Example Physical Science Assessment Items

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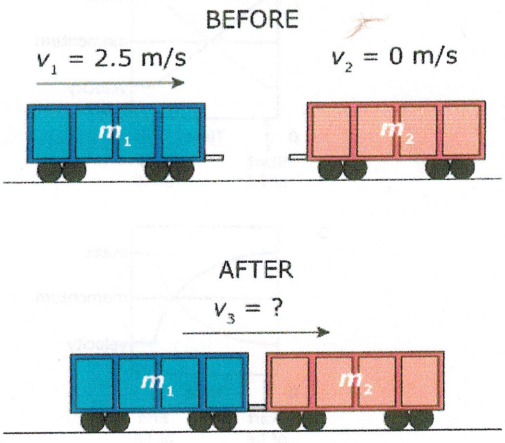
As a railcar (Car 1) moves through the Oak Island Yard in Newark, New Jersey, it collides with a stationary railcar (Car 2), changing the velocity of both cars, as shown in Figure 1.

Car 1 has a mass (m_1) of 28,000 kilograms (kg) and is moving at 2.5 meters per second (v_1) before impact. Car 2 has a mass (m_2) of 30,000 kg and is stationary before impact. Both railcars are empty. When the railcars collide, they link together and move as a unit at a different velocity, v_3. The equation for momentum is given:

momentum (p) = mass (m) × velocity (v)

Assume that all collisions occur at the object's center of mass and are 100 percent inelastic. Ignore gravity, friction, air resistance, and any other force on the system.

Figure 1: Cars 1 and 2 before and after Collision



What is the momentum of Car 2, in kilograms-meters per second (kg × m/s), before the impact?

- A. 0
- B. 750
- C. 7,500
- D. 75,000

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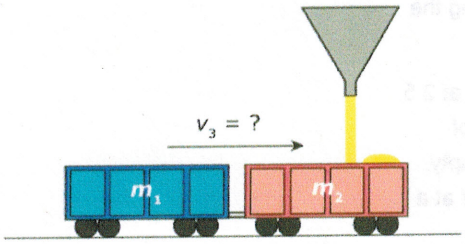
Figure 2 shows the two rail cars passing under a grain silo to be filled with grain. The cars continue moving as they are filled.

Figure 2: Railcars Filling



The silo releases grain at a constant rate. Select the graph that correctly shows the relationship between mass, velocity, and momentum over time as the car on the right fills with grain. (Assume the rail is frictionless.)

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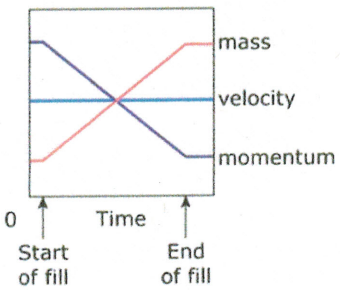
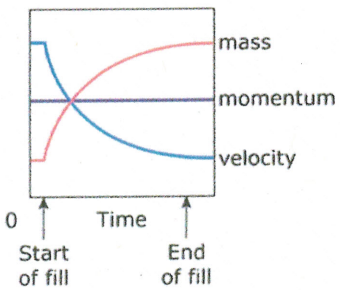
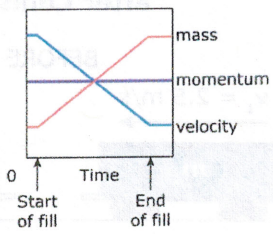
A.



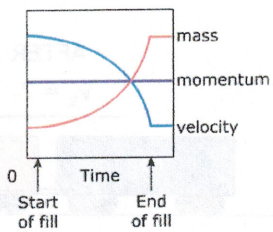
B.



C.



D.



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A student claims that the momentum of the railcar system may be lost due to outside forces. Select **all** of the factors that would most likely cause this system to lose momentum.

