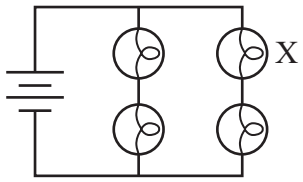
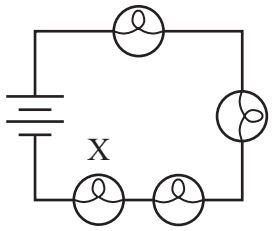


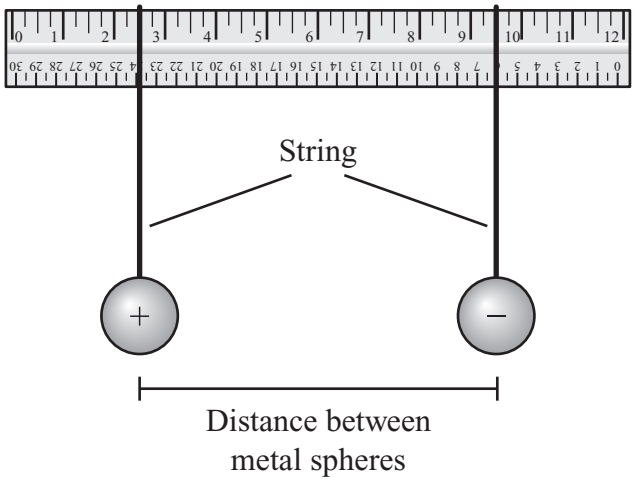
C.



D.



18 Some students have two metal spheres, each with the same mass. The students hang each sphere by a string from a ruler. They give one sphere a positive charge and the other sphere a negative charge. The spheres do not appear to move when they are charged. The diagram shows the setup.



Which of the following changes could the students make to **increase** the force of attraction between the spheres?

A. use metal spheres that have less mass

B. give both metal spheres a positive charge

C. decrease the distance between the metal spheres

D. remove the positive charge from the sphere on the left

19 Which of the following is a characteristic of a mechanical wave but **not** a characteristic of an electromagnetic wave?

A. The wave needs a medium to transmit energy.

B. The wave maintains a constant speed within a medium.

C. When the amplitude of the wave increases, the speed of the wave increases.

D. When the frequency of the wave increases, the wavelength of the wave decreases.

20 A load with a resistance of 5 Ω is connected to a 30 V source. How much current is drawn by the load?

A. 0.16 A

B. 6.0 A

C. 35 A

D. 150 A

21 Neglecting friction, which of the following statements describes the relationship between the energy of an object and the work done on it?

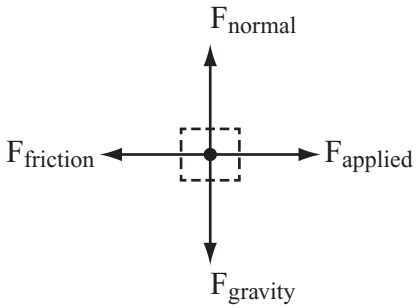
A. Work is needed for an object to keep a constant kinetic energy.

B. Work is needed for an object to keep a constant potential energy.

C. Increasing the kinetic energy of an object increases the amount of work needed to stop it.

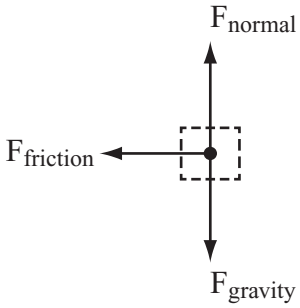
D. Increasing the potential energy of an object decreases the amount of work needed to stop it.

22 A box is moving at a constant velocity along a rough, horizontal surface. An applied force opposes the frictional force, as represented in the free-body force diagram below.

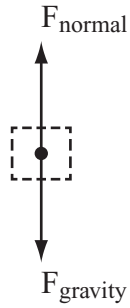


Which free-body force diagram represents the forces acting on the object the moment after the applied force is removed, but while the box is still moving forward?

