This print-out should have 60 questions. Multiple-choice questions may continue on the next column or page – find all choices before answering.

Charges 05
001 10.0 points

Consider the following statements.

I. Objects with large amounts of charge have bigger electric fields than do objects with small amounts of charge;
II. Like charges repel;
III. Electrons have a positive charge.

Which statement(s) is/are true?

1. I and III only

2. II and III only

3. All are true.

4. None is true.

5. III only

6. I and II only **correct**

7. I only

8. II only

Explanation:
Electrons have a negative charge.

Hewitt CP9 11 E01
002 10.0 points

How does the mass of an object change when it acquires a positive charge?

1. More information is needed.

2. Decreases **correct**

3. Increases

4. Doesn't change

Explanation:
When an object acquires a positive charge, it loses electrons, so its mass decreases.

Hewitt CP9 22 E30
003 10.0 points

What keeps an inflated balloon from falling down if you rub it against your hair and place it against a wall?

1. Rubbing distorts the atoms inside the ballon and polarizes it.

2. Rubbing polarizes the air inside of the balloon.

3. When you rub the balloon against your hair, it will remove some mass from the balloon and make it lighter.

4. Rubbing leaves a balloon electrically charged; the charged balloon polarizes the wall. **correct**

5. When you rub the balloon against your hair, the balloon may have some oil attached to it, which can be sticky.

Explanation:
The charged balloon induces polarization of the molecules in the wall material. Oppositely charged sides of the molecules in the surface of the wall face the balloon.

Meters 01
004 10.0 points

An instrument used to detect a static electric charge is called

1. a transformer.

2. an ohmmeter.

3. a generator.

4. a motor.

5. a voltmeter.

6. an electroscope. **correct**

7. an ammeter.

Explanation:

Hewitt CP9 22 E31
005 10.0 points

How can a charged atom (an ion) attract a neutral atom?

1. The charged atom can produce secondary electrons to interact with the neutral atom and make it positively charged or negatively charged.

2. The charged atom can emit x-rays to induce ionization of the neutral atom.

3. An ion polarizes a nearby neutral atom, so that the part of the atom nearer to the ion acquires a charge opposite to the charge of the ion, and the part of the atom farther from the ion acquires a charge of the same sign as the ion. **correct**

4. The charged atom can hit the neutral atom and make it positively charged or negatively charged.

Explanation:

An ion polarizes a nearby neutral atom, so that the part of the atom nearer to the ion acquires a charge opposite to the charge of the ion, and the part of the atom farther from the ion acquires a charge of the same sign as the ion.

Lightning Charge 02
006 (part 1 of 2) 10.0 points

A strong lightning bolt transfers about 21.2 C to Earth.

How many electrons are transferred? The elemental charge is 1.602×10^{-19} C.

Correct answer: 1.32335×10^{20}.

Explanation:

$$\text{Let :} \quad q = 21.2 \text{ C} \quad \text{and}$$
$$q_e = -1.602 \times 10^{-19} \text{ C}\,.$$

The charge is proportional to the number of electrons, so

$$q = n\,|q_e|$$

$$n = \frac{q}{|q_e|} = \frac{21.2 \text{ C}}{|-1.602 \times 10^{-19} \text{ C}|} = \boxed{1.32335 \times 10^{20}}\,.$$

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007 (part 2 of 2) 10.0 points

The lightning bolt discharge lasts one millisecond.

What is the average current flowing from the cloud to ground?

Correct answer: 21200 A.

Explanation:

$$\text{Let :} \quad t = 1 \text{ ms} = 0.001 \text{ s}\,.$$

$$I = \frac{q}{t} = \frac{21.2 \text{ C}}{0.001 \text{ s}} = \boxed{21200 \text{ A}}\,.$$

Hewitt CP9 22 E29
008 10.0 points

Why is a good conductor of electricity also a good conductor of heat?

1. They all carry energies for both electricity and heat.

2. For both electricity and heat, the conduction is via atoms, which in a metal are loosely bound, easy flowing, and easy to start moving.

3. For both electricity and heat, the conduction is via electrons, which in a metal are loosely bound, easy flowing, and easy to start moving. **correct**

4. If there is a current through a conductor, there should also be heat produced by resistance.

5. Bound electrons do not exist in materials that are good conductors for both heat and electricity.

Explanation:

Electrons in a metal are loosely bound, flow easily, and start moving easily; an important requirement for heat and electricity.

Hewitt CP9 22 E37
009 10.0 points

Suppose that a metal file cabinet is charged.

How will the charge concentration at the corners of the cabinet compare with the charge concentration on the flat parts of the cabinet?

1. Lower than the concentration at the flat parts

2. Higher than the concentration at the flat parts **correct**

3. More information is needed.

4. None of these

5. Equal everywhere

Explanation:

Charge is concentrated where the radius of curvature is the smallest; *i.e.*, the sharpest places. As an example, the charge is concentrated on the head of a pin or the point of a lightening rod. Charges will be more concentrated on the corners.

Electric Field Intensity
010 10.0 points

A positive charge of 8.81×10^{-5} C experiences a force of 0.172 N when located at a certain point.

What is the electric field magnitude at that point?

Correct answer: 1952.33 N/C.

Explanation:

$$\text{Let :} \quad q = 8.81 \times 10^{-5}\ \text{C} \quad \text{and}$$
$$F = 0.172\ \text{N}\,.$$

The electric field is

$$E = \frac{F}{q} = \frac{0.172\ \text{N}}{8.81 \times 10^{-5}\ \text{C}} = \boxed{1952.33\ \text{N/C}}.$$

Electric Field Vector
011 10.0 points

From the electric field vector at one point, one can determine which of the following?

A. The electrostatic charge at that point.

B. The direction of the electrostatic force on a test charge of known sign at that point.

C. The magnitude of the electrostatic force exerted per unit charge on a test charge at that point.

1. B only

2. None is true.

3. A and B only

4. A and C only

5. B and C only **correct**

6. All are true.

7. A, B, and C

8. C only

9. A only

Explanation:

The electric field is a vector with magnitude and direction, and the electric force is parallel (anti-parallel) to the electric field for a positive (negative) test charge.

Only a closed surface integration can determine the amount of charge enclosed in the surface.

Hewitt CP9 22 P08
012 (part 1 of 2) 10.0 points

In 1909 Robert Millikan was the first to find the charge of an electron in his now-famous oil drop experiment. In the experiment tiny oil drops are sprayed into a uniform electric field between a horizontal pair of oppositely charged plates. The drops are observed with a magnifying eyepiece, and the electric field is adjusted so that the upward force $q\,E$ on some negatively charged oil drops is just sufficient to balance the downward force $m\,g$ of gravity. Millikan accurately measured the charges on many oil drops and found the values to be whole-number multiples of 1.6×10^{-19} C — the charge of the electron. For this he won the Nobel Prize.

If a drop of mass 2.44898×10^{-13} kg remains stationary in an electric field of 1×10^{6} N/C, what is the charge on this drop? The acceleration due to gravity is $9.8\ \text{m/s}^2$.

Correct answer: 2.4×10^{-18} C.

