A Styrofoam cup is hanging by a thread. A person wants to know if the cup is charged. The person brings a charged object near the cup. The object attracts the cup. Is the cup necessarily charged?

a) Yes.
b) No.
c) The cup would never be attracted.

A Styrofoam cup is hanging by a thread. A person wants to know if the cup is charged. The person brings a charged object near the cup. The object repels the cup. Is the cup necessarily charged?

a) Yes.
b) No.
c) The cup would never be repelled.

A charged Styrofoam cup is hanging by a thread. A person touches the cup with an initially-neutral metal ball (on the end of a neutral quartz rod that serves as a handle). What happens to the cup?

a) It is only attracted to the ball.
b) It is only repelled by the ball.
c) It is first (prior to contact) attracted to, and then repelled by, the ball.
d) It is neither attracted to, nor repelled by, the ball.
e) It is first (prior to contact) attracted to the ball. What happens after contact depends on how much charge is transferred as a result of that contact.

A charged comb is brought near a neutral scrap of paper. Is the paper attracted to the comb? If so, why?

a) **No.**
b) **Yes. The paper becomes polarized, meaning it takes on the charge opposite that of the comb, and opposites attract.**
c) **None of the above.**

(Demo) I rub a rubber rod with animal fur, bring the rod near one side of a metal ball while the other side is in contact with an electrical outlet metal cover plate, and, keeping the rod close to the ball (but never touching) move both away from the plate. Then I move the ball away from the rod. What kind of charge does the ball have after all this?

a) Positive.
b) Negative.
c) None of the above.

(Demo) I touch a negatively-charged rubber rod to the ball of an electroscope. The leaves spread out and remain spread out. Now I bring a metal ball near the ball of the electroscope. The leaves become less spread out when the ball is near, and then resume their earlier spread-out position when the metal ball is retracted. Can one conclude that the metal ball has positive charge?

a) Yes.

b) No.

Is it possible to use a charged object to charge another object by induction such that the newly-charged object has the same kind of charge as the originally-charged object?

a) Yes.
b) No.

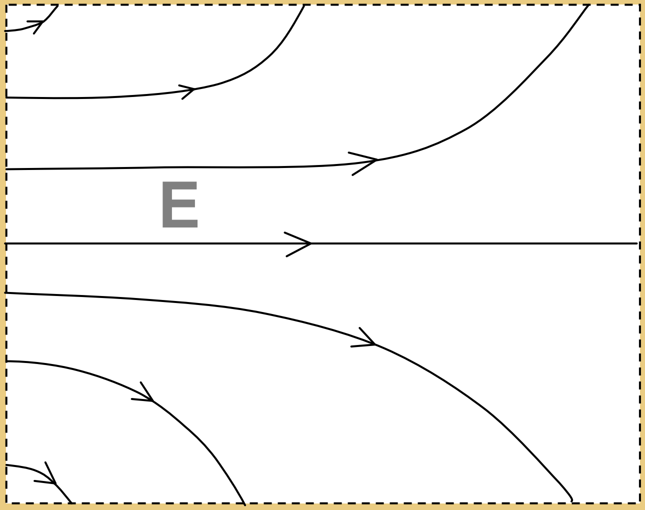
A spherical object having a positive charge of a billion coulombs is in the vicinity of a proton (a particle that has a positive charge of 1.6×10^{-19} coulombs). Which object exerts the greater electrostatic force on the other?

a) The spherical object.

b) The proton.

c) Neither.

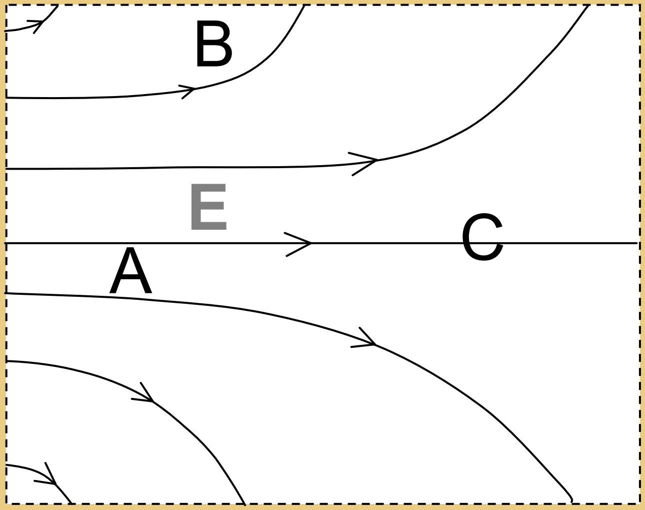
Depicted at right is the electric field in a region of space. In that region of space, is the electric field uniform?



a) Yes

b) No

Depicted at right is the electric field in a region of space. Among the three labeled points, where is the electric field strongest?

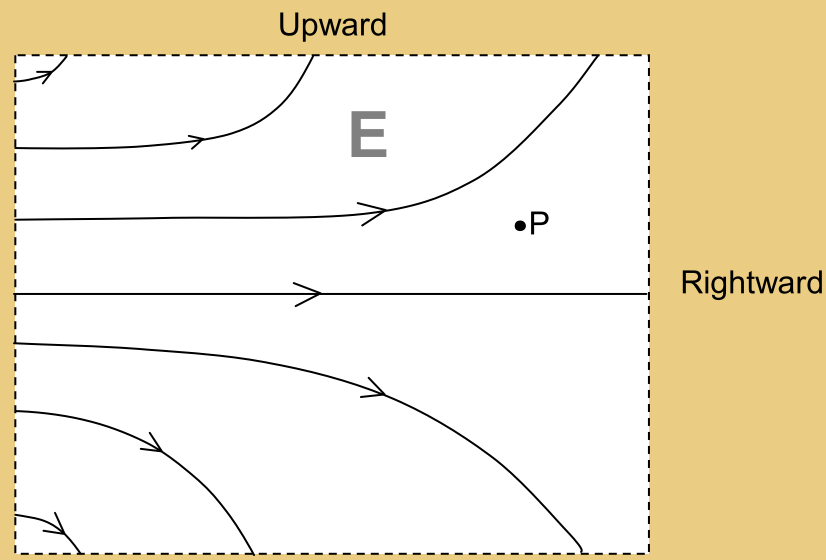


a) A

b) B

c) C

Depicted at right is the electric field in a region of space. What is the direction of the electric field at point P?

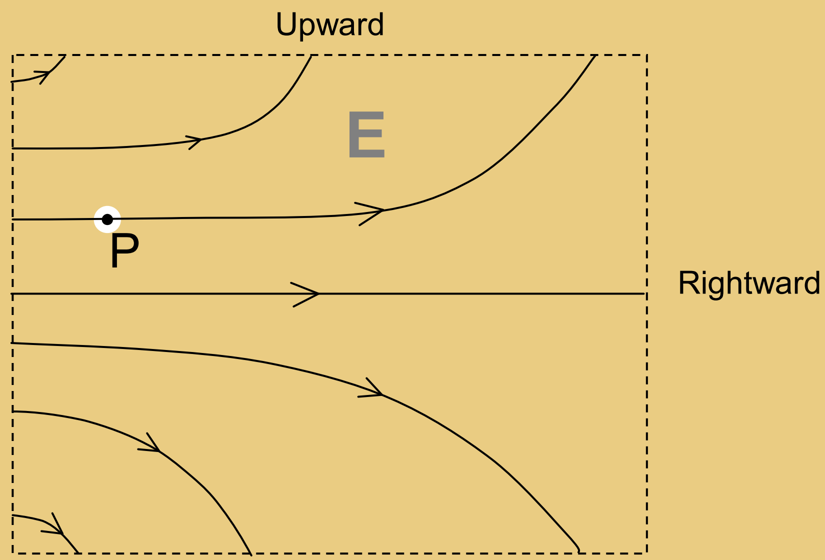


a) Up and to the right.

b) Down and to the left.

c) There is no electric field at point P.

Suppose that a positively charged particle is released from rest at point P. Will the particle move along the electric field line on which it lies?



a) Yes. It will stay on the "line".

b) No. It will depart from the "line".

A student states that the motion of a positively charged particle in a uniform electric field is essentially the same as projectile motion near the surface of the earth. Is the student correct?

a) Yes.

b) No.

At time zero, a negatively charged particle is moving rightward in a uniform, rightward-directed, electric field. It is always in the uniform electric field. Describe the subsequent motion of the particle.

a) It moves rightward at an ever decreasing speed until it achieves, just for an instant, a speed of zero. Then it starts moving leftward at an ever increasing speed.

b) It moves rightward at an ever increasing speed.

Two charged particles of opposite charge are placed in a uniform, rightward, external electric field and released from rest. Assuming no forces act on the particles other than the electrostatic force, is it possible for the particles to accelerate away from each other?

a) No. Unlike charges attract.

b) Yes. Unlike charges repel.

c) Yes, if the positive particle is to the right of the negative particle.

d) Yes, if the positive particle is to the left of the negative particle.

The effect of an electric field is to exert a force on any charged particle that finds itself at a point in space at which the electric field exists.

a) True

b) False

The direction of the electric field at a point in space is the direction of the force that would be exerted on any charged particle that might find itself at that point in space.

a) True

b) False

The electric field is a vector field.

a) True.

b) False.

The electric field is a vector.

a) True.

b) False.

Is the electric field a characteristic of a particle or is it a characteristic of space?

a) Particle.

b) Space.

Can an electric field exist in the absence of a charged particle for it to exert a force on?

a) Yes.

b) No.

Assuming no force besides that due to the electric field, is it possible for a charged particle to be in an external electric field without its kinetic energy changing?

a) Yes.

b) No.

At time zero, a charged particle is moving in an electric field. (No force other than that of the electric field acts on the particle.) Is it possible for the particle to, at some later time, have the same kinetic energy as it had at time zero?

a) Yes.

b) No.

Assuming no force besides that due to the electric field is it possible for a charged particle to be in an external electric field without its momentum changing?

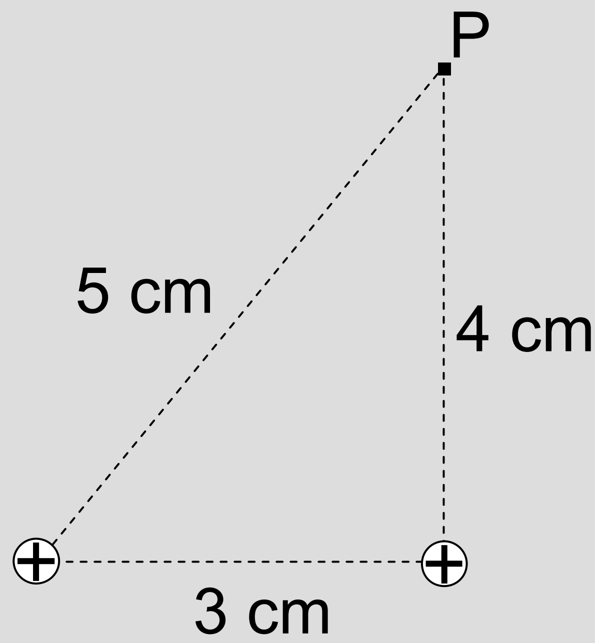
a) Yes.

b) No.

Given a uniform electric field, if we put a positive point charge in it, the electric field is changed. The new electric field, at each point in space, is the vector sum of the original electric field vector at that point in space and the electric field vector, at that point in space, due to the point charge. So why would the point charge experience a constant acceleration to the right?

a) **It wouldn't. The new total electric field is not uniform.**
b) **The point charge would be a test charge. A test charge does not produce an electric field.**
c) **The electric field due to a positive point charge, does not exert a force on the positive point charge itself.**

In calculating the electric field at point P due to the two positive point charges, what distance does one not substitute into the expression for the electric field due to a point charge.

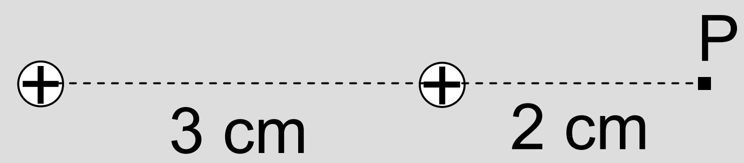


a) 3 cm

b) 4 cm

c) 5 cm

In calculating the electric field at point P due to the two positive point charges, what distance does one not substitute into the expression for the electric field due to a point charge.



a) 2 cm

b) 3 cm

c) 5 cm

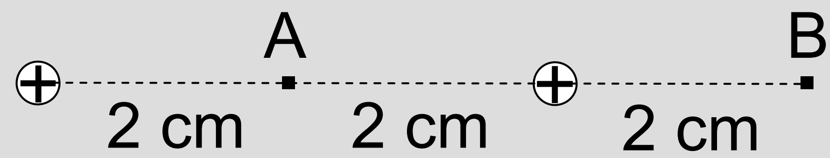
In calculating the electric field at point P due to the two positive point charges, what distance does one <u>not</u> substitute into the expression for the electric field due to a point charge.

a) 1 cm

b) 2 cm

c) 4 cm

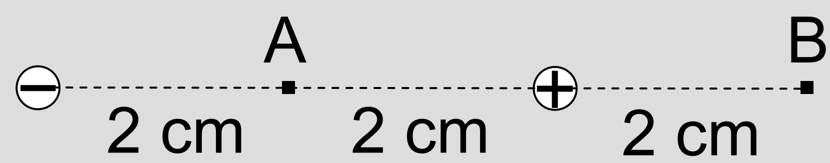
At which point in space is the magnitude of the electric field due to the two particles, having one and the same charge, greater?



a) Point A

b) Point B

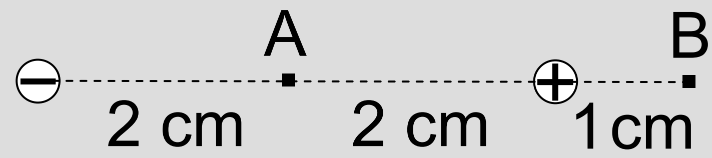
At which point in space is the magnitude of the electric field due to the two particles, having equal but opposite charge, greater?



a) Point A

b) Point B

At which point in space is the magnitude of the electric field due to the two point charges, having equal but opposite charge, greater?



a) Point A

b) Point B

A positively charged particle is fixed at a point in space by means not specified. A second positively charged particle is released from rest at a point in the vicinity of the first one. Does the second particle experience constant acceleration subsequent to its release?

a) Yes.

b) No.