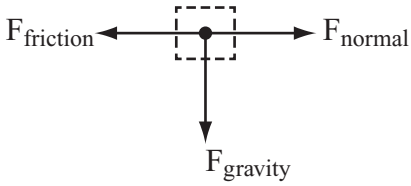
A.



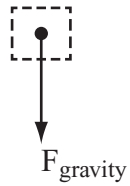
C.



B.



D.

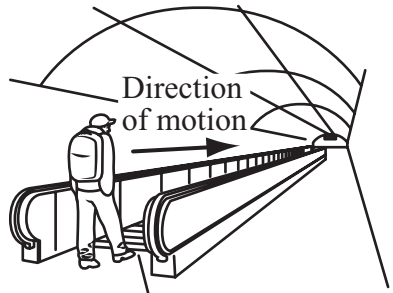


Question 23 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 23 in the space provided in your Student Answer Booklet.

23 A moving walkway is like a sidewalk that moves at a constant speed. It is used to transport people from one location to another within a large building, such as an airport. The diagram shows a moving walkway.



The table shows data about two people on the same moving walkway. Person 1 steps onto the walkway from rest and stands on it. Person 2 steps onto the walkway while already walking and continues to walk.

Person	Mass (kg)	Distance Moved on Walkway (m)	Time on Walkway (s)
1	88	120	240
2	52	120	70

a. Using the data for person 1, calculate the speed of the walkway. Show your calculations and include units in your answer.

Stepping onto the walkway, person 1 accelerates from an initial speed of 0 m/s to the speed of the walkway in 0.6 s.

b. Calculate the acceleration of person 1. Show your calculations and include units in your answer.

c. Calculate the net force that accelerated person 1. Show your calculations and include units in your answer.

Person 1 and person 2 have the same acceleration as they step onto the moving walkway.

d. Identify whether the net force acting on person 1 is greater than, less than, or equal to the net force acting on person 2. Explain your answer.

Introductory Physics
Session 2

DIRECTIONS

This session contains nineteen multiple-choice questions and three open-response questions. Mark your answers to these questions in the spaces provided in your Student Answer Booklet. You may work out solutions to multiple-choice questions in the test booklet.

24 A student investigating heat transfer places a 60°C piece of heated aluminum into a beaker of 20°C water. Which of the following best describes the process of heat transfer in the investigation?

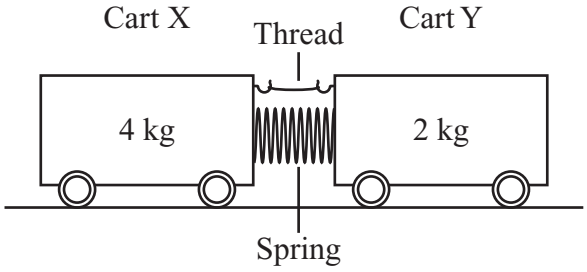
A. The aluminum transfers heat to the water mostly by conduction, and within the water, heat is transferred mostly by radiation.

B. The aluminum transfers heat to the water mostly by conduction, and within the water, heat is transferred mostly by convection.

C. The aluminum transfers heat to the water mostly by radiation, and within the water, heat is transferred mostly by conduction.

D. The aluminum transfers heat to the water mostly by radiation, and within the water, heat is transferred mostly by convection.

25 The diagram shows a compressed spring between two carts that are initially at rest. Cart X has a mass of 4 kg and cart Y has a mass of 2 kg. A thread tied to a hook on each cart holds the carts together.



When the thread is cut, the spring is released and the carts move apart. How does the speed of cart Y compare to the speed of cart X after the thread is cut?