Explanation:

$$\begin{aligned}\text{Let :}\quad & m = 2.44898 \times 10^{-13}\ \text{kg}\,, \\ & E = 1 \times 10^{6}\ \text{N/C}\,, \quad \text{and} \\ & g = 9.8\ \text{m/s}^2\,.\end{aligned}$$

When suspended,

$$\begin{aligned} m\,g &= E\,q \\ q &= \frac{m\,g}{E} \\ &= \frac{(2.44898 \times 10^{-13}\ \text{kg})\,(9.8\ \text{m/s}^2)}{1 \times 10^{6}\ \text{N/C}} \\ &= \boxed{2.4 \times 10^{-18}\ \text{C}}\,. \end{aligned}$$

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013 (part 2 of 2) 10.0 points

How many extra electrons are on this particular oil drop (given the presently known charge of the electron)?

Correct answer: 15.

Explanation:

$$\text{Let :}\quad e = 1.6 \times 10^{-19}\ \text{C}\,.$$

The number of electrons can be calculated from the charges on the oil drop:

$$N = \frac{q}{e} = \frac{2.4 \times 10^{-18}\ \text{C}}{1.6 \times 10^{-19}\ \text{C}} = \boxed{15}\,.$$

Charge in Electric Field

014 10.0 points

A particle of charge q is placed in a uniform electric field of magnitude E. Consider the following statements about the resulting forces on the particle:

I. It has magnitude $q\,E$.
II. It is perpendicular to the direction of the field.
III. It is parallel to the direction of the field.

Identify the true statement(s).

1. All are true.

2. I and II only

3. II and III only

4. None is true.

5. I and III only **correct**

6. I only

7. III only

8. II only

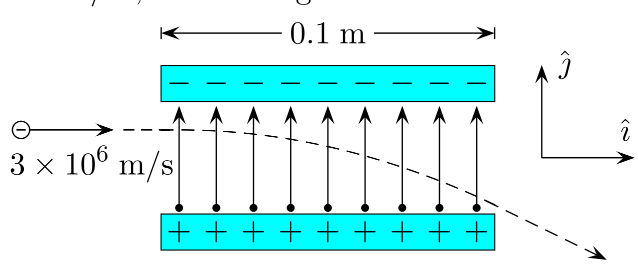
Explanation:

The electric field at some point in space is the force per unit charge that the test charge would feel at that point, so the electric force the charge experiences is of magnitude $q\,E$ and in the same direction as the direction of the electric field.

Electron Deflection

015 (part 1 of 3) 10.0 points

An electron traveling at 3×10^{6} m/s enters a 0.1 m region with a uniform electric field of 106 N/C , as in the figure.



Find the magnitude of the acceleration of the electron while in the electric field. The mass of an electron is 9.109×10^{-31} kg and the fundamental charge is 1.602×10^{-19} C.

Correct answer: 1.86422×10^{13} m/s^2.

Explanation:

$$\begin{aligned} \text{Let :} \quad q_e &= -1.602 \times 10^{-19}\ \text{C}\,, \\ m_e &= 9.109 \times 10^{-31}\ \text{kg}\,, \quad \text{and} \\ E &= 106\ \text{N/C}\,. \end{aligned}$$

$$\begin{aligned} F &= m\,a = q\,E \\ a &= \frac{q_e\,E}{m_e}\,\hat{\jmath} \\ &= \frac{(-1.602 \times 10^{-19}\ \text{C})(106\ \text{N/C})}{9.109 \times 10^{-31}\ \text{kg}}\,\hat{\jmath} \\ &= (-1.86422 \times 10^{13}\ \text{m/s}^2)\,\hat{\jmath}\,, \end{aligned}$$

with a magnitude of $\boxed{1.86422 \times 10^{13}\ \text{m/s}^2}$.

016 (part 2 of 3) 10.0 points

Find the time it takes the electron to travel through the region of the electric field, assuming it doesn't hit the side walls.

Correct answer: 3.33333×10^{-8} s.

Explanation:

$$\begin{aligned} \text{Let :} \quad \ell &= 0.1\ \text{m}\,, \quad \text{and} \\ v_0 &= 3 \times 10^6\ \text{m/s}\,. \end{aligned}$$

The horizontal distance traveled is

$$\begin{aligned} \ell &= v_0\,t \\ t &= \frac{\ell}{v_0} = \frac{0.1\ \text{m}}{3 \times 10^6\ \text{m/s}} \\ &= \boxed{3.33333 \times 10^{-8}\ \text{s}}\,. \end{aligned}$$

017 (part 3 of 3) 10.0 points

What is the magnitude of the vertical displacement Δy of the electron while it is in the electric field?

Correct answer: 0.0103568 m.

Explanation:

Using the equation for the displacement in the vertical direction and the results from the first two parts of the problem,

$$\begin{aligned} \Delta y &= \frac{1}{2}\,a\,t^2 \\ &= \frac{-1.86422 \times 10^{13}\ \text{m/s}^2}{2} \\ &\quad \times (3.33333 \times 10^{-8}\ \text{s})^2 \\ &= -0.0103568\ \text{m}\,, \end{aligned}$$

with a magnitude of $\boxed{0.0103568\ \text{m}}$.

Moving a Charge

018 10.0 points

It takes 112 J of work to move 2.5 C of charge from the negative plate to the positive plate of a parallel plate capacitor.

What voltage difference exists between the plates?

Correct answer: 44.8 V.

Explanation:

$$\begin{aligned} \text{Let :} \quad W &= 112\ \text{J} \quad \text{and} \\ q &= 2.5\ \text{C}\,. \end{aligned}$$

The voltage difference is

$$V = \frac{W}{q} = \frac{112\ \text{J}}{2.5\ \text{C}} = \boxed{44.8\ \text{V}}\,.$$

Serway CP 16 06

019 10.0 points

To recharge a 12 V battery, a battery charger must move 3.5×10^5 C of charge from the negative terminal to the positive terminal.

How much work is done by the battery charger?

Correct answer: 4.2×10^6 J.

Explanation:

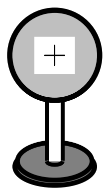
$$\begin{aligned} \text{Given :} \quad q &= 3.5 \times 10^5\ \text{C} \quad \text{and} \\ V &= 12\ \text{V}\,. \end{aligned}$$

The potential difference is

$$
\begin{aligned}
V &= \frac{W}{q}, \\
W &= q\,V \\
&= (3.5 \times 10^5\ \text{C})\,(12\ \text{V}) \\
&= \boxed{4.2 \times 10^6\ \text{J}}.
\end{aligned}
$$

Solid Conducting Sphere v2
020 10.0 points

A positive charge of 10^{-6} coulomb is placed on a solid conducting sphere that is mounted on an insulating post.



What is true?

1. When a second conducting sphere is connected by a conducting wire to the first sphere, charge is transferred until the electric potentials of the two spheres are equal. **correct**

2. The charge resides uniformly throughout the sphere.

3. The electric field inside the sphere is constant in magnitude, but not zero.

4. An insulated metal object acquires a net positive charge when brought near to, but not in contact with, the sphere.

5. The electric field in the region surrounding the sphere increases with increasing distance from the sphere.

Explanation:

Every point in the conductor becomes equipotential, and the electric field is defined as the gradient of the electric potential, so inside the conducting sphere, all points are equipotential and there is no electric field.

Outside the conducting sphere, the electric field is the same when there are net charges at the center of the sphere, so the electric field decreases with increasing distance from the sphere.

If there is no net charge on the insulated metal object when brought near to, but not in contact with the sphere, there is also no net charge on it. Only the charge distribution changes.

Since there is repulsion among like charges, charges reside uniformly on the surface of the sphere.