Particle number 2, having charge +0.001 C, is due north of particle number 1 which has charge -0.001 C. Which of the following best characterizes the direction of the electric field at a point in space that is due east of particle number 1?

a) Northeasterly

b) Southeasterly

c) Southwesterly

d) Northwesterly

Relative to the effort it would take to thoroughly read the chapter once, how much effort did you put into doing the reading assignment?

a) 0-20%

b) 20-50%

c) 50-90%

d) 90-110%

e) 110-150%

f) 150-200%

g) >200%

Consider a thin spherical shell of radius 9.0 cm made of a perfectly conducting material centered on the origin of a Cartesian coordinate system. Two charged particles lie outside the ball on the x-axis of the same coordinate system: a particle with –5.0 microcoulombs of charge at x = –11 cm and a particle with charge +5.5 microcoulombs of charge at x = +11 cm. What is the direction of the electric field at the origin.

a) **The electric field is in the +x direction at the origin.**
b) **The electric field is in the –x direction at the origin.**
c) **The electric field is 0 at the origin. It has no direction.**

1.00 Coulomb of charge is placed on a solid sphere made of a perfectly conducting material. Find the magnitude of the electric field at a distance of 1.00 meters from the center of the sphere. Assume the radius of the sphere to be less than 1.00 meters

a) 8.99 x 10^9 N/C

b) 1.00 N/C

c) 0.00 N/C

d) None of the above.

Why is the interior of a car considered to be a good place to be during a thunder storm?

a) A typical car is a good approximation to a conducting shell. Inside a conducting shell, the electric field is zero.

b) A typical car is a good approximation to a conducting shell. Inside a conducting shell, the electric field is uniform (but not zero).

Consider an empty spherical gold shell having an inner radius 25.0 cm and thickness 1.5 mm (and hence an outer radius of 26.5 cm) and a charge of +2.40 μC. What is the direction of the electric field at a point on the interior surface of the sphere?

- **a) Radially inward (toward the center of the sphere).**
- **b) Radially outward.**
- **c) There is no direction because the electric field is zero.**

Consider an empty spherical gold shell having an inner radius 25.0 cm and thickness 1.5 mm (and hence an outer radius of 26.5 cm) and a charge of +2.40 μC. What is the direction of the electric field at a point 1 nm inside the outer surface of the sphere?

a) Radially inward (toward the center of the sphere).

b) Radially outward.

c) There is no direction because the electric field is zero.

Consider an empty spherical gold shell having an inner radius 25.0 cm and thickness 1.5 mm (and hence an outer radius of 26.5 cm) and a charge of +2.40 μC. What is the direction of the electric field at a point 1 nm outside the outer surface of the sphere?

a) Radially inward (toward the center of the sphere).

b) Radially outward.

c) There is no direction because the electric field is zero.

Suppose you calculate a force using $\vec{\mathbf{F}}=q\vec{\mathbf{E}}$ and then use that force in Newton's 2nd Law to calculate an acceleration. For the latter step, what kind of diagram is required?

a) A before and after picture.
b) A free body diagram.
c) No diagram at all.

What is wrong with the following expression?

$$\vec{\mathbf{E}} = 15\ \frac{\mathrm{N}}{\mathrm{C}}$$

a) The quantity on the left is a vector whereas the quantity on the right is a scalar. A non-zero vector cannot be equal to a scalar.

b) Nothing.

What is wrong with the following expression?

$$E = 15\ \frac{\mathrm{N}}{\mathrm{C}}\ \text{Westward}$$

a) The quantity on the left is a vector whereas the quantity on the right is a scalar.

b) The quantity on the left is a scalar whereas the quantity on the right is a vector.

c) Nothing.

What is wrong with the following expression?

$$\vec{\mathbf{E}} = 15\,\frac{\mathrm{N}}{\mathrm{C}}\ \ \text{Southward}$$

a) The quantity on the left is a vector whereas the quantity on the right is a scalar. A non-zero vector cannot be equal to a scalar.

b) Nothing.

What is wrong with the following expression?

$$E = 15\ \frac{\mathrm{N}}{\mathrm{C}}$$

a) The quantity on the left is a vector whereas the quantity on the right is a scalar.

b) The quantity on the left is a scalar whereas the quantity on the right is a vector.

c) Nothing.

Suppose, during a test, you need the mass or charge of an electron or proton. Where do you find it?

a) One doesn't "find" any of these values. They have to be memorized.

b) One finds the masses and the value of e, in coulombs, on the formula sheet. One has to know that the charge of a proton is +1e and the charge of an electron is –1e.

The following experiment is carried out in vacuum in a weightless environment. An astronaut is holding onto one end of a massless uncharged string. On the other end of the string is a plastic ball having a charge of 1.0 coulombs. The electric potential due to an unspecified distribution of charge (not including that of the ball), at the location of the ball, is 100 volts. The ball is at rest. The astronaut pulls the ball 1 meter toward herself. It takes her 25 joules of work to do so. After doing so, the ball is again at rest. What is the electric potential at the new location of the ball. (Again we are talking about the electric potential due to the unspecified charge distribution, not due to the charge on the ball.)

a) 0 volts **c) Some value between 0 and 25 volts**

b) 25 volts **d) None of the above.**

What causes an electric potential to exist in a region of space?

a) A charged particle or distribution of charged particles.

b) A conductor.

c) An insulator.

d) None of the above.

If, using the definition of work (force along the path times the length of the path), you find that the work done on a particle with charge +1 μC by the electric field it is in, as the particle moves from point A, where the electric potential is 10 volts, to point B, is 4 μJ, what is the electric potential at point B?

a) 4 volts

b) 6 volts

c) 14 volts

d) None of the above.

What happens to the kinetic energy of a proton that moves from a point in space where the electric potential (due to an unspecified charge distribution) is 75 V to a point in space where the electric potential is 15 V (with no force on it other than that of the electric field characterized by the electric potential in question)?

a) That can’t happen.
b) It increases.
c) It decreases.
d) It stays the same.

What happens to the kinetic energy of a proton that moves from a point in space where the electric potential (due to an unspecified charge distribution) is **15 V** to a point in space where the electric potential is **75 V** (with no force on it other than that of the electric field characterized by the electric potential in question)?

a) That can’t happen.
b) It increases.
c) It decreases.
d) It stays the same.

What happens to the kinetic energy of **an electron** that moves from a point in space where the electric potential (due to an unspecified charge distribution) is 15 V to a point in space where the electric potential is 75 V (with no force on it other than that of the electric field characterized by the electric potential in question)?

a) That can’t happen.
b) It increases.
c) It decreases.
d) It stays the same.

What happens to the kinetic energy of an electron that moves from a point in space where the electric potential (due to an unspecified charge distribution) is **75 V** to a point in space where the electric potential is **15 V** (with no force on it other than that of the electric field characterized by the electric potential in question)?

a) That can’t happen.
b) It increases.
c) It decreases.
d) It stays the same.

A particle moves from a point in space at which the electric potential is 250 volts to another point in space where the electric potential is 250 volts. The particle is moving faster at the new location. Which one of the following must be the case?

a) The particle must be positively charged.
b) The particle must be negatively charged.
c) The particle must be neutral.
d) None of the above.

A positively charged particle is on the end of a neutral quartz rod. A person has the other end of the rod in her hand. She moves the particle in one direction along a line which is everywhere collinear with an external electric field. Point B is midway between points A and C. It takes more work for her to move the particle from A to B then it does for her to move the particle from B to C. (In both cases it takes a positive amount of work.) Which point is at the highest potential?

a) A
b) B
c) C

A positively charged particle is on the end of a quartz rod. A person has the other end of the rod in her hand. She moves the particle in one direction along a line which is everywhere collinear with an external electric field. Point B is midway between points A and C. It takes more work for her to move the particle from A to B then it does for her to move the particle from B to C. Define $V_{AB} \equiv V_B - V_A$ and $V_{BC} \equiv V_C - V_B$. How does V_{AB} compare with V_{BC}?

a) $V_{AB} > V_{BC}$
b) $V_{AB} < V_{BC}$
c) $V_{AB} = V_{BC}$

A positively charged particle is on the end of a quartz rod. A person has the other end of the rod in her hand. She moves the particle in one direction along a line which is everywhere collinear with an external electric field. Point B is midway between points A and C. It takes more work for her to move the particle from A to B then it does for her to move the particle from B to C. (In both cases it takes a positive amount of work.) How does the average value of the magnitude of the **electric field** between A and B compare with the average value of the electric field between B and C?

a) It is greater between A and B.
b) It is greater between B and C.
c) It is the same.

A positively charged particle is on the end of a quartz rod. A person has the other end of the rod in her hand. She moves the particle in one direction along a line which is everywhere collinear with an external electric field. Point B is closer to point A than it is to point C. $V_{AB} = V_{BC}$. How does the average value of the magnitude of the electric field between A and B compare with the same quantity between B and C.

a) It is greater between A and B.

b) It is greater between B and C.

c) It is the same.

Consider two points in the vicinity of a positively-charged particle. Point A is closer to the particle than point B is.

At which empty point in space is the electric potential greater?

a) Point A

b) Point B

c) None of the above.

A negatively-charged particle is released from rest at a position that is a given distance from a positively-charged particle that is fixed in space. You are asked to find the speed of the negatively-charged particle when it arrives at a point closer to the positively charged particle. Is it okay to use one of the constant acceleration equations to solve this problem?

a) Yes

b) No

A positively-charged particle with charge q_1 is at the origin of a Cartesian coordinate system. A negatively-charged particle with charge q_2 ($|q_2| > q_1$) is at (12 cm, 0). Where on the x-y plane (besides at infinity) is the electric potential zero?

a) Only at one point, on the x axis, to the left of both.
b) Only at one point, on the x axis, between the two.
c) Only at one point, on the x axis, to the right of both.
d) At two points, both on the x axis. One between the two, and the other to the left of both.
e) There are an infinite number of points on the x-y plane at which $V = 0$.

Consider two positively-charged particles separated by a distance *d*. The particles are surrounded by empty space. Are there any points in space, besides at infinity, at which the electric *field*, due to the pair, is zero?

a) Yes

b) No

Consider two positively-charged particles separated by a distance *d*. The particles are surrounded by empty space. Are there any points in space, besides at infinity, at which the electric *potential*, due to the pair, is zero?

a) Yes

b) No

(Trick question?) What is the direction of the electric potential due to a negatively charged particle at a point in space in the vicinity of the negatively-charged particle?

a) Toward the particle.

b) Away from the particle.

c) None of the above.

What principle do you apply when asked to find the velocity of a charged particle that is released from rest near a fixed charge, when it is at a specified point other than the release point?

a) **Newton's Second Law and Constant Acceleration.**

b) **Conservation of Energy.**

c) **Conservation of Momentum.**

What principle do you apply when asked to find the acceleration of a charged particle that is at a point in space in the vicinity of a fixed charge?

a) Newton’s Second Law

b) Conservation of Energy.

c) Conservation of Momentum.

d) None of the above.

What kind of diagram is required whenever you apply Newton's 2nd Law in this class?

a) A Free Body Diagram.

b) None of the above.

What happens if you use r^2 in the denominator when calculating the electric potential due to a point charge (at any empty point in space a distance r from the point charge)?

a) You get it right.

b) You get it wrong.

What is the shape of an equipotential surface for a uniform electric field?

a) A flat sheet.

b) A box.

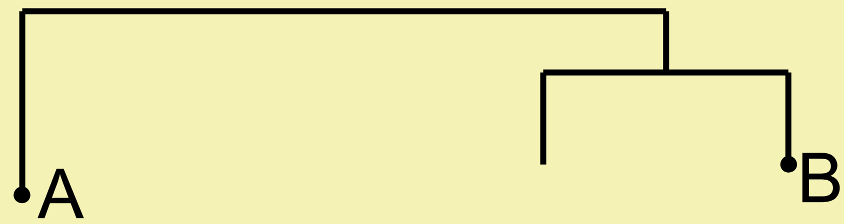
c) A shield.

d) An egg shell.

e) Insufficient information.