A. The speed of cart Y is half the speed of cart X.

B. The speed of cart Y is the same as the speed of cart X.

C. The speed of cart Y is two times the speed of cart X.

D. The speed of cart Y is four times the speed of cart X.

26 Which property of waves explains why a straight flower stem may look bent when placed in a glass of water?

A. absorption
B. diffraction
C. reflection
D. refraction

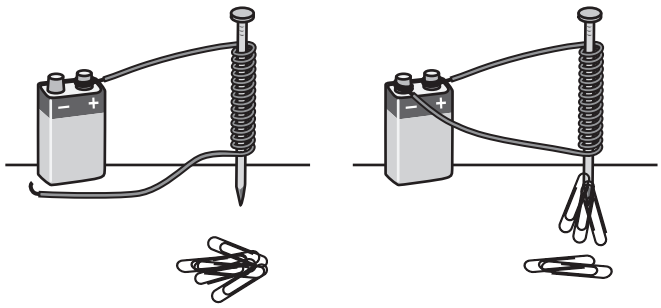
27 Which of the following types of waves is longitudinal?

A. light wave
B. microwave
C. radio wave
D. sound wave

28 A 6 kg table has a net force of 15 N acting on it. What is the magnitude of the acceleration of the table?

A. 0.4 m/s^2
B. 2.5 m/s^2
C. 6 m/s^2
D. 60 m/s^2

29 A student began an investigation by wrapping several coils of insulated wire around a steel nail. As shown in the diagram, when the ends of the wire were connected to a battery, the student was able to pick up several steel paper clips with the end of the steel nail.



Which of the following claims is best supported by the student's investigation?

A. An electric current in the wire produces a magnetic field.
B. An electric current in the wire produces a potential difference.
C. A magnetic field can produce an electric current in the wire.
D. A magnetic field can produce an electric current in steel paper clips.

30 A space shuttle enters Earth's upper atmosphere with a velocity of 11,200 m/s and experiences an acceleration of -70 m/s^2.

What is the magnitude of the shuttle's velocity 10 s after the shuttle enters the upper atmosphere?

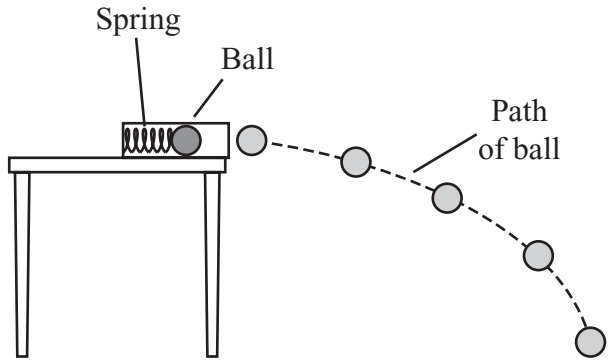
A. 7,700 m/s

B. 10,500 m/s

C. 11,900 m/s

D. 14,700 m/s

31 A ball is launched horizontally when a spring is released, as shown below.



A student knows the amount of stored elastic potential energy in the spring before it is released. What additional quantity can the student determine using only this piece of information?

A. the mass of the ball

B. the distance the ball travels

C. the velocity of the ball just before it hits the ground

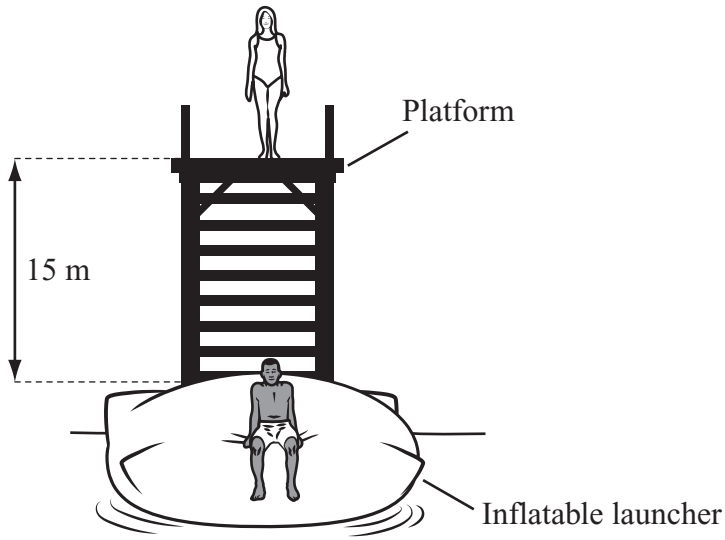
D. the kinetic energy of the ball just as the spring is fully released

Question 32 is an open-response question.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF THE QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 32 in the space provided in your Student Answer Booklet.