Hewitt CP9 23 09
021 (part 1 of 2) 10.0 points

What is the effect on the current in a wire if both the voltage across it and its resistance are doubled?

1. The current is 4 times bigger.

2. The current does not change. **correct**

3. The current is doubled.

4. The current is halved.

5. The current is reduced to a quarter of its original value.

6. It cannot be determined.

Explanation:

By Ohm's law $V = I\,R$. $I_1 = \dfrac{V}{R}$, so if both the voltage V and resistance R are doubled, there is no change in the current:

$$
I_2 = \frac{2\,V}{2\,R} = \frac{V}{R} = I_1\,.
$$

022 (part 2 of 2) 10.0 points

What is the effect on the current in a wire if both the voltage across it and its resistance are halved?

1. The current is 4 times bigger.

2. The current does not change. **correct**

3. The current is reduced to a quarter of its original value.

4. The current is halved.

5. It cannot be determined.

6. The current is doubled.

Explanation:

If both the voltage V and resistance R are halved, there is no change in the current:

$$I_2 = \frac{\frac{1}{2}\,V}{\frac{1}{2}\,R} = \frac{V}{R} = I_1\,.$$

Power in Wires
023 10.0 points

A wire of resistance R dissipates power P when a current I passes through it. The wire is replaced by another wire with resistance $3\,R$.

What is the power dissipated by the new wire when the same current passed through it?

1. $6\,P$

2. $3\,P$ **correct**

3. P

4. $\dfrac{P}{9}$

5. $\dfrac{P}{3}$

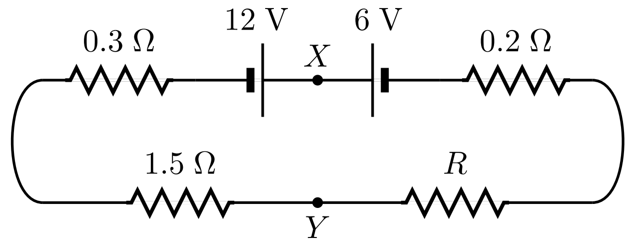
Explanation:

The power dissipated by a resistor is given by $P = I^2\,R$, so

$$P' = I^2\,(3\,R) = 3\,(I^2\,R) = 3P\,.$$

Series Circuit 01
024 (part 1 of 3) 10.0 points

The current in the circuit below is 2 amperes.



What is the resistance R?

1. 4 Ω

2. 1 Ω **correct**

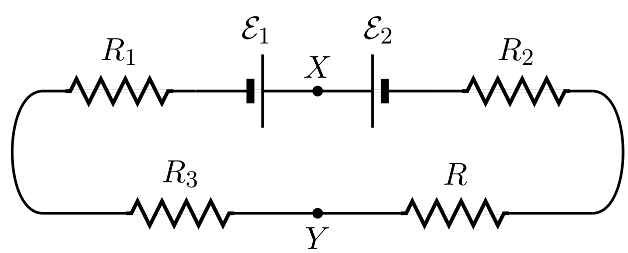
3. 2 Ω

4. 5 Ω

5. 3 Ω

Explanation:

$$\begin{aligned} \text{Let :}\quad & R_1 = 0.3\ \Omega\,,\\ & R_2 = 0.2\ \Omega\,,\\ & R_3 = 1.5\ \Omega\,,\\ & \mathcal{E}_1 = 12\ \text{V}\,,\quad \text{and}\\ & \mathcal{E}_2 = 6\ \text{V}\,. \end{aligned}$$



From Ohm's law, the total resistance of the circuit is

$$R_{total} = \frac{V}{I} = \frac{12\ \text{V} - 6\ \text{V}}{2\ \text{A}} = 3\ \Omega\,.$$

Therefore, the resistance R is

$$R = R_{total} - 0.3\ \Omega - 1.5\ \Omega - 0.2\ \Omega = 1\ \Omega\,.$$

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025 (part 2 of 3) 10.0 points

What is the potential difference between points X and Y?

1. 12.2 V

2. 6.0 V

3. 1.2 V

4. 10.8 V

5. 8.4 V **correct**

Explanation:
The current in the circuit is counterclockwise, so the potential difference between X and Y is

$$6\text{ V} + (0.2\ \Omega)\,(2\text{ A}) + (1\ \Omega)\,(2\text{ A}) = 8.4\text{ V}\,.$$

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026 (part 3 of 3) 10.0 points

How much energy is dissipated by the 1.5-Ω resistor in 60 seconds?

1. 360 J **correct**

2. 6 J

3. 720 J

4. 1440 J

5. 180 J

Explanation:
We have the basic equation as

$$\begin{aligned} W &= P\,t = V\,I\,t = I^2\,R\,t \\ &= (2\text{ A})^2\,(1.5\ \Omega)\,(60\text{ sec}) \\ &= 360\text{ J}\,. \end{aligned}$$

Electron in a Magnetic Field
027 10.0 points

An electron in a vacuum is first accelerated by a voltage of 1.019×10^5 V and then enters a region in which there is a uniform magnetic field of 0.636 T at right angles to the direction of the electron's motion.

The mass of the electron is 9.11×10^{-31} kg and its charge is 1.60218×10^{-19} C.

What is the magnitude of the force on the electron due to the magnetic field?

Correct answer: 1.92915×10^{-11} N.

Explanation:

$$\begin{aligned} \text{Let :}\quad V &= 1.019 \times 10^5\text{ V}\,, \\ B &= 0.636\text{ T}\,, \\ m &= 9.11 \times 10^{-31}\text{ kg}\,, \\ q_e &= 1.60218 \times 10^{-19}\text{ C}\,. \end{aligned}$$

The kinetic energy K gained after acceleration is $K = \frac{1}{2}\,m\,v^2 = q_e\,V$, so the velocity is

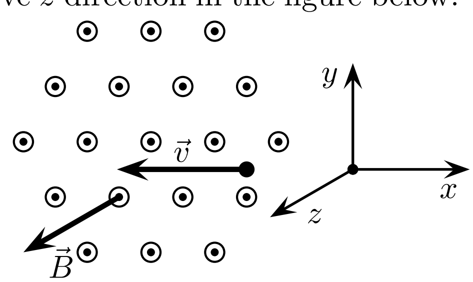
$$\begin{aligned} v &= \sqrt{\frac{2\,q_e\,V}{m}} \\ &= \sqrt{\frac{2\,(1.60218 \times 10^{-19}\text{ C})(1.019 \times 10^5\text{ V})}{9.11 \times 10^{-31}\text{ kg}}} \\ &= 1.89321 \times 10^8\text{ m/s}\,. \end{aligned}$$

Then the force on it is

$$\begin{aligned} f &= q\,v\,B \\ &= (1.60218 \times 10^{-19}\text{ C}) \\ &\quad \times (1.89321 \times 10^8\text{ m/s})\,(0.636\text{ T}) \\ &= \boxed{1.92915 \times 10^{-11}\text{ N}}\,. \end{aligned}$$

Charge in a Magnetic Field 04
028 10.0 points

A particle with charge q and mass m has speed v. At $t = 0$, the particle is moving along the negative x axis in the plane perpendicular to the magnetic field $\vec{B}$, which points in the positive z direction in the figure below.



Find the direction of the instantaneous acceleration $\widehat{a}$ at $t = 0$ if q is negative.