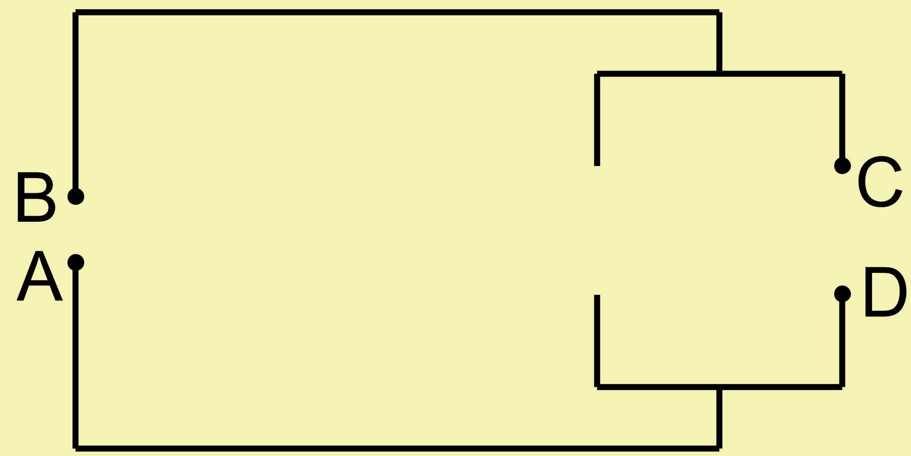
f) None of the above.

Depicted are some connected, perfectly-conducting wires under static conditions. A and B are points on the wires. How does the electric potential at B compare with the electric potential at A?



- **a) *V* at A is greater than *V* at B.**
- **b) *V* at A is the same as *V* at B.**
- **c) *V* at A is less than *V* at B.**
- **d) Not enough information is provided to determine how they compare.**
- **e) None of the above.**

Depicted are two sets of connected perfectly-conducting wires under static conditions. The potential at point B is 6 volts greater than the potential at point A. A particle of charge 1e is caused to move from point C to point D. What is the change in the electric potential energy of the particle?



a) **–6 eV**

b) **0**

c) **+6 eV**

d) **None of the above because the eV is not a unit of energy.**

Demo: I have a Ping-Pong ball and a rubber ball that is about the size of a baseball, each coated with conducting paint. I use a high voltage power supply to cause each, in relative isolation, to have a potential of 2400 volts. At that potential, which has more charge on it?

a) The Ping-Pong ball.

b) The rubber ball.

c) Neither.

Consider a charged capacitor whose plates are separated by air (dielectric constant 1.00). The capacitor is electrically isolated from its surroundings (meaning that the terminals of the capacitor are not touching anything). A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the capacitance of the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is electrically isolated from its surroundings (meaning that the terminals of the capacitor are not touching anything). A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the charge on the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is electrically isolated from its surroundings. A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the voltage across the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is electrically isolated from its surroundings. A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the energy stored in the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is connected across an ideal battery. A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the voltage across the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is connected across an ideal battery. A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the charge on the capacitor?

a) It doubles.

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c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. The capacitor is connected across an ideal battery. A person slips some plastic in between the plates without changing the plate separation. The plastic has a dielectric constant of 2.00 and it completely fills the region between the plates. What happens to the energy stored in the capacitor?

a) It doubles.

b) It becomes one half of what it was.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person increases the separation of the plates while keeping the plates electrically isolated from each other and the surroundings. What happens to the charge of the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person increases the separation of the plates while keeping the plates electrically isolated from each other and the surroundings. What happens to the voltage across the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person increases the separation of the plates while keeping the plates electrically isolated from each other and the surroundings. What happens to the energy stored in the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person uses a power supply to maintain a constant potential difference between the plates while she increases the separation of the plates. What happens to the voltage across the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person uses a power supply to maintain a constant potential difference between the plates while she increases the separation of the plates. What happens to the charge of the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

Consider a charged capacitor whose plates are separated by air. A person uses a power supply to maintain a constant potential difference between the plates while she increases the separation of the plates. What happens to the energy stored in the capacitor?

a) It increases.

b) It decreases.

c) It stays the same.

d) None of the above.

A battery has two terminals, a higher potential terminal, often called the positive terminal, and a lower potential terminal, often called the negative terminal. When a battery is connected across a resistor, positive charge (in the conventional charge flow model) flows through the battery; it flows in one end, and out the other. Which end of the battery does the charge flow into and which end does it flow out of?

a) The (positive) charge flows into the battery via the positive terminal and out of the battery via the negative terminal.

b) The (positive) charge flows into the battery via the negative terminal and out of the battery via the positive terminal.

Imagine that you are looking at a seat of EMF connected across a resistor arranged such that, from your point of view, the direction of the current through the resistor is right-to-left. Which end of the resistor is at the higher value of electric potential?

a) The left terminal.

b) The right terminal.

c) Insufficient information is provided.

Imagine that you are looking at a seat of EMF connected across a resistor (only) arranged such that, from your point of view, the direction of the current through the seat of EMF is right-to-left. Which terminal of the seat of EMF is at the higher value of electric potential?

a) The left terminal.

b) The right terminal.

c) Insufficient information is provided.

Imagine that you are looking at a seat of EMF connected in a circuit such that, from your point of view, the direction of the current through the seat of EMF is right-to-left. Which terminal of the seat of EMF is at the higher value of electric potential?

a) The left terminal.

b) The right terminal.

c) Insufficient information is provided.

A seat of EMF is connected across a resistor. There are two “perfect” conductors (wires) in this circuit—one at high potential, the other at low potential. In the conventional current model, which way do positive charge carriers go through the resistor?

a) From the conductor at high potential to the one at low potential.

b) From the conductor at low potential to the one at high potential.

c) Insufficient information is provided.

In going through a resistor, a positive charge carrier goes from high potential to low. So why doesn’t it gain speed?

a) It does.

b) There is a retarding force on the charged particle which, on the average, cancels out the electrostatic force characterized by the potential in question, making the net force zero.

In traveling through a resistor, a positive charge carrier is moving from high potential to low potential so it is losing potential energy. So why doesn't it have more kinetic energy once it gets to the low potential terminal of the resistor than it had at the high potential terminal?

a) It does.

b) In the resistor, the potential energy of the charged particle is converted into thermal energy.

A seat of EMF is connected across a resistor. There are two “perfect” conductors (wires) in this circuit—one at high potential, the other at low potential. One terminal of the resistor is connected to one of these conductors and the other terminal of the resistor is connected to the other. At which terminal is the current greater?

a) There is no such thing as current “at a terminal.”

b) The high potential terminal.

c) The low potential terminal.

d) Neither. The current has one and the same value at each of the two terminals.

A seat of EMF is connected across a resistor. There are two “perfect” conductors (wires) in this circuit—one at high potential, the other at low potential. In the conventional current model, which way do positive charge carriers go through the seat of EMF?

a) From the conductor at high potential to the one at low potential.

b) From the conductor at low potential to the one at high potential.

A seat of EMF is connected across a resistor. There are two “perfect” conductors (wires) in this circuit—one at high potential, the other at low potential. Since the electric field is directed from high potential toward low potential, why, in the conventional current model, do positive charge carriers move from low to high inside the seat of EMF?

a) They don’t.

b) The force of such an electric field on positive charge carriers is directed from low to high.

c) Unspecified forces inside the seat of EMF push positive charge carriers in the direction opposite that of the electric field characterized by the electric potential in question.

A seat of EMF is connected across a resistor. There are two “perfect” conductors (wires) in this circuit—one at high potential, the other at low potential. In the conventional current model, charged particles move through the seat of EMF from low potential to high potential. Thus they gain potential energy. Why don’t they lose kinetic energy?

a) They do.

b) The premise of the question is flawed. Positive charge carriers *lose* potential energy in going through the seat of EMF.

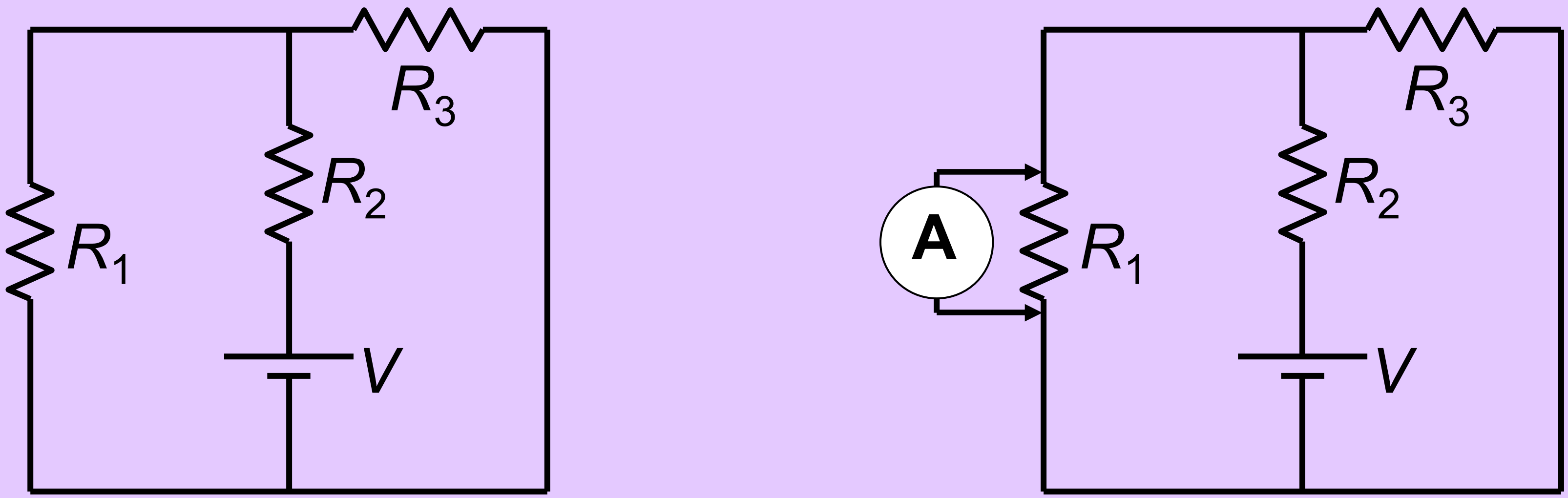
c) Energy is transferred from the seat of EMF to the charged particles as they go through the seat of EMF.

A seat of EMF is connected across a resistor. At which terminal of the seat of EMF is the current greater?

a) The higher potential terminal.

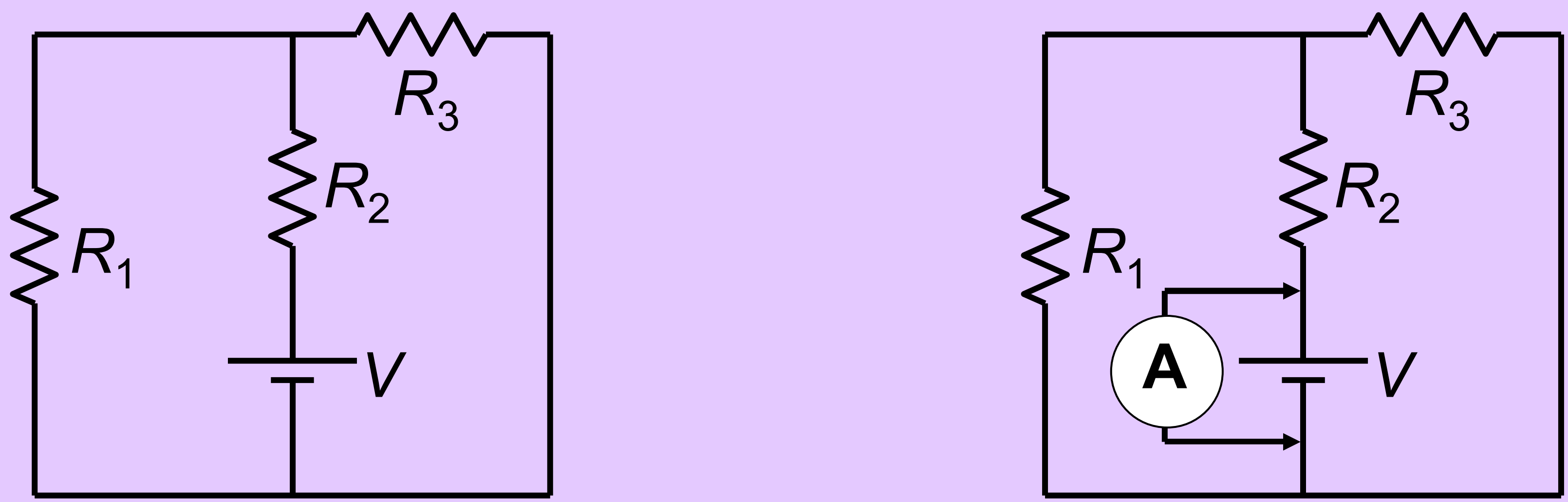
b) The lower potential terminal.