32 Inflatable launchers are large, air-filled bags that float on the surface of the water at lakes, water parks, and community pools. A launcher works by transferring energy from one person to another. A person sitting on a launcher is launched into the air when another person jumps onto the bag. The diagram shows a boy and a girl using an inflatable launcher at a lake.



The 75 kg girl is standing on a platform 15 m above the top of the launcher.

a. Calculate the gravitational potential energy of the girl relative to the top of the launcher. Show your calculations and include units in your answer.

The girl steps off the platform and lands on the launcher.

b. Describe how the girl's kinetic energy and gravitational potential energy change during the time interval that begins when she steps off the platform and ends just before she lands on the launcher.

The boy is launched several meters into the air but wants to be launched higher.

c. Describe one change that could be made so that the boy would be launched higher. Explain your reasoning.

Mark your answers to multiple-choice questions 33 through 43 in the spaces provided in your Student Answer Booklet. Do not write your answers in this test booklet, but you may work out solutions to multiple-choice questions in the test booklet.

33 Four students took turns pushing a box. The table below shows the forces they exerted on the box, the distances they pushed it, and the amount of time they pushed it.

Student	Force (N)	Distance (m)	Time (s)
W	10	4	5
X	5	8	8
Y	5	12	10
Z	1	14	8

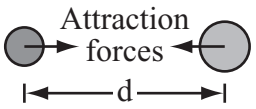
Which two students did the same amount of work?

A. students W and X
B. students X and Y
C. students Y and Z
D. students Z and W

34 The frequency of a note played on a piano is 262 Hz. Given that the velocity of sound at 20°C is 343 m/s, what is the wavelength of the note?

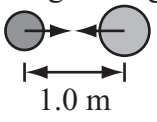
A. 0.25 m
B. 0.76 m
C. 1.31 m
D. 4.05 m

35 The diagram below represents the gravitational attraction forces between two masses.

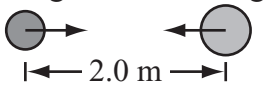


Which of the following combinations will result in the **greatest** force of gravitational attraction between two masses?

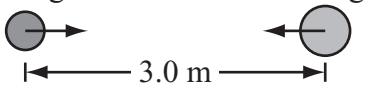
A. 3.0 kg 4.0 kg



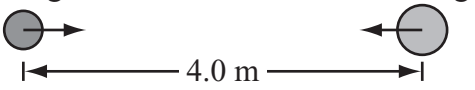
B. 5.0 kg 6.0 kg



C. 7.0 kg 8.0 kg



D. 8.0 kg 10.0 kg



36 The table shows the speed of sound in various substances under different conditions.

Substance	Speed (m/s)	State	Temperature (°C)
carbon dioxide	280	gas	51
methane	466	gas	41
helium	972	gas	0
ethanol	1144	liquid	25
water	1402	liquid	1
lubricating oil	1461	liquid	25
lead	2060	solid	20
wood	3450	solid	20
steel	6100	solid	20

Which of the following conclusions is **best** supported by the data in the table?

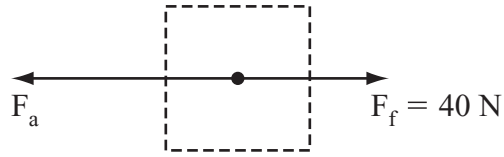
A. Sound generally travels at a faster speed in solid substances than in liquid substances.