1. $\widehat{a} = \hat{j} + \hat{k}$

2. $\widehat{a} = \hat{i} + \hat{j}$

3. $\widehat{a} = -\hat{k}$

4. $\widehat{a} = -\hat{j}$ **correct**

5. $\widehat{a} = -\hat{i}$

6. $\widehat{a} = \hat{j}$

7. $\widehat{a} = -\hat{k} + \hat{i}$

8. $\widehat{a} = \hat{k}$

9. $\widehat{a} = \hat{i}$

10. $\widehat{a} = \hat{k} + \hat{i}$

Explanation:

The particle is moving along the negative x-axis in this instant

$$\vec{v} = -v\,\hat{i}\,;$$

since it is moving in a circle, we need to talk about instantaneous direction.

The force F_B is equal to $q\,\vec{v} \times \vec{B}$ at all times. $\vec{B}$ points in the z direction, so

$$\vec{B} = B\,\hat{k}\,, \quad \text{and}$$

$$\begin{aligned} \vec{F}_B &= q\,v\,(-\hat{i}) \times B\,\hat{k} \\ &= q\,v\,B\,(-\hat{i} \times \hat{k}) = q\,v\,B\,\hat{j}\,. \end{aligned}$$

The charge q is negative $(q = -|q|)$, so

$$\vec{F}_B = -|q|\,v\,B\,\hat{j} = |q|\,v\,B\,(-\hat{j})\,.$$

All quantities are positive, so the actual direction in which $\vec{F}_B$ points is the negative y direction, or $\widehat{a} = -\hat{j}$.

Circular Orbit of a Proton
029 10.0 points

What is the radius of the largest possible circular orbit that a proton with energy 0.75 MeV can have in a 2 T magnetic field? The mass of a proton is 1.67×10^{-27} kg and its charge is 1.609×10^{-19} C.

Correct answer: 0.0623873 m.

Explanation:

$$\begin{aligned} \text{Let :} \quad & m = 1.67 \times 10^{-27}\ \text{kg}\,, \\ & Q = 1.609 \times 10^{-19}\ \text{C}\,, \\ & B = 2\ \text{T}\,, \quad \text{and} \\ & E = 0.75\ \text{MeV}\,. \end{aligned}$$

The energy of a proton is

$$\begin{aligned} E &= \frac{1}{2}\,m\,v^2 \\ v &= \sqrt{\frac{2\,E}{m}} \\ &= \sqrt{\frac{2(0.75\ \text{MeV})}{1.67 \times 10^{-27}\ \text{kg}}\,\frac{1 \times 10^6\ \text{MeV/eV}}{1\ \text{MeV}}} \\ &\quad \times \sqrt{\frac{1.609 \times 10^{-19}\ \text{J/eV}}{1\ \text{eV}}} \\ &= \boxed{1.20217 \times 10^7\ \text{m/s}}\,. \end{aligned}$$

If the proton is shot into the magnetic field with a velocity at right angles to the direction of the field, we will get the largest radius

$$\begin{aligned} r &= \frac{m\,v}{B\,q} \\ &= \frac{(1.67 \times 10^{-27}\ \text{kg})\,(1.20217 \times 10^7\ \text{m/s})}{(2\ \text{T})\,(1.609 \times 10^{-19}\ \text{C})} \\ &= \boxed{0.0623873\ \text{m}}\,. \end{aligned}$$

Bulbs in a Circuit 01
030 (part 1 of 8) 10.0 points

Unlike most real bulbs, the resistances of the bulbs in the questions below do not change as the current through them changes. All bulbs considered in this problem are identical. Assume all batteries are ideal (they have no internal resistance) and connecting wires have no resistance.

What is true when one bulb is brighter than another?

1. The current passing through the brighter bulb is smaller.

2. The current passing through both bulbs are the same.

3. Not enough information is given.

4. The current passing through the brighter bulb is larger. **correct**

Explanation:

The brightness depends on the power

$$P = I^2 R .$$

When one bulb is brighter, it has a larger P. Since the bulbs are identical, the resistances are equal, so the current I must be larger in the brighter bulb.

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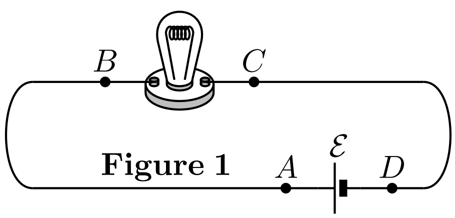
031 (part 2 of 8) 10.0 points

A light bulb and a battery are connected as shown in Figure 1.



What is true about the current passing through various points in this circuit?

1. The current passing through point C is largest.

2. The current is the same through AB and larger than through CD.

3. The current passing through point B is largest.

4. The current passing through point A is largest.

5. The current passing through point D is largest.

6. The current is the same through AB and smaller than through CD.

7. The current is the same everywhere except through the battery.

8. The current is the same everywhere except through the bulb.

9. The current is the same everywhere in the circuit. **correct**

10. None of these

Explanation:

Choose two points which are very close to each other along the circuit, say P_1 and P_2, with current flowing from P_1 to P_2. Since charge is conserved, the number of electrons flowing out of P_1 should equal that flowing into P_2, giving them the same current; expanding this along all points in the circuit, every point should have the same current passing through it.

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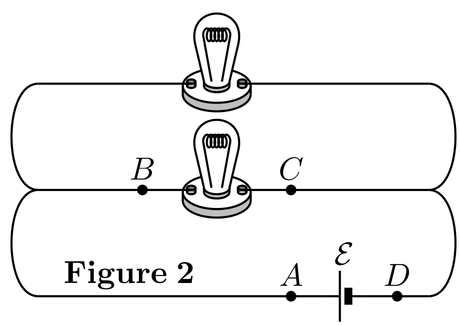
032 (part 3 of 8) 10.0 points

Two light bulbs and a battery are connected as in Figure 2.



Compare the current through A in Figure 2 to the current through A in Figure 1.

1. None of these

2. The current through A is now twice as large as before. **correct**

3. The current through A is now half as large as before.

4. The current through A is now the same as before.

5. The current through A is now larger than before but not twice as large.

6. The current through A is now smaller than before but not half as large.

Explanation:

The two bulbs are connected in parallel, so the effective resistance is half of one bulb's resistance, and

$$I_A = \frac{\mathcal{E}}{R_{eff}} = 2\,\frac{\mathcal{E}}{R}\,,$$

where R is the resistance of one bulb.

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033 (part 4 of 8) 10.0 points

Compare the brightness of the bulb BC in Figure 2 to what it was in Figure 1.

1. The bulb is brighter than it was before.

2. The bulb is dimmer than it was before.

3. The bulb is just as bright as before. **correct**

Explanation:

$V_{BC} = \mathcal{E}$, the same as in Figure 1.

---

034 (part 5 of 8) 10.0 points

Compare the potential difference across the bulb BC in Figure 2 to what it was in Figure 1.

1. The potential difference is now the same as before. **correct**

2. None of these

3. The potential difference is now smaller than before but not half as large.

4. The potential difference is now half as large as before.

5. The potential difference is now twice as large as before.

6. The potential difference is now larger than before but not twice as large.

Explanation:

$$P = \frac{V_{BC}^2}{R}\,.$$

Since the potential doesn't change, the power, as well as the brightness, will remain the same as in Figure 1.

---

035 (part 6 of 8) 10.0 points

Two light bulbs and a battery are connected as in Figure 3.