- A. heat
- B. sound
- C. wind resistance
- D. friction between the railcar and the rails
- E. internal friction between parts of the railcar

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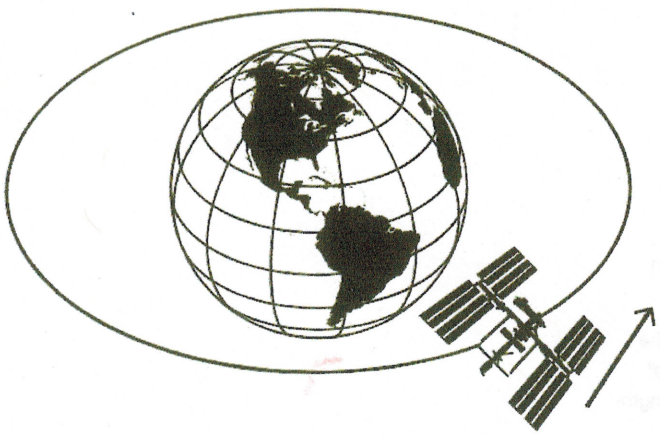
A object circling Earth will either fall toward Earth if it is too slow or escape Earth's gravity and move into space if it is too fast. The International Space Station (ISS) must move at a specific velocity to stay in Earth's orbit.

The orbit of the ISS is shown in Figure 1.

ISS Orbit around Earth



Since the ISS is in a stable orbit, the gravitational and centripetal forces on it must be equal, as shown.

$$\frac{G \times m \times M}{r^2} = \frac{m \times v^2}{r}$$

The distances involved are summarized by the equation

$$r = c + s$$

where r is the distance between the center of Earth and the ISS, c is the distance between the center and surface of Earth, and s is the distance between the surface of Earth and the ISS.

The table displays relevant data for the ISS at a point in its orbit.

Centripetal and Gravitational Forces

Quantity	Description	Value
G	gravitational constant	$6.7 \times 10^{-11} m^3 kg^{-1} s^{-2}$
v	velocity of ISS	$7.7 \times 10^3\ m/s$
M	mass of Earth	$6.0 \times 10^{24}\ kg$
r	distance between the center of Earth and the ISS	
c	distance between the center and surface of Earth	$6.4 \times 10^6\ m$
s	distance between the surface of Earth and the ISS	

Which value is the distance between the ISS and the surface of Earth, based on the information in the table?

- A. 180,000 m
- B. 280,000 m
- C. 380,000 m
- D. 480,000 m

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A clear marble made of a type of absorbent polymer (a type of plastic) is easily visible when held, but seems to disappear when placed in a glass of water.

Light with a frequency of 5.60×10^{14} Hz (Hertz) is used to test the behavior of light through the different substances. The velocity of light (v) is measured as the product of frequency (f) and wavelength (λ):

$$v = f\lambda$$

Figure 1 shows a polymer marble before and after it is dropped into a glass of distilled water. As indicated, the light changes velocity when it passes through each substance.

Figure 1: Model of Polymer Marble Before and After Being Placed Into a Glass of Clear Water (Not to Scale)

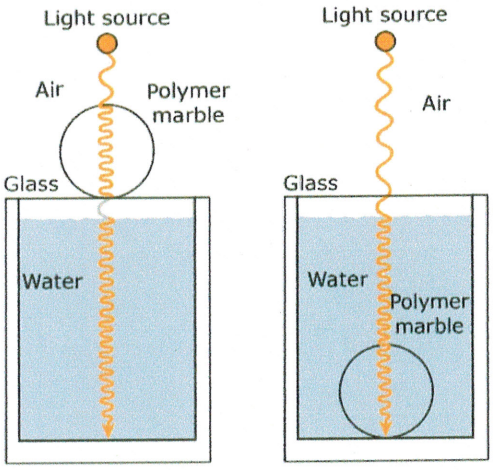

Table 1 shows light velocity data, in meters per second (m/s), for various substances.

Table 1: Velocity of Light through Different Substances

	Air	Water	Polymer	Glass
Velocity ($\times 10^8$ m/s)	3.00	2.25	2.25	2.00

Which wavelength (λ) of the light results as it passes from water into the polymer ball?