B. Sound generally travels at a faster speed in gaseous substances than in liquid substances.

C. Sound generally travels at a slower speed when the temperature of a substance is increased.

D. Sound generally travels at a slower speed when the temperature of a substance is decreased.

37 The diagram below represents two forces acting on a wagon being pulled to the left. The force applied to the wagon is labeled F_a and the force of friction on the wagon is labeled F_f.



If the net force acting on the wagon is 20 N to the left, what is the magnitude of the applied force?

A. 20 N

B. 40 N

C. 60 N

D. 80 N

38 When 100 g of 20°C water is mixed with 50 g of 50°C water in a closed system, what is the final water temperature?

A. 20°C

B. 30°C

C. 35°C

D. 50°C

39 A large rock from space hit the surface of the Moon. Why were humans able to see the bright flash that occurred but unable to hear the sound of the impact?

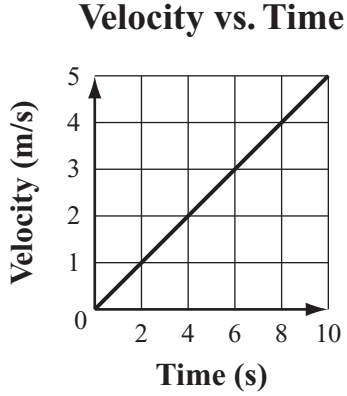
A. The sound waves required a medium for travel, but the light waves did not.

B. The low-energy sound waves were scattered by dust particles, but the high-energy light waves were not.

C. The high-energy sound waves were absorbed by the Moon's surface, and they were converted into visible light waves.

D. The sound waves arrived at Earth much later than the light waves, so they were not perceived as coming from the Moon.

40 The graph shows the velocity of an object over time.



Which of the following claims is supported by the graph?

A. The mass of the object is increasing.

B. The object has a displacement of zero.

C. The object has a constant acceleration.

D. The net force acting on the object is decreasing.

41 A person slides 1.2 m across a floor before coming to a stop. Why does the person come to a stop?

A. The force of gravity acts on the person.

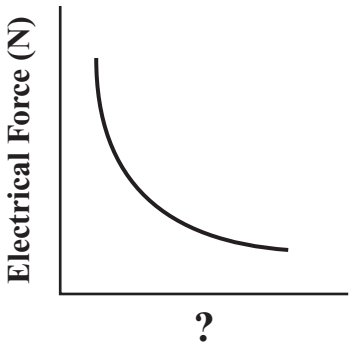
B. The force of friction acts on the person.

C. The force of inertia fails to keep the person in motion.

D. The normal force is greater than the friction force that acts on the person.

42 A student made the graph below to show how the amount of electrical force between two charged particles depends on another variable. The student's graph is missing a label for the *x*-axis.

Electrical Force between Two Charged Particles



What should the student label the *x*-axis?

A. Volume of Particles (m^3)

B. Mass of One Particle (kg)

C. Charge of One Particle (C)

D. Distance between Particles (m)

43 Three wave properties are listed below.

- Property 1: transverse
- Property 2: travel at the speed of light through a vacuum
- Property 3: travel faster through solids than through gases

Electromagnetic waves have which of these properties?

A. only property 1

B. only properties 1 and 2

C. only properties 2 and 3

D. only property 3

Questions 44 and 45 are open-response questions.

- **BE SURE TO ANSWER AND LABEL ALL PARTS OF EACH QUESTION.**
- **Show all your work (diagrams, tables, or computations) in your Student Answer Booklet.**
- **If you do the work in your head, explain in writing how you did the work.**

Write your answer to question 44 in the space provided in your Student Answer Booklet.

44 A student heated 235 g of water in a beaker until the water reached 100°C. The student removed the beaker from the heat and placed the beaker on a counter in a 23°C room. The student recorded the temperature of the water every 4 minutes for 20 minutes. The data are shown in the table.