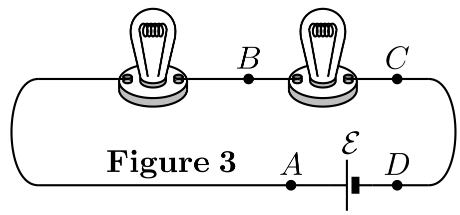


Figure 3

Compare the current through A in Figure 3 to the current through A in Figure 1.

1. The current through A is now half as large as before. **correct**

2. The current through A is now smaller than before but not half as large.

3. The current through A is now larger than before but not twice as large.

4. None of these

5. The current through A is now twice as large as before.

6. The current through A is now the same as before.

Explanation:

The two bulbs are connected in series, so R_{eff} is twice as the resistance of one bulb, and

$$I' = \frac{V}{R'} = \frac{V}{2\,R} = \frac{1}{2}\,\frac{V}{R} = \frac{1}{2}\,I\,.$$

---

036 (part 7 of 8) 10.0 points

Compare the potential difference across the bulb BC in Figure 3 to what it was in Figure 1.

1. The potential difference is now smaller than before but not half as large.

2. The potential difference is now larger than before but not twice as large.

3. The potential difference is now the same as before.

4. None of these

5. The potential difference is now twice as large as before.

6. The potential difference is now half as large as before. **correct**

Explanation:

In this case, the *emf* of the battery is shared by the two bulbs, so each one gets one half. From another point of view,

$$V_{BC} = I_{BC}\,R = \left(\frac{1}{2}\,I\right)\,R = \frac{1}{2}\,I\,R = \frac{1}{2}\,V\,.$$

---

037 (part 8 of 8) 10.0 points

Compare the brightness of the bulb BC in Figure 3 to what it was in Figure 1.

1. The bulb is dimmer than it was before. **correct**

2. The bulb is brighter than it was before.

3. The bulb is just as bright as before.

Explanation:

$$P = I^2\,R\,.$$

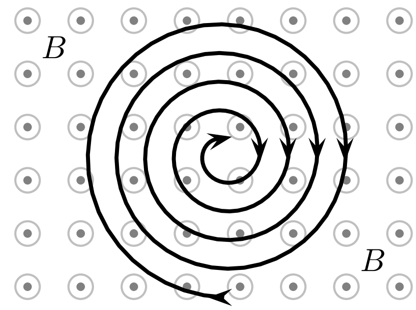
Since I is only one half as large as before, the power

$$P' = (I')^2\,R = \left(\frac{1}{2}\,I\right)^2\,R = \frac{1}{4}\,I^2\,R = \frac{1}{4}\,P\,,$$

so the bulb is dimmer.

Spiral Motion
038 10.0 points

A static uniform magnetic field is directed out of the page. A charged particle moves in the plane of the page following a clockwise spiral of decreasing radius as shown.



Neglect the effect due to gravity.

What is a reasonable explanation?

1. The charge is negative and slowing down.

2. The charge is negative and speeding up.

3. The charge is positive and speeding up.

4. The charge is neutral and speeding up.

5. The charge is positive and slowing down. **correct**

6. The charge is neutral and slowing down.

7. The charge is negative and with a constant speed.

8. None of these

9. The charge is positive and with a constant speed.

10. The charge is neutral and with a constant speed.

Explanation:

We know that when a charged particle moves in a uniform magnetic field with a constant speed, it undergoes a circular motion with the centripetal force provided by the magnetic force, namely

$$m\,\frac{v^2}{r} = q\,v\,B\,,$$

so we know that the radius is in fact proportional to the speed,

$$r = \frac{m}{q\,B}\,v\,.$$

Since the particle follows a spiral of decreasing radius, we can judge that it is slowing down.

The magnetic force $\vec{F} = q\,\vec{v} \times \vec{B}$ must be in the direction for the centripetal force $-\hat{r}$ (pointed inward) of this particle in clockwise circular motion. Since $\vec{v} \times \vec{B}$ is in the negative $\hat{r}$ direction, the particle has a positive charge.

Vertical Flat Mirror
039 10.0 points

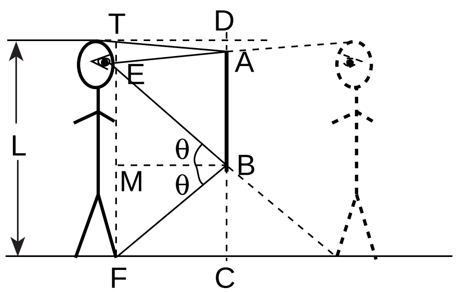
Hint: A ray diagram would be helpful.

Determine the minimum height of a vertical flat mirror in which a person 76 in. in height can see his or her full image.

Correct answer: 38 in..

Explanation:

In the figure, the mirror is labeled AB. A ray from the woman's foot F strikes the bottom of the mirror at B, with an angle equal to θ and proceeds to the woman's eye.



The two right triangles EBM and FBM are identical, since they share the common side MB and angle θ. Therefore

$$EM = MF = \frac{1}{2}EF$$

which is also the distance BC. Similarly, a ray from the top of the woman's head T strikes the top of the mirror at A and proceeds to her eye. The same line of reasoning as above leads to the conclusion that

$$DA = \frac{1}{2}TE$$

Thus the length AB of the mirror is $\frac{1}{2}(TE + EF)$, which is one half the woman's height. Note that the mirror's bottom edge must be exactly $\frac{1}{2}EF$ from the floor for a full-height image to be possible. Note also that the conclusions reached here are valid regardless of how far she stands from the mirror.

Conceptual 14 Q03
040 (part 1 of 4) 10.0 points

Consider two waves traveling through the same medium in the same time frame.

Compare the wavelengths.

1. B has the longer wavelength.
2. A and B have the same wavelength.
3. A has the longer wavelength. **correct**
4. Cannot be determined

Explanation:

A exhibits three complete wavelengths in the same time that B exhibits five complete wavelengths, so A has a longer wavelength.

---

041 (part 2 of 4) 10.0 points

Compare the amplitudes.

1. A and B have the same amplitude.
2. A has the smaller amplitude.
3. Cannot be determined
4. B has the smaller amplitude. **correct**

Explanation:

The vertical distance between the troughs and peaks of A is greater, so it has the larger amplitude.

042 (part 3 of 4) 10.0 points

Compare the frequencies.

1. A and B have the same frequency.

2. B has the higher frequency. **correct**

3. Cannot be determined

4. A has the higher frequency.

Explanation:

$$v = \lambda\, f$$
$$f = \frac{v}{\lambda}\,.$$

Since the speeds are the same and A has a longer wavelength λ, then A must have the lower frequency.

043 (part 4 of 4) 10.0 points

Compare the periods.

1. Cannot be determined.

2. B has the shorter period. **correct**

3. A has the shorter period.

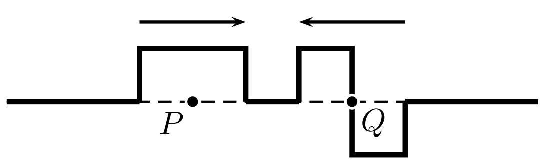
4. A and B have the same period.

Explanation:

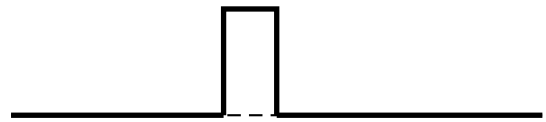
$T = \dfrac{1}{f}$. Since A has a lower frequency, its period must be larger.