- A. 3.57×10^{-7} m
- B. 4.02×10^{-7} m
- C. 5.35×10^{-7} m
- D. 7.12×10^{-7} m

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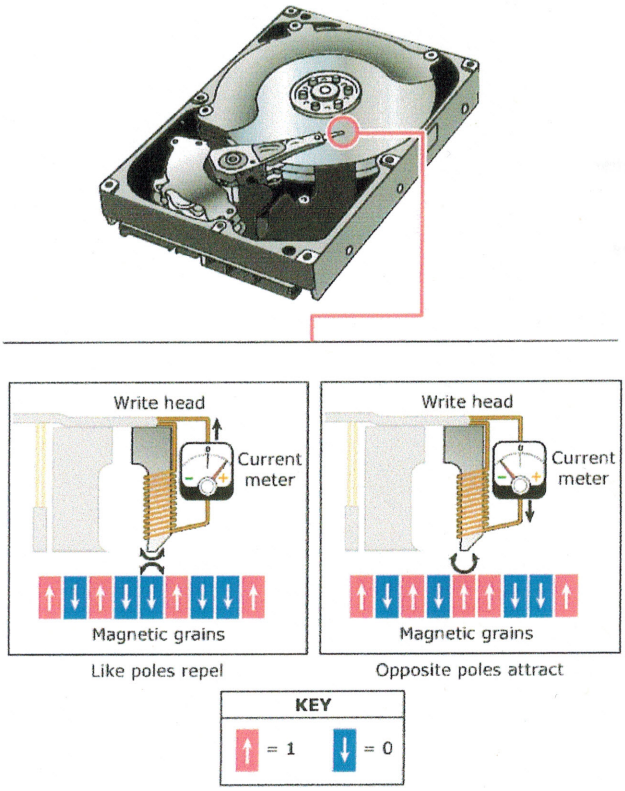
A single hard disk drive can contain all the information from many libraries. When putting the information onto the disk, the disk does not change in size or composition.

Hard disk drives were first introduced in 1954 and remained a dominant technology for over 50 years.

An electromagnetic wave is generated when the direction of current is repeatedly reversed. This wave creates an alternating magnetic field. Hard disk drives use a part called a write head to store information as bits. When current goes through the write head, it becomes magnetic, which magnetizes the grains. This magnetic interaction allows information to be stored in the magnetized grains of the disk as either a "0" or a "1," with each 0 or 1 being considered a single bit. This system of using zeros and ones to store information is known as binary code. Bits are shown as downward- or upward-pointing arrows in Figure 1.

Figure 1: Hard Disk Drives Store Information



Select the **two** statements that explain what is most important to the process of storing information on a hard disk drive.

- A. the sign of the current
- B. the size of the hard disk drive
- C. how fast the write head moves
- D. the different magnetic field directions
- E. how many previously written bits there are

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How many bits are required to store an image of 1 MB?

Enter your response in the box provided.

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The letter "Z" is written as "01011010" in binary code.

Select the correct combination of signs on the current meter to write the letter "Z."

Bit Number	Current Meter = Positive	Current Meter = Negative
Bit #1		
Bit #2		
Bit #3		
Bit #4		
Bit #5		
Bit #6		
Bit #7		
Bit #8		

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Each capital English letter is represented by a one-byte string that contains eight bits, as shown in the table. Each byte is read from left to right.

Table 2: 8-Bit Strings Representing English Capital Letters

Letter	Bit String	Letter	Bit String
A	01000001	G	01000111
B	01000010	H	01001000
C	01000011	I	01001001
D	01000100	J	01001010
E	01000101	K	01001011
F	01000110	L	01001100

The following bit string was recovered from a corrupted hard disk drive by measuring the magnetic interactions stored by the magnetic grains.

Bit Number	Magnetic Interaction
Bit #1	repulsive
Bit #2	attractive
Bit #3	repulsive
Bit #4	repulsive
Bit #5	attractive
Bit #6	repulsive
Bit #7	attractive
Bit #8	repulsive

Which capital letter was recovered?

Enter your response in the box provided.

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Each capital English letter is stored by a sequence of magnetic interactions between the write head and the magnetic grains, as shown in the table. A bit string is obtained by writing bits 1–8 from left to right.

Table 3: 8-Bit Strings Representing Two English Capital Letters

Bit Number	Magnetic Interaction Sequence	
	Letter "O"	Letter "R"
1	repulsive	repulsive
2	attractive	attractive
3	repulsive	repulsive
4	repulsive	attractive
5	attractive	repulsive
6	attractive	repulsive
7	attractive	attractive
8	attractive	repulsive

Construct an explanation about how wave interactions store information on a hard disk drive. Support your explanation using evidence from Figure 1.

B I U 1500

Use an English letter from Table 3 to construct an explanation about how the sequence of the magnetic interactions between the write head and the magnetic grains are used to store information. Support your explanation using evidence from Figure 1.

B I U 1500

Make a claim about:

- the type of magnetic interaction that is produced when a current is applied to the write head;
- why this magnetic interaction is produced, and
- the bit that results from this interaction.

Support your claim using evidence from Figure 1.

B I U 1500