Time (min)	Water Temperature (°C)
0	100.0
4	86.1
8	77.8
12	70.6
16	65.6
20	61.7

a. Did heat flow from the air to the water or from the water to the air? Include data from the table to support your answer.

b. Identify the average temperature of the air in the room at 20 min.

c. Were the water and the air in thermal equilibrium at 20 min? Explain your answer.

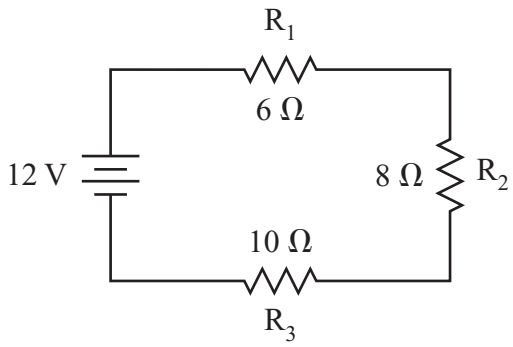
The specific heat of water is 4.19 J/g • °C.

d. Calculate the change in thermal energy of the water from 0 min to 20 min. Show your calculations and include units in your answer.

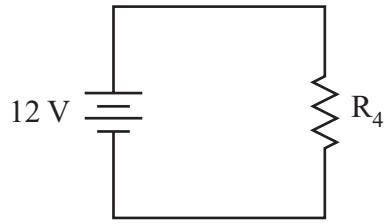
Write your answer to question 45 in the space provided in your Student Answer Booklet.

45 Two circuits, W and X, are shown in the diagrams.

Circuit W



Circuit X



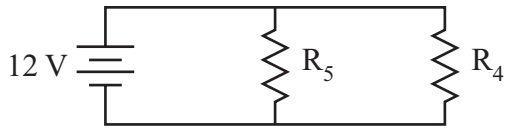
Circuit X has the same total resistance as circuit W, but circuit X has only one resistor, R_4.

a. Calculate the resistance of R_4. Show your calculations and include units in your answer.

b. Calculate the current through R_4. Show your calculations and include units in your answer.

Another circuit, Y, has the same battery and resistor as circuit X but also has another resistor, R_5, as shown.

Circuit Y



c. Determine whether adding R_5 increases or decreases the total current in circuit Y. Explain your reasoning.

d. In your Student Answer Booklet, copy circuit Y. On your circuit, add a third resistor labeled "R_{new}" in a location that will **not** change the current through R_4.

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 = $6.7 \times 10^{-11} \frac{N \bullet m^2}{kg^2}$