AP B 1993 MC 59
044 10.0 points

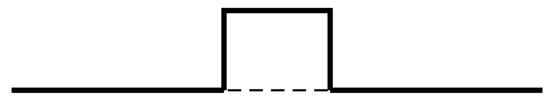
The figure shows two wave pulses that are approaching each other.

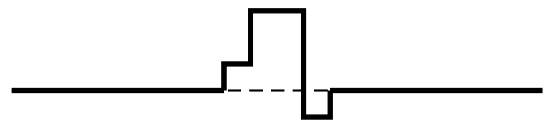


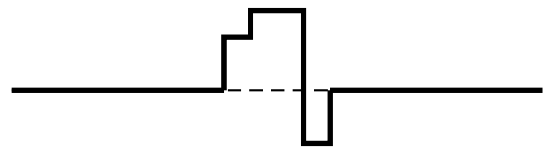
Which of the following best shows the shape of the resultant pulse when the centers of the pulses, points P and Q, coincide?

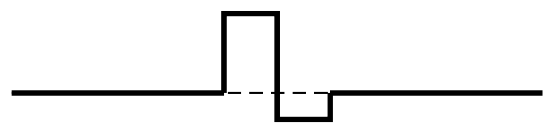
1.


correct

2.


3.


4.


5.


Explanation:

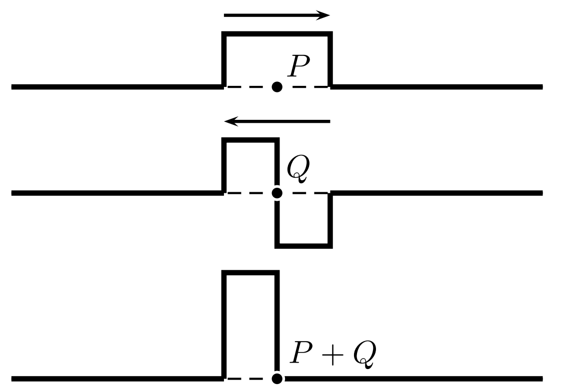
Notice that the two pulses have the same width and amplitude.

Choosing the the point P (the same as point Q when the two pulses coincide) as the origin, the two pulses can be described as:

$$P: \quad y_1 = \quad A \quad , -d \le x \le d$$
$$Q: \quad y_2 = \begin{cases} A & , -d \le x < 0 \\ -A & , \quad 0 < x < d \end{cases}$$

Using the principle of superposition, the resultant pulse is

$$y = y_1 + y_2 = \begin{cases} 2\,A & , -d \le x < 0 \\ 0 & , \quad 0 < x < d \end{cases}$$



Waves in a Pond
045 10.0 points

A rock dropped into a pond produces a wave that takes 14.4 s to reach the opposite shore, 24.7 m away. The distance between consecutive crests of the wave is 3.7 m.

What is the frequency of the wave?

Correct answer: 0.463589 Hz.

Explanation:

$$\begin{aligned} \text{Let :}\quad & t = 14.4\ \text{s}\,, \\ & d = 24.7\ \text{m}\,, \quad \text{and} \\ & \lambda = 3.7\ \text{m}\,. \end{aligned}$$

The wavelength λ is the distance d_1 between consecutive crests, so

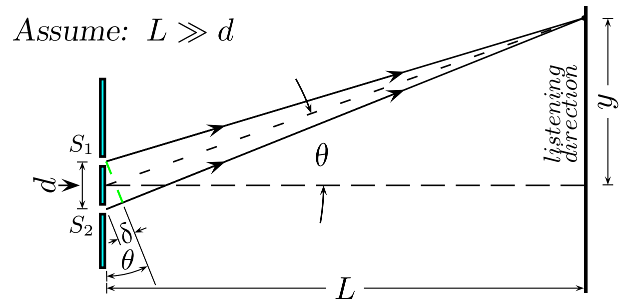
$$v = f\,\lambda = \frac{d}{t}$$

$$f = \frac{d}{t\,\lambda} = \frac{(24.7\ \text{m})}{(14.4\ \text{s})\,(3.7\ \text{m})} = \boxed{0.463589\ \text{Hz}}\,.$$

keywords:

Tipler PSE5 16 37
046 (part 1 of 2) 10.0 points

Two sound sources radiating in phase at a frequency of 490 Hz interfere such that maxima are heard at angles of 0° and 26° from a line perpendicular to that joining the two sources.

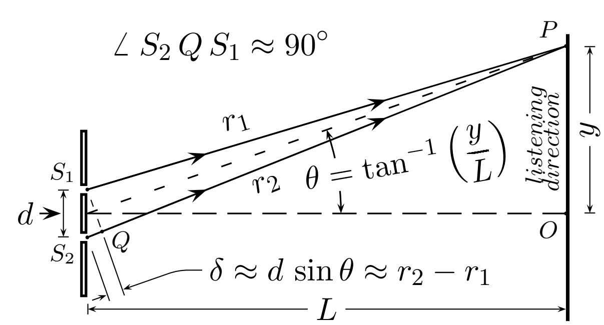


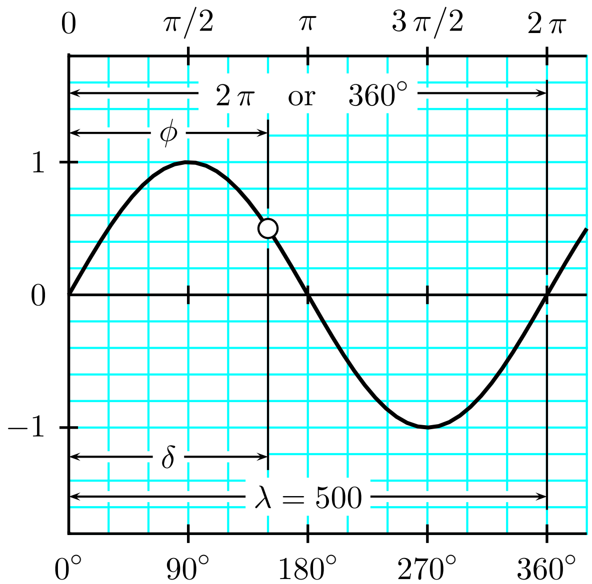
Find the separation between the two sources. The velocity of sound is 340 m/s.

Correct answer: 1.58285 m.

Explanation:

$$\begin{aligned} \text{Let :}\quad f &= 490\ \text{Hz}\,, \\ v &= 340\ \text{m/s}\,, \\ \theta_1 &= 0^\circ\,, \quad \text{and} \\ \theta_2 &= 26^\circ\,. \end{aligned}$$





$$\frac{\phi}{2\pi} = \frac{\delta}{\lambda} = \frac{d\sin\theta}{\lambda} = \frac{d}{\lambda}\,\frac{y}{\sqrt{L^2+y^2}} \approx \frac{d}{\lambda}\,\frac{y}{L}$$

Because a maximum is heard at 0° and the sources are in phase, we can conclude that the path difference is 0. Because the next maximum is heard at 26°, the path difference to that position must be one wavelength:

$$\sin\theta = \frac{\Delta s}{d}$$

$$d = \frac{\lambda}{\sin\theta} = \frac{v}{f\sin\theta} = \frac{340\text{ m/s}}{(490\text{ Hz})\sin 26^\circ} = \boxed{1.58285\text{ m}}.$$

---

047 (part 2 of 2) 10.0 points

Find the next larger angle at which a maximum intensity will be heard.