c) Neither



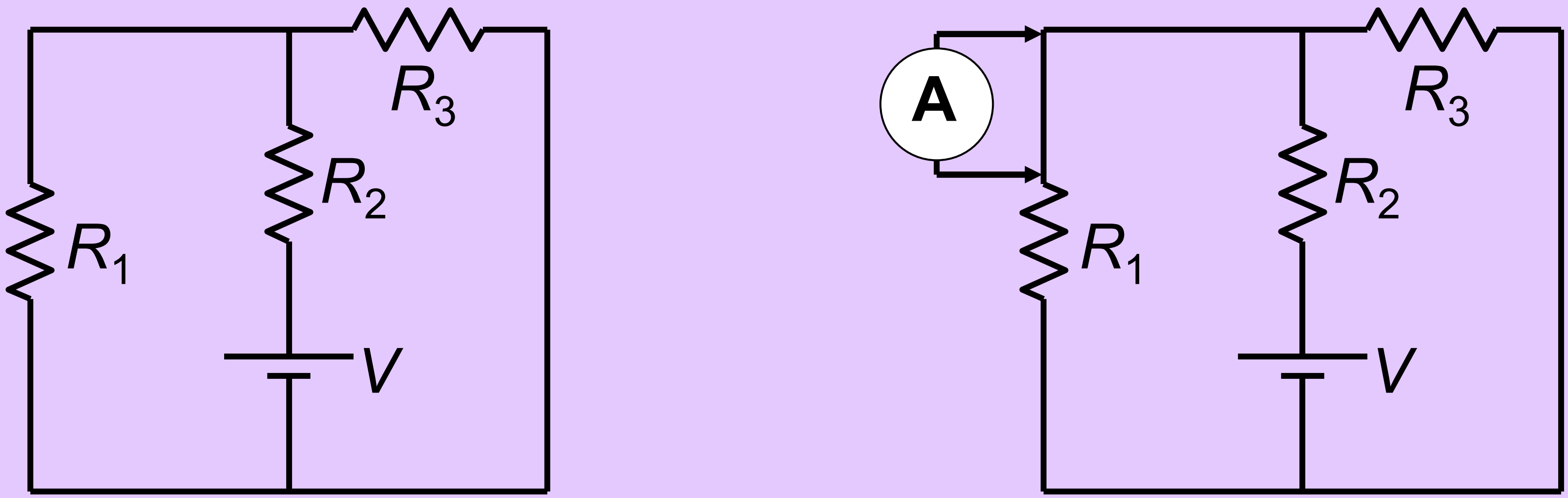
A person wishing to measure the current through R_1 in the circuit above left connects an ammeter as depicted above right. Will that work?

a) Yes
b) No



A person wishing to measure the current through the seat of EMF in the circuit above left connects an ammeter as depicted above right. Will that work?

a) Yes
b) No



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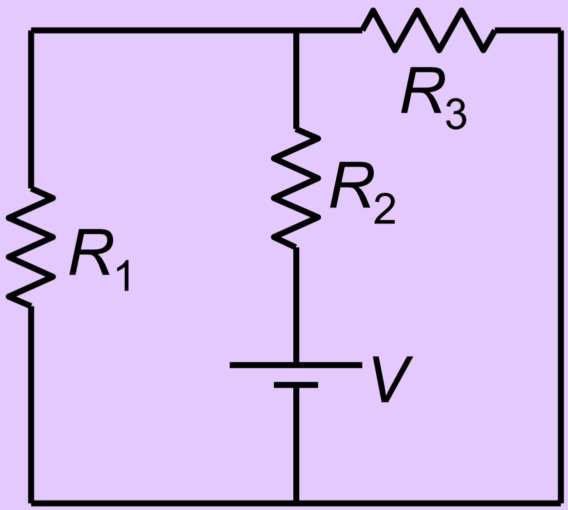
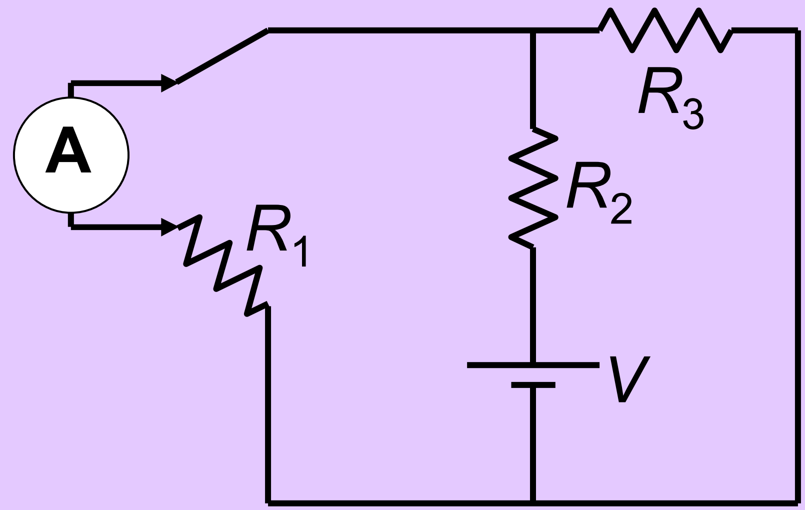
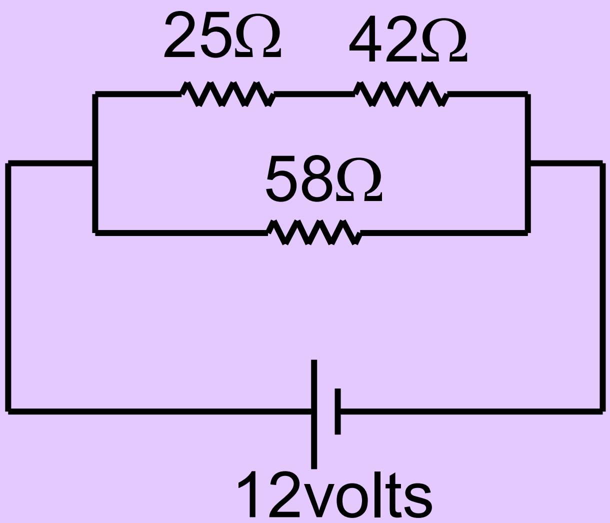
a) Yes
b) No

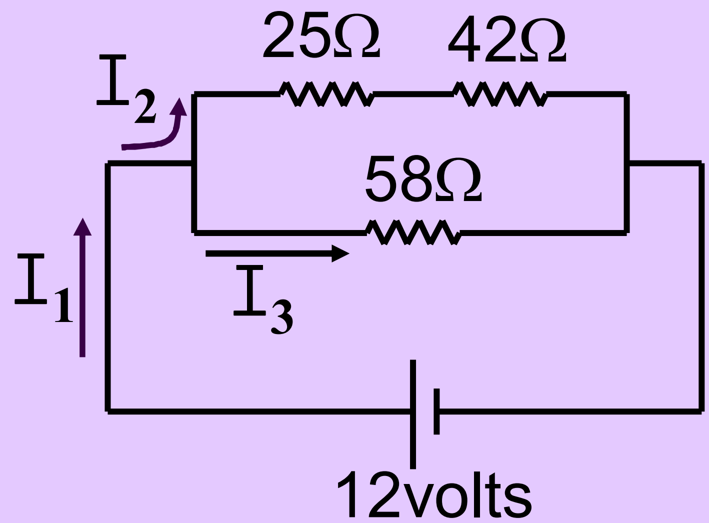




A person wishing to measure the current through R_1 in the circuit above left connects an ammeter as depicted above right. Will that work?

a) Yes
b) No





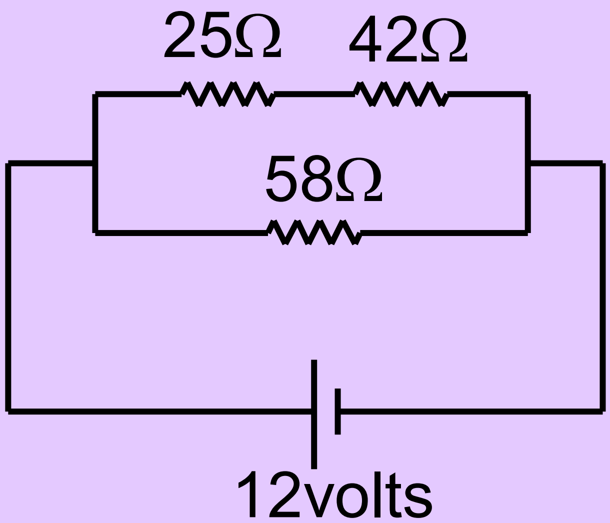
To analyze the circuit above left a person defines what he thinks is all the currents needed, by annotating the circuit as shown above right. What is wrong with the annotation?

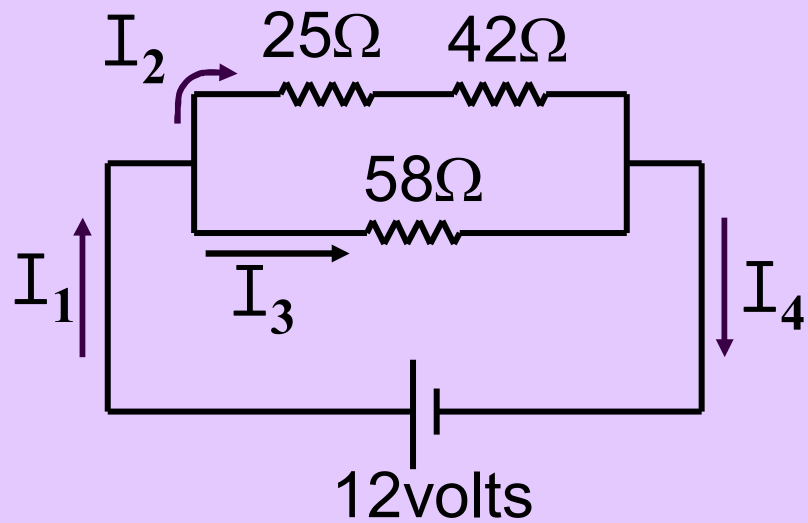
a) A current between the two top resistors needs to be defined.

b) A current into the seat of EMF needs to be defined.

c) The way I_2 is defined is nonsense.

d) Nothing.





To analyze the circuit above left a person defines what he thinks is all the currents needed, by annotating the circuit as shown above right. What is wrong with the annotation?

a) Too many currents have been defined. I_2 is the same as I_1.

b) Too many currents have been defined. I_4 is the same as I_1.

c) The way I_2 is defined is nonsense.

d) Nothing.

Electrical energy is converted into thermal energy in a resistor at the rate of 5 watts for 1 minute. What is the power for the resistor during that one minute?

a) 5 joules

b) 300 joules

c) 5 watts

d) 300 watts

e) None of the above

Electrical energy is converted into thermal energy in a resistor at the rate of 5 watts for 1 minute. How much energy is converted into thermal energy during that one minute?

a) 5 joules

b) 300 joules

c) 5 watts

d) 300 watts

e) None of the above

(Trick Question?) Consider two wires, wire A and wire B, each made of the same kind of metal and having the same length, but, with wire B having twice the diameter of wire A. How does the resistivity of wire B compare with that of wire A?

a) The resistivity of wire B is the same as that of wire A.

b) The resistivity of wire B is the half that of wire A.

c) The resistivity of wire B is one fourth that of wire A.

Consider two wires, wire A and wire B, each made of the same kind of metal and having the same length, but, with wire B having twice the diameter of wire A. How does the *resistance* of wire B compare with that of wire A?

a) The resistance of wire B is the same as that of wire A.

b) The resistance of wire B is the twice that of wire A.

c) The resistance of wire B is four times that of wire A.

d) None of the above.

Consider two wires, wire A and wire B, each made of the same kind of metal and having the same diameter, but, with wire B having twice the length of wire A. Why is the resistance of wire B less than that of wire A?

a) It isn’t.

b) Because the charged particles have farther to go in wire B so they run into more impurities and imperfections.

c) Because the electric field is weaker in wire B.

Consider two wires, wire A and wire B, each made of the same kind of metal and having the same diameter, but, with wire B having twice the length of wire A. Why is the resistance of wire B greater than that of wire A?

a) It isn't.

b) Because the charged particles have farther to go in wire B so they run into more impurities and imperfections.

c) Because the electric field is weaker in wire B.

Consider a building with many floors and lots of stairwells. The doors to all the rooms in the building are closed. The hallways and stairwells are chock full of people walking purposely forward. To the extent that a DC circuit is analogous to this situation, what in the building is analogous to voltage?

a) Elevation.

b) The speed of a person.

c) The people flow rate (how many people per minute go past a particular point in the building).

Consider a building with many floors and lots of stairwells. The doors to all the rooms in the building are closed. The hallways and stairwells are chock full of people walking purposely forward. To the extent that a DC circuit is analogous to this situation, what in the building is analogous to **current**?

a) Elevation.

b) The speed of a person.

c) The people flow rate (people per minute passing a particular point in the building).

Consider the function $V = \mathcal{E}(1 - e^{-\frac{t}{RC}})$ in which $\mathcal{E}$, *R*, and *C* are known constants. What is *V* at time 0?

a) 0

b) $\mathcal{E}$

c) *RC*

d) Insufficient information is given to say what *V* is at time 0.

e) None of the above.