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

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

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

1 J = 1 N • m

Updated June 2018

High School Introductory Physics
Spring 2019 Released Operational Items

Item No.	Page No.	Reporting Category	2006 Standard	2016 Standard	Correct Answer (MC)*
1	499	*Waves and Radiation*	STE.IP.Wave4.4	HS.PHY.4.5	D
2	499	*Electromagnetism*	STE.IP.EM5.2	HS.PHY.2.9	C
3	499	*Heat and Heat Transfer*	STE.IP.HHT3.3	HS.PHY.3.2	A
4	500	*Motion and Forces*	STE.IP.CEM2.5	HS.PHY.2.2	A
5	500	*Motion and Forces*	STE.IP.CEM2.1	HS.PHY.3.1	B
6	501	*Heat and Heat Transfer*	STE.IP.HHT3.1	None**	D
7	501	*Motion and Forces*	STE.IP.MF1.3	HS.PHY.2.10	D
8	502	*Electromagnetism*	STE.IP.EM5.2	HS.PHY.2.9	C
9	502	*Waves and Radiation*	STE.IP.EM6.1	HS.PHY.4.1	C
10	502	*Electromagnetism*	STE.IP.EM5.6	HS.PHY.2.5	D
11	502	*Motion and Forces*	STE.IP.CEM2.2	HS.PHY.3.2	C
12	503	*Waves and Radiation*	STE.IP.Wave4.1	HS.PHY.4.1	
13	504	*Heat and Heat Transfer*	STE.IP.HHT3.3	HS.PHY.3.2	C
14	505	*Waves and Radiation*	STE.IP.EM6.2	HS.PHY.4.1	B
15	505	*Motion and Forces*	STE.IP.MF1.3	HS.PHY.2.10	B
16	505	*Waves and Radiation*	STE.IP.Wave4.3	HS.PHY.4.1	C
17	506	*Electromagnetism*	STE.IP.EM5.3	HS.PHY.2.9	B
18	506	*Electromagnetism*	STE.IP.EM5.4	HS.PHY.2.4	C
19	507	*Waves and Radiation*	STE.IP.Wave4.2	HS.PHY.4.1	A
20	507	*Electromagnetism*	STE.IP.EM5.2	HS.PHY.2.9	B
21	507	*Motion and Forces*	STE.IP.CEM2.3	HS.PHY.3.1	C
22	508	*Motion and Forces*	STE.IP.MF1.5	HS.PHY.2.10	A
23	509	*Motion and Forces*	STE.IP.MF1.4	HS.PHY.2.1	
24	510	*Heat and Heat Transfer*	STE.IP.HHT3.1	None**	B
25	510	*Motion and Forces*	STE.IP.CEM2.5	HS.PHY.2.2	C
26	511	*Waves and Radiation*	STE.IP.Wave4.4	HS.PHY.4.5	D
27	511	*Waves and Radiation*	STE.IP.Wave4.3	HS.PHY.4.1	D
28	511	*Motion and Forces*	STE.IP.MF1.4	HS.PHY.2.10	B
29	511	*Electromagnetism*	STE.IP.EM5.6	HS.PHY.2.5	A
30	512	*Motion and Forces*	STE.IP.MF1.2	HS.PHY.2.10	B
31	512	*Motion and Forces*	STE.IP.CEM2.1	HS.PHY.3.3	D
32	513	*Motion and Forces*	STE.IP.CEM2.2	HS.PHY.3.1	
33	514	*Motion and Forces*	STE.IP.CEM2.3	HS.PHY.3.1	A
34	514	*Waves and Radiation*	STE.IP.Wave4.1	HS.PHY.4.1	C
35	514	*Motion and Forces*	STE.IP.MF1.7	HS.PHY.2.4	A
36	515	*Waves and Radiation*	STE.IP.Wave4.5	HS.PHY.4.1	A
37	515	*Motion and Forces*	STE.IP.MF1.5	HS.PHY.2.10	C
38	515	*Heat and Heat Transfer*	STE.IP.HHT3.4	HS.PHY.3.4	B
39	516	*Waves and Radiation*	STE.IP.Wave4.2	HS.PHY.4.1	A

Item No.	Page No.	Reporting Category	2006 Standard	2016 Standard	Correct Answer (MC)*
40	516	*Motion and Forces*	STE.IP.MF1.3	HS.PHY.2.10	C
41	517	*Motion and Forces*	STE.IP.MF1.4	HS.PHY.2.10	B
42	517	*Electromagnetism*	STE.IP.EM5.4	HS.PHY.2.4	D
43	517	*Waves and Radiation*	STE.IP.EM6.1	HS.PHY.4.1	B
44	518	*Heat and Heat Transfer*	STE.IP.HHT3.2	HS.PHY.3.4	
45	519	*Electromagnetism*	STE.IP.EM5.3	HS.PHY.2.9	

* Answers are provided here for multiple-choice items only. Sample responses and scoring guidelines for open-response items, which are indicated by the shaded cells, will be posted to the Department's website later this year.

**This content is currently found in standard 7.MS-PS3-6(MA) and was assessed on the 2019 MCAS Introductory Physics test. In future years, the content will be assessed on the MCAS grade 8 STE test instead.