Correct answer: 61.2519°.

Explanation:

For additional intensity maxima,

$$d\sin\theta_m = m\lambda, \quad m = 2, 3, 4, \ldots$$

$$\theta_m = \sin^{-1}\left(\frac{m\lambda}{d}\right), \quad m = 2, 3, 4, \ldots$$

The next angle is for $m = 2$:

$$\theta_{m=2} = \sin^{-1}\left(\frac{m\lambda}{d}\right) = \sin^{-1}\left(\frac{m\,v}{f\,d}\right)$$

$$= \sin^{-1}\left[\frac{2\,(340\text{ m/s})}{(490\text{ Hz})\,(1.58285\text{ m})}\right] = \boxed{61.2519^\circ}.$$

Conceptual 15 Q13

048 (part 1 of 2) 10.0 points

A pure tone with frequency 500 Hz is played through two stereo speaker plugged into the same jack. As you walk around the room, you notice that the loudness of the sound alternates from loud to soft repeatedly.

What is happening?

1. The waves are moving away from you.

2. You are hearing constructive interference.

3. You are experiencing alternating regions of constructive and destructive interference. **correct**

4. You are hearing destructive interference.

5. None of these

Explanation:

You are experiencing alternating regions of constructive and destructive interference.

---

049 (part 2 of 2) 10.0 points

Would anything be different if a 1000 Hz sound wave were used instead?

I) The wavelength becomes shorter
II) the distance between regions of interference is smaller
III) the distance between regions of interference is larger
IV) The wavelength becomes longer

1. I and II only **correct**

2. I and IV only

3. None of these

4. I and III only

5. II and IV only

Explanation:

If a 1000 Hz wave were used, the wavelength would be shorter, and the distance between regions of destructive and constructive interference would be smaller.

Diamond Critical Angle
050 10.0 points

The smallness of the critical angle θ_c for diamond means that light is easily "trapped" within a diamond and eventually emerges from the many cut faces. This makes a diamond more brilliant than stones with smaller n and larger θ_c. Traveling inside a diamond, a light ray is incident on the interface between diamond and air.

What is the critical angle for total internal reflection? The refraction index for diamond is 2.37 .

Your answer must be within ± 0.1%
Correct answer: 24.9572°.

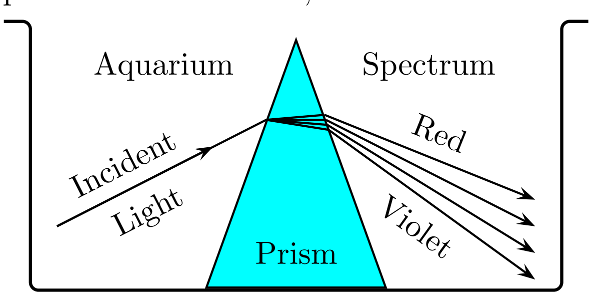
Explanation:

For diamond, the critical angle is

$$\sin\theta_c = \frac{1}{n} = \frac{1}{2.37}$$
$$\theta_c = 24.9572^\circ\,.$$

AP B 1998 MC 42
051 10.0 points

A beam of white light is incident on a triangular glass prism with an index of refraction of about 1.5 for visible light, producing a spectrum. Initially, the prism is in a glass aquarium filled with air, as shown.



If the aquarium is now filled with water, with an index of refraction of 1.3, which of the following is true?

1. Violet light will not emerge from the prism.

2. Red light will not emerge from the prism.

3. The spectrum has the same separation between red and violet as that produced in air.

4. The spectrum produced has less separation between red and violet than that produced in air. **correct**

5. No spectrum is produced.

6. The positions of red and violet are reversed in the spectrum.

7. A spectrum is produced, but the deviation of the beam is opposite to that seen in air.

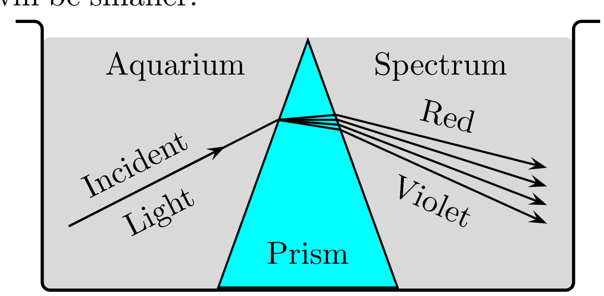
8. There is no light seen coming out of the prism.

9. The intensity of the light emerging increases.

10. The spectrum produced has greater separation between red and violet than that produced in air.

Explanation:

Since water has a larger index of refraction than air (but still smaller than the glass prism), the dispersion and deviation of the emerging light beam, caused by refraction, will be smaller.



Thus, the spectrum produced has less separation between red and violet than that produced in air.

Conceptual 20 02
052 10.0 points

If the speed of light through material Z is 2.5×10^8 m/s, what is this material's index of refraction? The speed of light in a vacuum is 3×10^8 m/s.

Correct answer: 1.2.

Explanation:

$$\text{Let :} \quad v = 2.5 \times 10^8 \text{ m/s} \quad \text{and}$$
$$c = 3 \times 10^8 \text{ m/s}\,.$$

$$\begin{aligned} n &= \frac{c}{v} \\ &= \frac{3 \times 10^8 \text{ m/s}}{2.5 \times 10^8 \text{ m/s}} \\ &= \boxed{1.2}\,. \end{aligned}$$

Concept 28 E09
053 10.0 points

A person in a dark room looking through a window can clearly see a person outside in the daylight.

Why can the person outside not see the person inside?

1. People inside the room are more sensitive to light than people outside.

2. Light is easier to transmit into the room than transmit out.

3. Window glass typically transmits about 92% of incident light, and the two surfaces reflect about 8%.

4. The reflected outside light is more intense than the inside light transmitted out. **correct**

Explanation:

A window both transmits and reflects light. Window glass typically transmits about 92% of incident light, and the two surfaces reflect about 8%. Percentage is one thing, total amount is another. The person outside in the daylight who looks at the window of a room sees 8% of the outside light reflected back and 92% of the inside light transmitted out; 8% of the bright outside light overpowers 92% of the dim inside light. On the other hand, a person inside a dark room receives 92% of the bright outside light and 8% of the dim, inside light and easily sees out.

AP B 1998 MC 27
054 10.0 points

When light passes from air into water, the frequency of the light remains the same.

What happens to the speed and the wavelength of the light as it crosses the boundary in going from air into water?

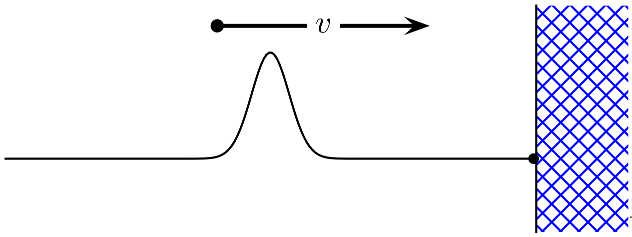
	Speed	Wavelength
1.	Decreases	Increases
2.	Decreases	Decreases **correct**
3.	Remains the same	Decrease
4.	Increases	Remains the same
5.	Remains the same	Remains the same

Explanation:

The speed of light in water is less than that in air. Since $\lambda = \dfrac{v}{f}$, the wavelength in water is also less than that in air. So both speed and wavelength decrease when the light goes from air into water.