Consider the function $V = \mathcal{E}(1 - e^{-\frac{t}{RC}})$ in which $\mathcal{E}$, *R*, and *C* are known constants. What does *V* go to as time goes to infinity?

a) 0

b) $\mathcal{E}$

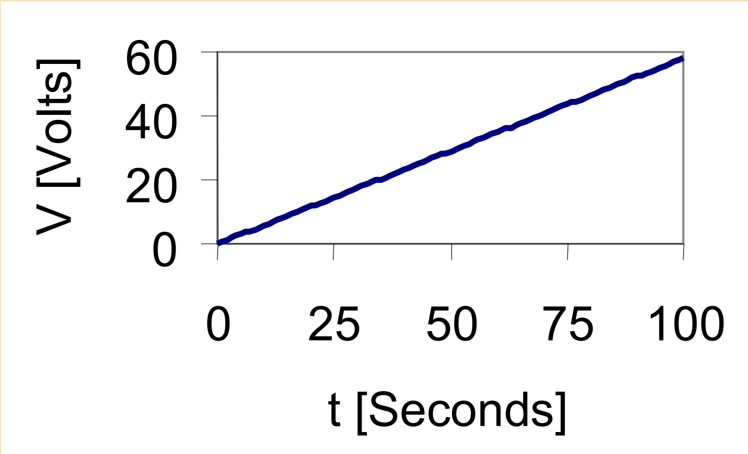
c) *RC*

d) Insufficient information is given to say what *V* goes to as time goes to infinity.

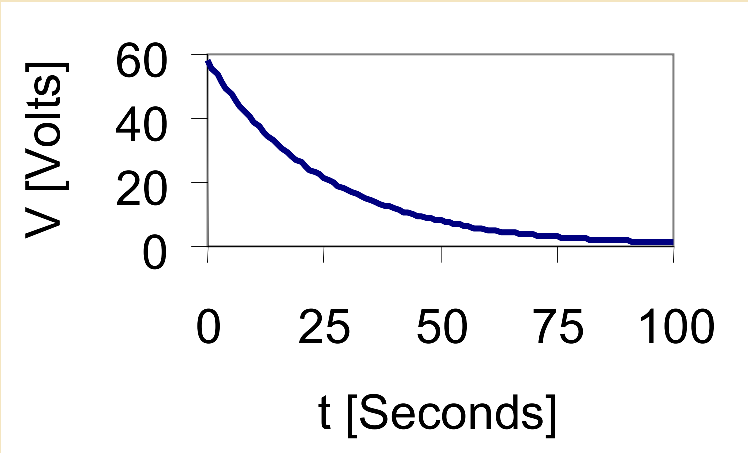
e) None of the above.

Which of the following best represents a graph of $V = \mathcal{E}(1 - e^{-\frac{t}{RC}})$ in which $\mathcal{E}$, *R*, and *C* are known constants?

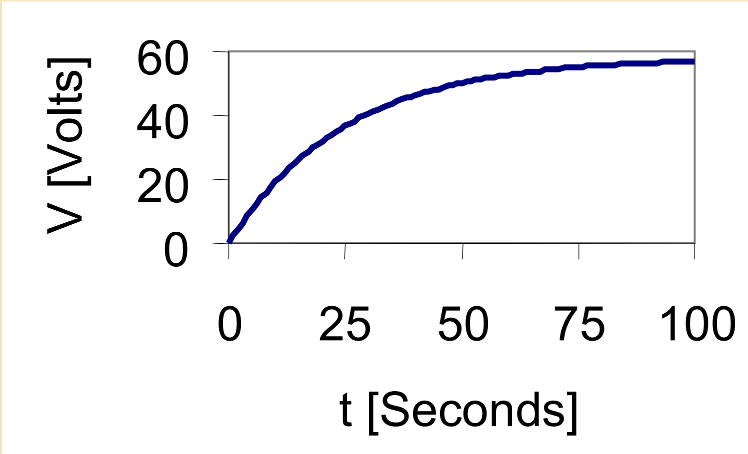
a)



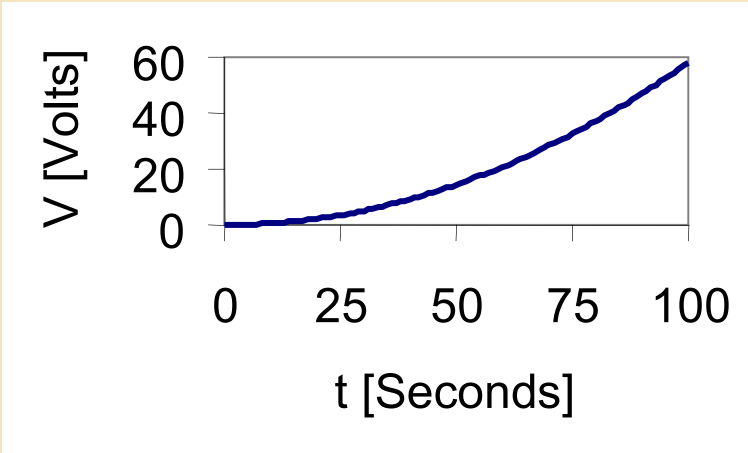
b)



c)



d)



Consider the function $V = \mathcal{E}(1 - e^{-\frac{t}{RC}})$ in which $\mathcal{E}$, *R*, and *C* are known constants. What does *V* represent? Choose the *best* answer.

- **a) The voltage across a discharging capacitor in an RC circuit.**
- **b) The voltage across a charging capacitor in an RC circuit.**
- **c) The voltage across the resistor in an RC circuit during the discharge of the capacitor.**
- **d) The voltage across the resistor in an RC circuit during the charging of the capacitor.**
- **e) There is more than one correct answer above.**

Consider the function $V = V_0 e^{-\frac{t}{RC}}$ **in which** ***V*₀**

V_0, *R*, and *C* are known constants. What is *V* at time 0?

a) 0

b) V_0

c) *RC*

d) Insufficient information is given to say what *V* is at time 0.

e) None of the above.

Consider the function $V = V_0 e^{-\frac{t}{RC}}$ in which V_0, R, and C are known constants. What does V go to as time goes to infinity?

a) 0

b) V_0

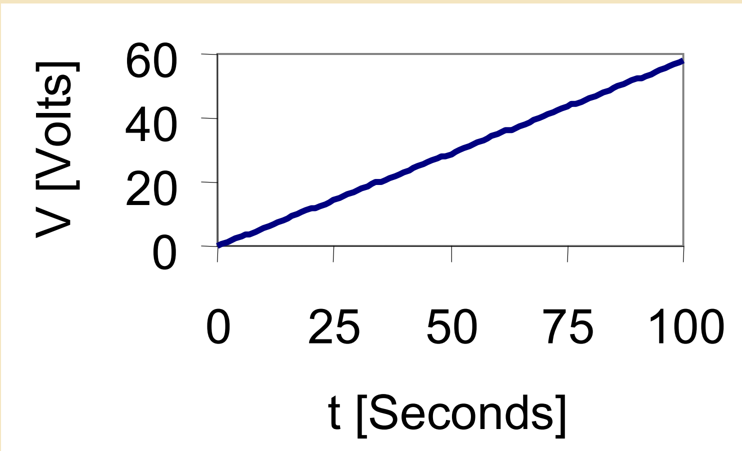
c) RC

d) Insufficient information is given to say what V goes to as time goes to infinity.

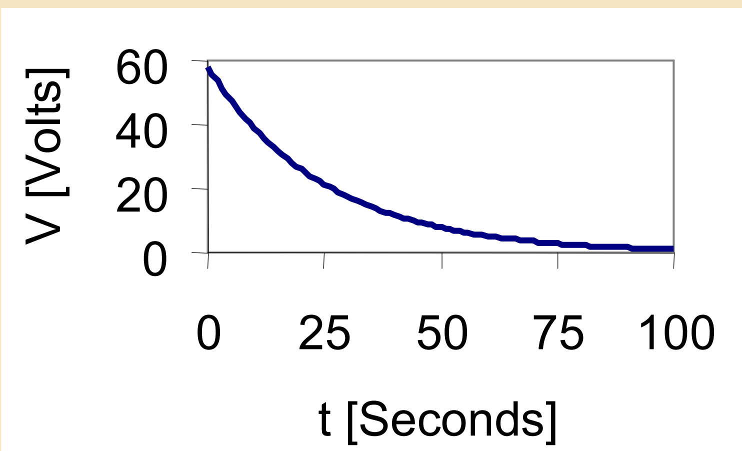
e) None of the above.

Which of the following best represents a graph of $V = V_0 e^{-\frac{t}{RC}}$ in which V_0, R, and C are known constants?

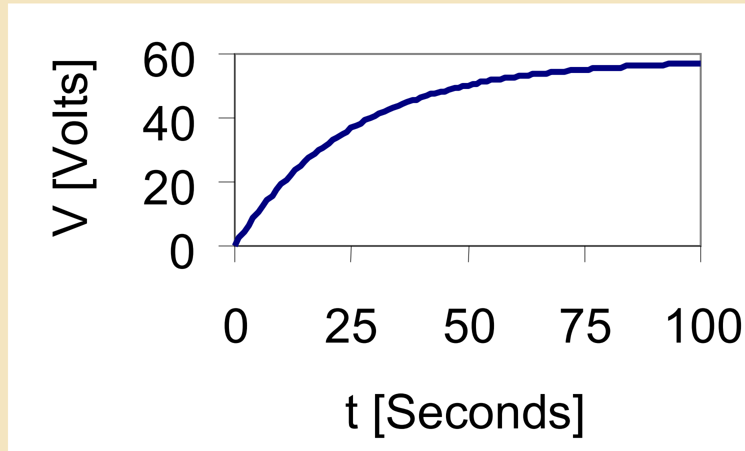
a)



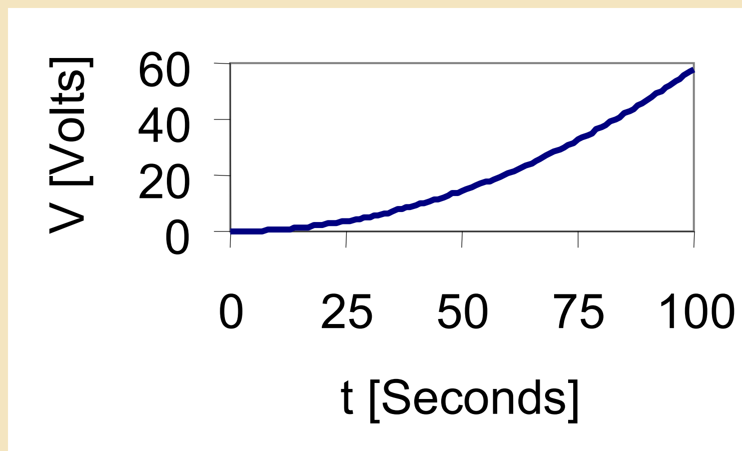
b)



c)



d)



Consider the function $V = V_0\, e^{-\frac{t}{RC}}$ **in which** V_0**,** R**, and** C **are known constants. What does** V **represent? Choose the *best* answer.**

a) **The voltage across a discharging capacitor in an RC circuit.**

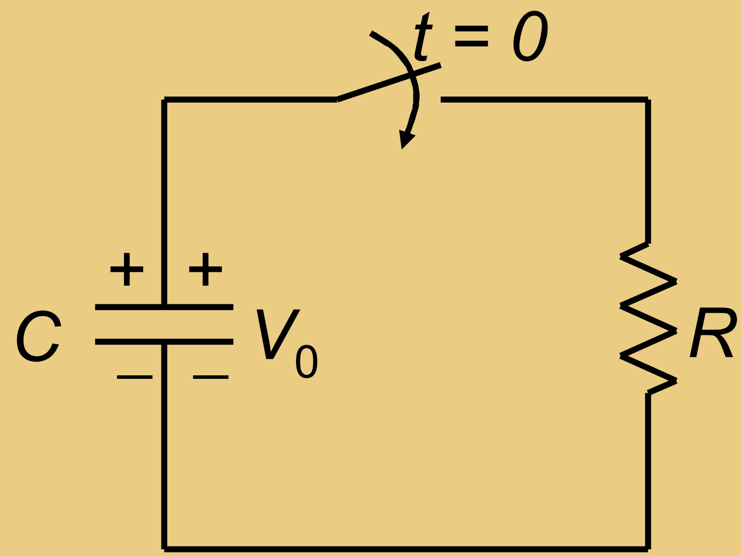
b) **The voltage across a charging capacitor in an RC circuit.**

c) **The voltage across the resistor in an RC circuit during the discharge of the capacitor.**

d) **The voltage across the resistor that in an RC circuit during the charging of the capacitor.**

e) **There is more than one correct answer above.**

The diagram at right represents a circuit with a switch that is closed at time 0. Consider V_0, C, and R to be known. What



is the charge on the capacitor at time 0+ ?

a) IR

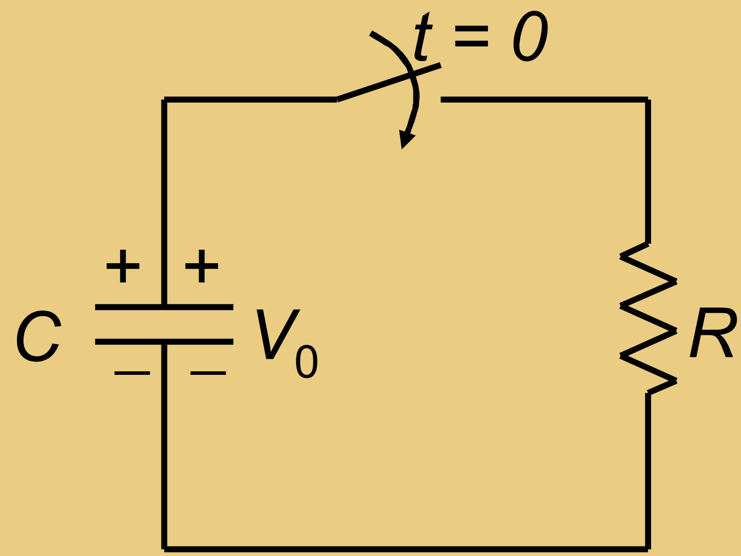
b) V_0/R

c) CV_0

d) 0

e) None of the above.