AP B 1998 MC 29
055 10.0 points

One end of a horizontal string is fixed to a wall. A transverse wave pulse in the form of a crest is generated at the other end and moves toward the wall, as shown. Consider the pulse after it has been reflected by the wall.



What is/are correct concerning the **reflected pulse**?

A) The reflected pulse forms a crest.
B) The reflected pulse has a greater speed than that of the incident pulse.
C) The reflected pulse forms a valley.
D) The reflected pulse has a greater amplitude than that of the incident pulse.

1. B and D only

2. C only **correct**

3. A, B and D only

4. D only

5. B only

6. A and C only

7. A and B only

8. B and C only

9. A and D only

10. A only

Explanation:

The speed of the pulse is determined by the tension of the string and the mass per unit length, and is the same for the incident and reflected pulses.

The reflected pulse cannot have an amplitude greater than that of the incident pulse, since no energy is added to the pulse at the wall.

There is a phase shift of π at the wall, because the end fixed at the wall cannot move, so the reflected pulse is on the opposite side of the string from the incident pulse, forming a valley.

Incident crests reflect as valleys, and vice versa.

Ray and Its Wave Front
056 (part 1 of 2) 10.0 points

A ray always intersects its wave front at right angle.

1. True **correct**

2. False

Explanation:

$$\frac{\lambda_1}{\lambda_2} = \frac{n_2}{n_1}$$

A ray is defined to be perpendicular to the wave front.

---

057 (part 2 of 2) 10.0 points

Wave fronts are closer together where the index of refraction is smaller.

1. True

2. False **correct**

Explanation:

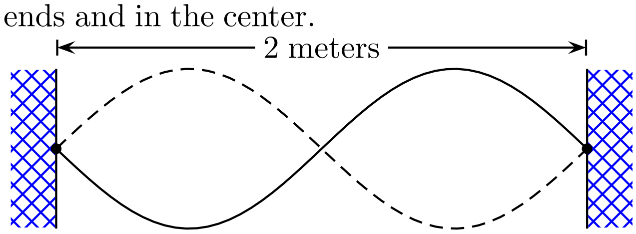
If $n_2 > n_1$, then

$$\frac{\lambda_2}{\lambda_1} = \frac{n_1}{n_2} < 1 \Longrightarrow \lambda_2 < \lambda_1$$

Wave fronts are closer together where the wave length λ is smaller. Thus, wave fronts are closer where the index of refraction is greater.

AP B 1993 MC 27 28
058 (part 1 of 2) 10.0 points

A standing wave of frequency 5 hertz is set up on a string 2 meters long with nodes at both ends and in the center.



Find the speed at which waves propagate on the string.

1. 10 m/s **correct**

2. 2.5 m/s

3. 5 m/s

4. 0.4 m/s

5. 20 m/s

Explanation:

$$\text{Let :}\quad f = 5\,\text{Hz} \quad \text{and}$$
$$\lambda = 2\,\text{m}\,.$$

The wavelength is $\lambda = 2$ m, so the wave speed is

$$|\vec{v}| = f\,\lambda = (5\text{ Hz})(2\text{ m}) = \boxed{10\text{ m/s}}.$$

---

059 (part 2 of 2) 10.0 points

Find the fundamental frequency of vibration of the string.

1. 10 Hz

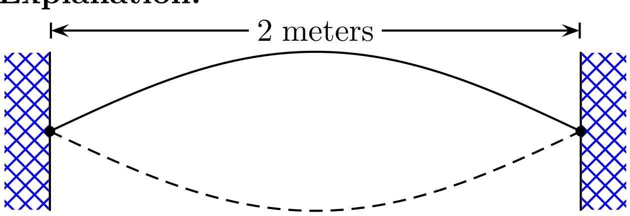
2. 2.5 Hz **correct**

3. 1 Hz

4. 5 Hz

5. 7.5 Hz

Explanation:



The fundamental wave has only two nodes at the ends, so its wavelength is $\lambda = 4$ m and the fundamental frequency is

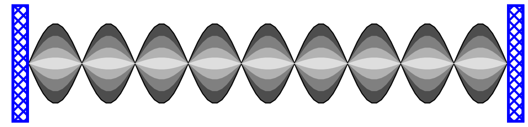
$$f = \frac{v}{\lambda} = \frac{10\text{ m/s}}{4\text{ m}} = \boxed{2.5\text{ Hz}}.$$

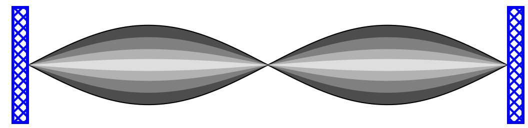
Wavelength 01

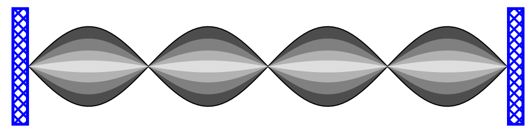
060 10.0 points

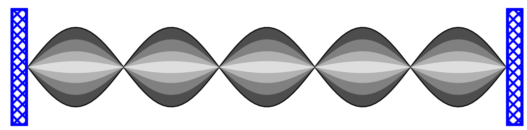
Consider standing waves on a string of length 96 cm.

Which wave has a wavelength 38.4 cm?

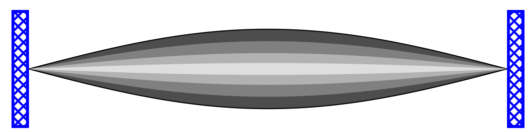
1. 

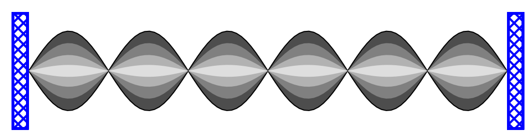
2. 

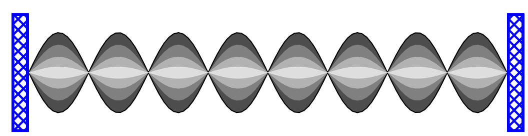
3. 

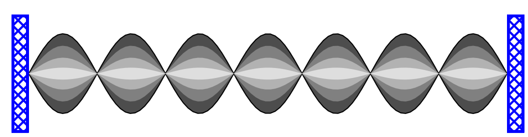
4. 

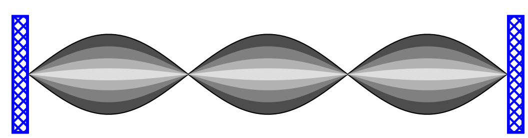
correct

5. 

6. 

7. 

8. 

9. 

Explanation:

$$\text{Let :}\quad L = 96\text{ cm} \quad \text{and}$$
$$\lambda = 38.4\text{ cm}\,.$$

A standing wave on a string has nodes where the string does not vibrate; these nodes are spaced half-wavelengths from each other, so

$$L = n\left(\frac{\lambda}{2}\right), \quad n = 1, 2, 3, \ldots,$$

where n is the number of vibrating segments of the string. More precisely, the wave on the string has

$$n = \frac{2\,L}{\lambda} = \frac{2\,(96\text{ cm})}{38.4\text{ cm}} = 5$$

antinodes and 6 nodes: one node at each end, and 4 in the middle.