The diagram at right represents a circuit with a switch that is closed at time 0. Consider V_0, C, and R to be known. What is the current through the resistor at time 0+ ?



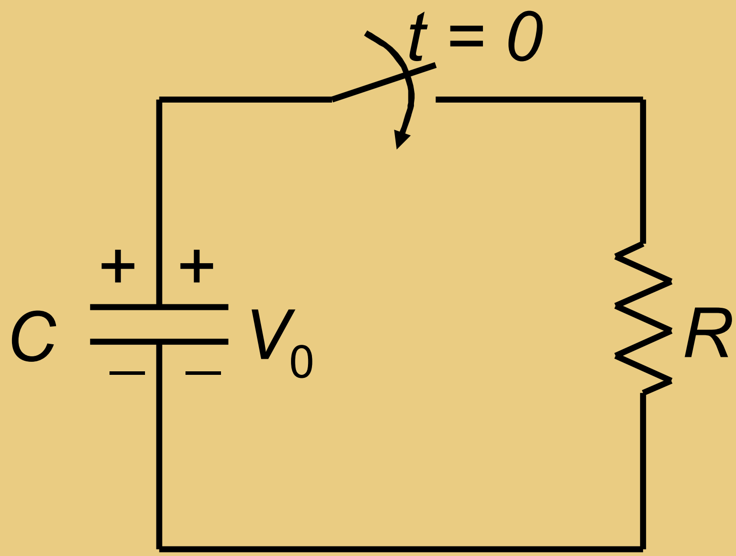
a) 0

b) V_0/R

c) Insufficient information.

d) None of the above.

The diagram at right represents a circuit with a switch that is closed at time 0. Consider V_0, C, and R to be known. What is the current through the resistor at time infinity?



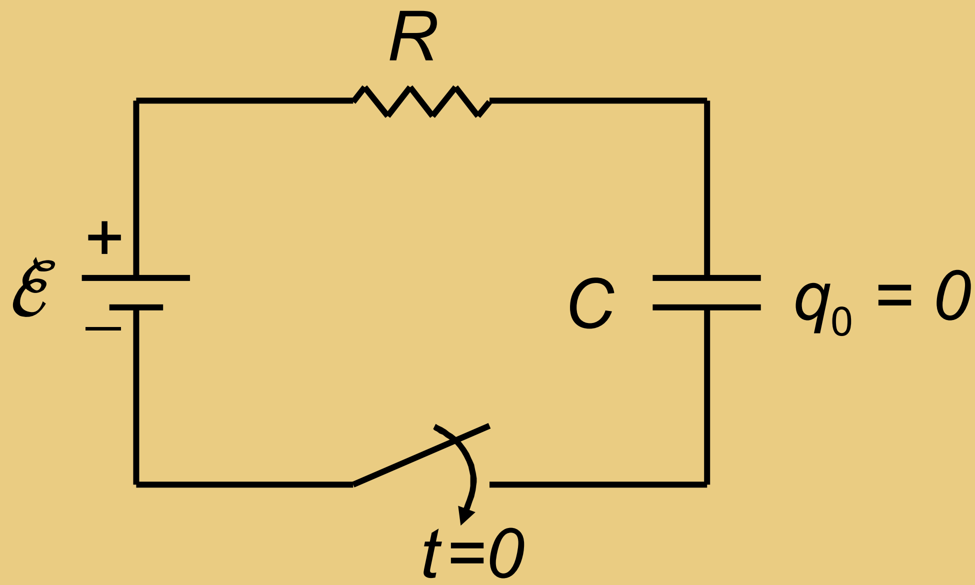
a) 0

b) V_0/R

c) Insufficient information.

d) None of the above.

Consider $\mathcal{E}$, *R*, and *C* to be known. What is the voltage across *C* at time 0+ ?



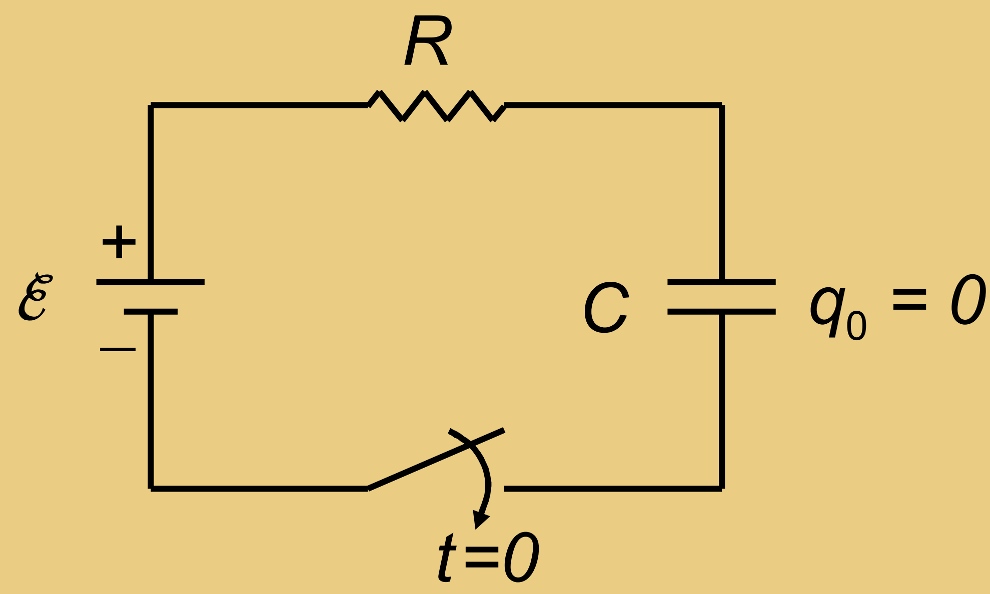
a) 0

b) $\mathcal{E}$

c) Insufficient information is provided to determine what it is.

d) None of the above.

Consider $\mathcal{E}$, *R*, and *C* to be known. What is the voltage across *R* at time 0+ ?



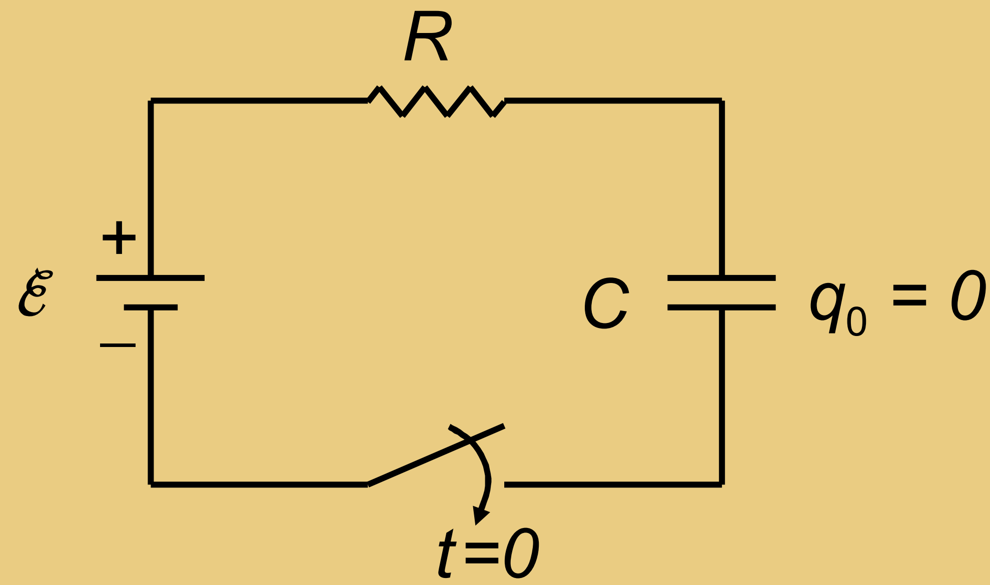
a) 0

b) $\mathcal{E}$

c) Insufficient information is provided to determine what it is.

d) None of the above.

Consider $\mathcal{E}$, *R*, and *C* to be known. What is the current through *R* at time 0+ ?



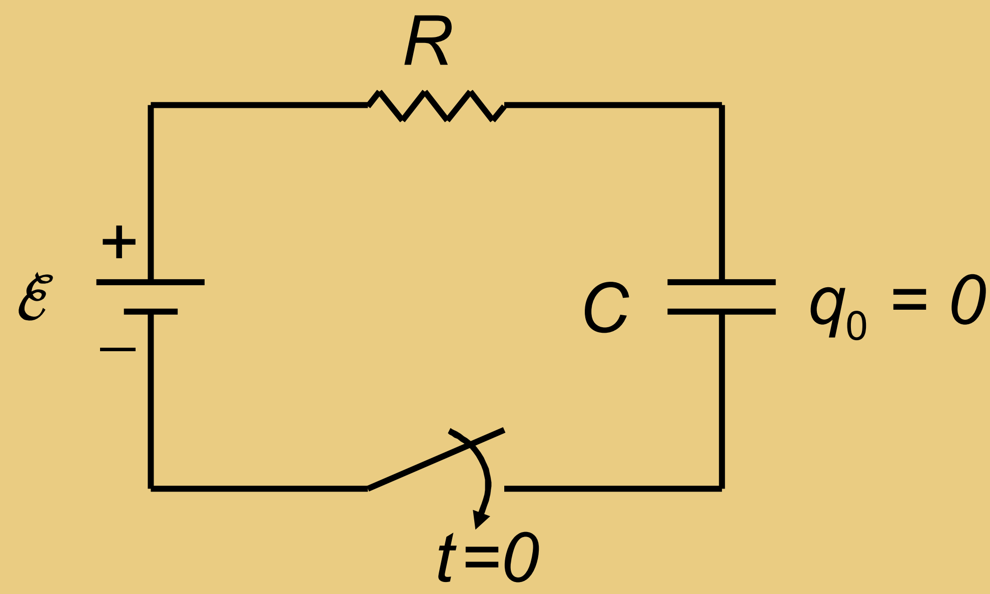
a) 0

b) $\mathcal{E}/R$

c) Insufficient information is provided to determine what it is.

d) None of the above.

Consider $\mathcal{E}$, *R*, and *C* to be known. What is the current through *R* at time infinity?



a) 0

b) $\mathcal{E}/R$

c) Insufficient information is provided to determine what it is.

d) None of the above.

Consider 2 unequal capacitors in parallel with each other. Suppose that the parallel combination is in series with a battery and a resistor. What is the same about the two capacitors?

a) The charge.

b) The voltage.

c) Both a and b.

d) None of the above.

Consider 2 unequal capacitors in **series** with each other. Suppose that the series combination is in series with a battery and a resistor. What is the same about the two capacitors?

a) The charge.

b) The voltage.

c) Both a and b.

d) None of the above.

Consider a seat of EMF in series with three capacitors having capacitance 1mF, 2mF, and 3mF respectively. Which capacitor has the most charge?

a) The 1mF capacitor.

b) The 2mF capacitor.

c) The 3mF capacitor.

d) They all have the same amount of charge.

Consider a seat of EMF in series with three capacitors having capacitance 1mF, 2mF, and 3mF respectively. Across which capacitor is the voltage the greatest?

a) The 1mF capacitor.

b) The 2mF capacitor.

c) The 3mF capacitor.

d) They all have the same voltage.

A battery, an open switch, a resistor, and an uncharged capacitor are connected in series with each other in a closed loop. Then the switch is closed. The capacitor charges. A person measures the time it takes for the voltage across the capacitor to reach 99% of the battery voltage. The switch is opened and a person discharges the capacitor. Then, that same person places a second capacitor in parallel with the first one, while leaving the original circuit intact. The person closes the switch and again measures the time it takes for the voltage across the original capacitor to reach 99% of the battery voltage. In which case is the measured time greater?

a) In the first case, with just the one capacitor.

b) In the second case, with the two capacitors in parallel with each other.

c) The two times are the same.

A battery, an open switch, a resistor, and an uncharged capacitor are connected in series with each other in a closed loop. Then the switch is closed. The capacitor charges. A person measures the time it takes for the voltage across the capacitor to reach 99% of the battery voltage. The switch is opened and a person discharges the capacitor. Then, that same person places a second uncharged capacitor in **series** with the first one. The person closes the switch and measures the time it takes for the voltage across the pair of capacitors to reach 99% of the battery voltage. In which case is the measured time greater?

a) In the first case, with just the one capacitor.

b) In the second case, with the two capacitors in series with each other.

c) The two times are the same.

Suppose you had a bunch of 10μF capacitors but what you needed was a 2.5μF capacitor. How could you create the latter from the former?

a) Just connect the appropriate number of the 10μF capacitors in series with each other.

b) Just connect the appropriate number of the 10μF capacitors in parallel with each other.

c) None of the above.

Suppose you had a bunch of 10μF capacitors but what you needed was a **25μF** capacitor. How could you create the latter from the former?

a) Just connect the appropriate number of the 10μF capacitors in series with each other.

b) Just connect the appropriate number of the 10μF capacitors in parallel with each other.

c) None of the above.

Consider a vertical bar magnet, north end up. What is the direction of the magnetic dipole moment of the bar magnet?

a) A bar magnet has no magnetic dipole moment.
b) Insufficient information is provided.
c) Upward.
d) Downward.

Does a uniform magnetic field exert a torque on a bar magnet that is in that uniform magnetic field?

a) Yes.
b) No.

Does a uniform magnetic field exert a ***force*** on a bar magnet that is in that uniform magnetic field?

a) Yes.
b) No.

Does a uniform magnetic field exert a torque on a magnetic dipole that is in that uniform magnetic field?

a) Yes.
b) No.

Does a uniform magnetic field exert a ***force*** on a magnetic dipole that is in that uniform magnetic field?

a) Yes.
b) No.

An electric field is a force-per-charge at every point in space. A magnetic field is a…

a) **force-per-magnetic-dipole-moment at every point in space.**
b) **torque-per-magnetic-dipole-moment at every point in space.**
c) **torque-per-charge at every point in space.**

A bar magnet, in a downward-directed magnetic field is aligned so that it points eastward (with the bar magnet, for orientation purposes, treated as an arrow whose head is at the north end of the bar magnet). What is the direction of the torque exerted on the bar magnet by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Upward
f) Downward
g) There is no torque.

A bar magnet, in an ***eastward***-directed magnetic field, is aligned so that it points ***upward*** (with the bar magnet, for orientation purposes, treated as an arrow whose head is at the north end of the bar magnet). What is the direction of the torque exerted on the bar magnet by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Upward
f) Downward
g) There is no torque.

A bar magnet, in an ***upward***-directed magnetic field, is aligned so that it points upward (with the bar magnet, for orientation purposes, treated as an arrow whose head is at the north end of the bar magnet). What is the direction of the torque exerted on the bar magnet by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Upward
f) Downward
g) There is no torque.

A particle, in a downward-directed magnetic field is aligned so that its magnetic dipole moment is eastward. What is the direction of the torque exerted on the particle by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Upward
f) Downward
g) There is no torque.

What is the direction of the gradient of the gravitational potential energy of a marker in this room?

a) Upward.
b) Downward.
c) None of the above.

What is the direction of the gradient of the pressure in a swimming pool?

a) Upward.

b) Downward.

c) None of the above.

The earth is in the gravitational field of the sun. What is the direction of the gradient of the gravitational energy of the earth?

a) Toward the sun.
b) Away from the sun.
c) None of the above.

A vertical bar magnet, north end up, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$ is in an eastward-directed uniform magnetic field $\vec{\mathbf{B}}$. What is $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) 0

b) μB

c) $-\mu B$

d) None of the above.

A vertical bar magnet, north end up, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$ is in an ***upward-directed*** uniform magnetic field $\vec{\mathbf{B}}$. What is $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) 0

b) μB

c) $-\mu B$

d) None of the above.

A vertical bar magnet, north end up, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$, is in an upward-directed uniform magnetic field $\vec{\mathbf{B}}$. What is ***the direction of the gradient*** of $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) Upward.
b) Downward.
c) None of the above.

A vertical bar magnet, north end up, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$, is in an eastward-directed *non-uniform* magnetic field $\vec{\mathbf{B}}$ for which the greater the elevation of the position under consideration, the greater the magnitude of the magnetic field. What is the direction of the gradient of $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) Upward.

b) Downward.

c) None of the above.

A *horizontal* bar magnet, north pole to the east, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$, is in an eastward-directed non-uniform magnetic field $\vec{\mathbf{B}}$ for which the greater the elevation of the position under consideration, the greater the magnitude of the magnetic field. What is the direction of the gradient of $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) Upward.

b) Downward.

c) None of the above.

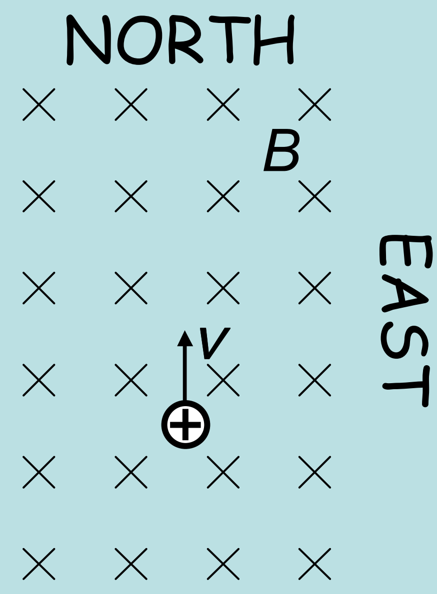
A vertical bar magnet, north end up, with magnetic dipole moment $\vec{\boldsymbol{\mu}}$, is in an ***upward***-directed non-uniform magnetic field $\vec{\mathbf{B}}$ for which the greater the elevation of the position under consideration, the greater the magnitude of the magnetic field. What is the direction of the gradient of $\vec{\boldsymbol{\mu}} \cdot \vec{\mathbf{B}}$?

a) Upward.

b) Downward.

c) None of the above.

A positively-charged particle moves horizontally in a uniform downward-directed magnetic field as depicted at right. What is the direction of the force exerted on the particle by the magnetic field at the instant in question?



a) Northward

b) Southward

c) Upward

d) Downward

e) Eastward

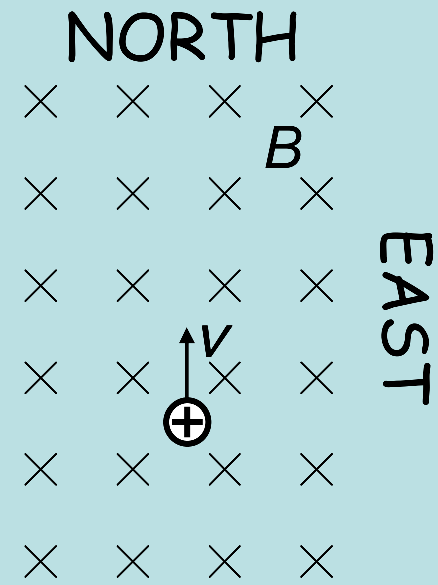
f) Westward

g) Clockwise as viewed from above.

h) Counterclockwise as viewed from above.

i) There is no force.

A positively-charged particle moves horizontally in a uniform downward-directed magnetic field as depicted above. The particle remains in the magnetic field for the entire time period under consideration here. No force but that of the magnetic field acts on the particle. As time goes by:

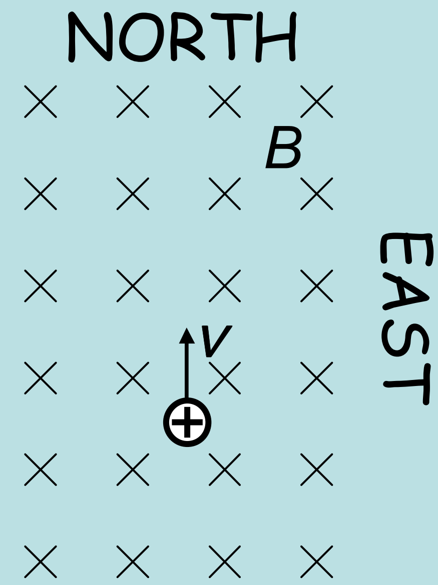


a) The speed of the particle increases.

b) The speed of the particle decreases.

c) The speed of the particle stays the same.

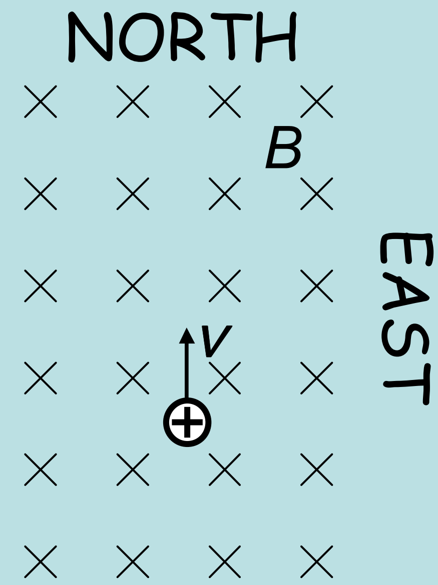
A positively-charged particle moves horizontally in a uniform downward-directed magnetic field as depicted above. The particle remains in the magnetic field for the entire time period under consideration here. No force but that of the magnetic field acts on the particle. As time goes by:



a) The velocity of the particle changes.

b) The velocity of the particle stays the same.

A positively-charged particle moves horizontally in a uniform downward-directed magnetic field as depicted at right. The particle remains in the magnetic field for the entire time period under consideration here. No force but that of the magnetic field acts on the particle. As time goes by, the kinetic energy of the particle…



a) increases.

b) decreases.

c) stays the same.

What can one say about the work being done on a charged particle (with no magnetic dipole moment) by a magnetic field when that charged particle is moving in the magnetic field?

a) It is always zero.

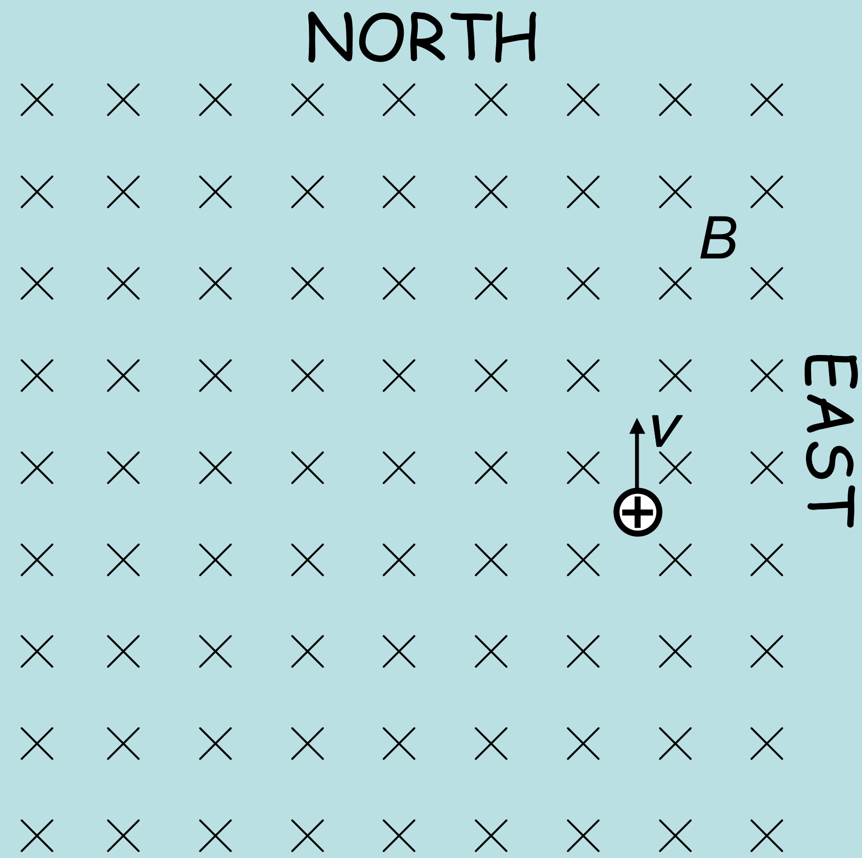
b) It is zero if the velocity of the particle is collinear with the magnetic field vector at the location of the particle and non-zero otherwise.

c) The work done is always greater than zero.

d) The work done is always less than zero (negative).

e) It is zero if the magnetic field is uniform, but, it can be zero or non-zero if the field is non-uniform.

A positively-charged particle moves horizontally in a uniform downward-directed magnetic field as depicted at right. The particle remains in the magnetic field for the entire time period under consideration here. No force but that of the magnetic field acts on the particle. On what kind of path does the particle move as time elapses?



a) A circle.

b) A parabola.

c) A hyperbola.

d) A straight line.

e) A sinusoidal path.

A positively charged particle is moving northward in a downward-directed magnetic field. What is the direction of the force exerted on the particle by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Upward
f) Downward
g) There is no force.

A negatively-charged particle is moving upward in an eastward-directed magnetic field. What is the direction of the force exerted on the particle by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Northwestward
i) Upward
j) Downward

A negatively-charged particle is moving northeastward in an upward-directed magnetic field. What is the direction of the force exerted on the particle by the magnetic field?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Northwestward
i) Upward
j) Downward

Where is the magnetic field of a bar magnet strongest?

a) Outside the magnet, near the north pole of the magnet.

b) Outside the magnet, near the south pole of the magnet.

c) Beside the magnet.

d) Inside the magnet.

What does it mean to say that a bar magnet is pointing eastward?

a) The bar magnet is aligned west to east with the west end being the south pole of the magnet and the east end being the north pole of the bar magnet.

b) The bar magnet is aligned west to east with the west end being the north pole of the magnet and the east end being the south pole of the bar magnet.

c) A bar magnet never points eastward. By definition, a bar magnet always points northward.

d) None of the above.

A current flows northeastward in a horizontal wire in a downward directed magnetic field. What is the direction of the magnetic field due to the wire at a point that is at the same elevation of the wire and is southeast of the wire?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

What is the direction of the force, if any, on a positively charged particle that has a northward velocity and is just east of (and at the same elevation as) a straight horizontal wire which is carrying a northward current?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

What is the direction of the magnetic field, if any, at the center of a horizontal loop carrying a current which is counterclockwise as viewed from above?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

What is the direction of the force, if any, on a negatively charged particle that has a westward velocity and is at the center of a horizontal loop carrying a current which is counterclockwise as viewed from above?

- **a) Northward**
- **b) Southward**
- **c) Eastward**
- **d) Westward**
- **e) Northeastward**
- **f) Southeastward**
- **g) Southwestward**
- **h) Upward**
- **i) Downward**
- **j) None of the above.**

What is the direction of the force, if any, on a negatively charged particle that has a westward velocity and is directly above a vertical bar magnet aligned north pole down?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

What is the direction of the force, if any, on a positively charged particle that has an upward velocity and is due east of the center of, and outside of, a vertical bar magnet aligned north pole up?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

What is the direction of the force, if any, on a positively charged particle that has a *southward* velocity and is due east of the center of, and outside of, a vertical bar magnet aligned north pole up?

a) Northward
b) Southward
c) Eastward
d) Westward
e) Northeastward
f) Southeastward
g) Southwestward
h) Upward
i) Downward
j) None of the above.

A gold ring is dropping toward vertical a bar magnet whose south end is its upper end. The ring is oriented horizontally, and as it continues to drop, it will encircle the bar magnet. But it is not encircling the bar magnet yet, it is dropping toward it. What is the direction of the current, if any, induced in the gold ring?

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) No current is induced in the ring.

A bar magnet is hanging, south end down, at rest by a string tied to the ceiling. The lower end of the magnet is two centimeters above the floor. The magnet is centered over a copper loop which is lying flat on the floor. A person pulls the magnet eastward and lets go. As the magnet swings back toward its equilibrium position, current is induced to flow in the loop in what direction?

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) No current is induced to flow in the loop.

A vertical stick has a long wire with non-zero resistance wrapped one way around it. This coil of wire is encircled by a horizontal silver hoop. The ends of the long wire are connected across a charged capacitor. The capacitor is discharging through the wire such that the current in the coil is clockwise as viewed from above. Find the current, if any, induced to flow in the hoop.

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) There is no induced current.

Consider a wall clock whose second hand is a bar magnet whose north pole is the second indicator. Assume the clock to have a copper ring positioned above it like a halo. What is the direction of the current induced to flow in the copper ring when the second hand is between the 12 and the 3?

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) No current is induced in the ring.

Consider a wall clock whose second hand is a bar magnet whose north pole is the second indicator. Assume the clock to have a copper ring positioned above it like a halo. What is the direction of the current induced to flow in the copper ring when the second hand is between the 3 and the 6?

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) No current is induced in the ring.

Consider a wall clock whose second hand is a bar magnet whose north pole is the second indicator. Assume the clock to have a copper ring positioned above it like a halo. What is the direction of the current induced to flow in the copper ring when the second hand is between the 6 and the 9?

a) Clockwise as viewed from above.

b) Clockwise as viewed from below.

c) No current is induced in the ring.

A horizontal copper loop is due east of, at the same elevation as, a straight horizontal wire carrying a steady current due north. What is the direction of the current induced to flow in the loop by the steady current in the wire?

a) Upward.

b) Downward.

c) Clockwise as viewed from above.

d) Counterclockwise as viewed from above.

e) There is no current induced in the loop by the steady current in the wire.

f) None of the above.

What is the purpose of transformers?

a) To step AC voltage up.

b) To step AC voltage down.

c) To convert AC to DC.

d) To convert DC to AC.

e) To convert Electrical Energy to Mechanical Energy.

f) To convert Mechanical Energy to Electrical Energy.

g) Both a and b.

h) Both c and d.

i) Both e and f.

Do transformers work with AC or DC?

a) AC.

b) DC.

c) Neither.

d) Both.

How does a transformer work?

a) **A changing current through one coil causes creates a magnetic field through a second coil which is changing because the current through the first coil is changing. This changing magnetic field through the second coil induces a current in the second coil.**

b) **A current through one coil creates a magnetic field through a second coil which causes a current in the second coil.**

c) **A changing magnetic field causes a magnet to spin.**

In a transformer, is it the current in the primary that causes the primary coil's magnetic field or is it the changing of the current in the primary that causes the primary coil's magnetic field?

a) The current itself.

b) The changing of the current.

In a transformer, is it the magnetic field through the region encircled by the secondary that causes the current in the secondary, or, is it the changing of that magnetic field that causes the current in the secondary?

a) The magnetic field itself.

b) The changing of the magnetic field.

Which of the following is a better description of a generator?

a) A spinning magnet near a coil that induces current to flow in that coil.

b) A changing current in a coil that causes a nearby magnet to spin.

What is the purpose of a generator?

a) **To convert mechanical energy into electrical energy.**

b) **To convert electrical energy into mechanical energy.**

c) **To spin a magnet.**

In a generator, what spins the magnet?

a) The changing magnetic field due to the current in the coil.

b) It varies. Steam engines, water turbines, diesel engines and other devices are used to spin magnet.

A long straight vertical wire carries an increasing current straight upward. Right beside the wire is a horizontal conducting loop. Which way is current induced to flow in the loop by the changing magnetic field of the wire?

a) Upward.

b) Downward.

c) Clockwise as viewed from above.

d) Counterclockwise as viewed from above.

e) There is no current induced in the loop.

f) None of the above.

A horizontal copper loop is due east of, at the same elevation as, a straight horizontal wire carrying a decreasing current due north. What is the direction of the current induced to flow in the loop by the changing current in the wire?

a) Clockwise as viewed from above.

b) Counterclockwise as viewed from above.

c) There is no current induced in the loop.

d) None of the above.

A bar magnet is spinning clockwise as viewed from a position south of the magnet, about a horizontal, north-south axis that is perpendicular to, and passes through the center of, the bar magnet. What is the direction of the electric field, if any, directly above the magnet at an instant when the magnet is vertical with its north end up?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no electric field.

h) None of the above.

A tiny lead pellet having a negative charge is falling toward the ground. In the rest frame of the ground, at a point due north of the pellet at the same elevation as the pellet, what is the direction of the magnetic field, if any, due to the falling particle?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no magnetic field.

h) None of the above.

A horizontal loop carries a current that is clockwise as viewed from above, but, the loop is rotating counterclockwise as viewed from above. What is the direction of the electric field, if any, due to the rotating loop at a point at the same elevation as, and due north of, the loop?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no electric field.

h) None of the above.

A positively charged particle is moving northward, directly toward point P. In the reference frame in which point P is at rest, what is the direction of the magnetic field, if any, at point P?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no magnetic field.

h) None of the above.

In your reference frame, a downward-directed magnetic field vector is moving eastward at the speed of light. In your reference frame, what is the direction of the corresponding electric field, if any?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no electric field.

h) None of the above.

In your reference frame, a northward-directed electric field vector is moving downward. In your reference frame, what is the direction of the corresponding magnetic field, if any?

a) Northward

b) Southward

c) Eastward

d) Westward

e) Upward

f) Downward

g) There is no magnetic field.

h) None of the above.

In the case of sound waves in air, it is air molecules that are doing the “waving”. What is “waving” in the case of light?

a) Electrons.

b) Protons.

c) Both a and b.

d) Electric and magnetic fields.

e) None of the above.

When you see a sinusoidal curve that is supposed to represent light, what is the displacement of the points on the curve from the “x axis” supposed to represent?

a) **The component of the electric field in a particular direction.**
b) **The component of the magnetic field in a particular direction.**
c) **Either a or b.**
d) **The intensity of the wave.**
e) **Time or position.**

Does sound travel through vacuum?

a) Yes

b) No.

Does light travel through vacuum?

a) Yes

b) No.

The wave equation on your first-semester formula sheet reads:

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What does the *y* represent in the case of light waves?

a) The electric field component in a particular direction.

b) The magnetic field component in a particular direction.

c) Either a or b above.

d) The displacement of a charged particle in a direction transverse to the wave velocity direction.

The wave equation on your first-semester formula sheet reads:

$$\frac{\partial^2 y}{\partial x^2} = \frac{1}{v^2}\frac{\partial^2 y}{\partial t^2}$$

What is the *v* in the case of light waves?

a) **The speed-along-the-light-path of the charged particles making up the light.**

b) **The speed-transverse-to-the-light-path of the charged particles making up the light.**

c) **The rate at which the electric field is growing, and/or, the rate at which the magnetic field is growing.**

d) **None of the above.**

Huygens's principle is a conceptual idea conveyed to you by means of a whole lot of words and diagrams but as far as facilitation of understanding of an observed phenomenon, we only used it:

a) to help understand why light travels forward.

b) in regard to the Young's double slit experiment to justify treating the slits in the two slit mask as point sources (actually line sources viewed end on) from which light emanated in all forward directions.

Regarding 2-slit interference, when we say that a maximum occurs at an angle, the angle is the angle between what and what?

a) The screen and the beam.

b) The mask and the line on which the intensity of the light is a maximum.

c) The straight-ahead direction and the line on which the intensity of the light is a maximum.

In a Young's double slit experiment, does a particular maximum occur only at the screen or does it occur essentially everywhere along a line segment extending from the mask to the screen?

a) Only at the screen.

b) Everywhere along the specified line segment.

Plane waves of a single wavelength of light are normally incident on a double slit. The center of a screen that is normal to the initial direction of travel of the light is in the "straight ahead" direction. A total of 9 bright fringes are visible on the screen. What is the order of the highest order fringe that can be seen?

a. First order.
b. Third order.
c. Fifth order.
d. Seventh order.
e. Ninth order.
f. None of the above.

In the expression

$$m\lambda = d\sin(\theta)$$

relevant to two-slit interference, the *d* is:

a) The center-to-center slit separation.

b) The path difference traveled by light from one slit to a particular point on the screen as compared to light from the other slit.

c) The distance from the mask with the double slit in it to the screen.

d) A differential operator.

e) The width of the screen.

f) The distance from the crest of one wave to the trough of the next.

Consider two double slit experiments, A, and B, identical in every respect, except that in experiment B, the slit spacing is smaller. On the screen:

a) The fringes are farther apart in experiment B than they are in experiment A .

b) The fringes are closer together in experiment B than they are in experiment A .

Consider two double slit experiments, A, and B, identical in every respect, except that in experiment B, the **screen is farther away** from the double slit. On the screen:

a) The fringes are farther apart in experiment B than they are in experiment A .

b) The fringes are closer together in experiment B than they are in experiment A .

When we talk about completely destructive interference in the context of the Young's double slit experiment, what exactly is it that is adding up to zero?

a) The wavelengths of the waves.

b) The amplitudes of the waves.

c) Electric and magnetic fields.

What happens to the fringes in a single-slit diffraction pattern if you increase the slit width?

a) They spread apart.

b) They move closer together.

What happens to the fringes in a diffraction pattern if you switch to a longer wavelength?

a) They spread apart.

b) They move closer together.

In single slit diffraction we see light in what we might expect to be shaded regions. The same thing happens with radio waves. If, relative to the broadcast antennas of a radio station broadcasting in both AM and FM, you are in the “shade” of a building, which kind of station are you more likely to receive?

a) AM

b) FM

Does the single-slit diffraction effect take place in the double-slit experiment?

a) Yes

b) No

In single slit interference, a point in space forward of the slit, is getting many different contributions which are said to interfere with each other. Interference refers to the adding up of the contributions to yield a whole that is different than the parts. The question is, in the case of light, contributions of exactly what?

a) Frequencies.

b) Amplitudes.

c) Wavelengths.

d) Electric field vectors.

Consider a single slit of adjustable width upon which light of a single wavelength is incident. Upon passing through the slit, the light hits a semi-cylindrical screen centered on the slit and aligned such that any light that passes through the slit hits the screen. Under what conditions will there be no diffraction minima (dark spots)?

a) The wavelength of the light must be less than the slit width.

b) The wavelength of the light must be greater than the slit width.

c) There will always be at least one diffraction minimum.

d) None of the above.

In terms of light normally incident on a mask with one or more slits, how does interference differ from diffraction?

a) Interference involves the interference of light that passes through one slit with the light that passes through another slit whereas diffraction involves light passing through one part of a slit interfering with light that passes through another part of the same slit.

b) Interference involves the interference of light waves whereas diffraction involves the bending of light.

c) Interference involves several different wavelengths of light whereas diffraction involves a single wavelength.

d) None of the above.

What do we mean by temporal coherence?

a) **The electric field oscillations at one point along the path on which the light is traveling are in synchronization with the electric field oscillations at a point that is ahead of or behind the first point.**

b) **Defining the direction in which the light is traveling to be the forward direction, we mean that the electric field oscillations at one point in a light beam are in synchronization with the electric field oscillations at a point whose position is transverse to (above, below, or beside) the first point.**

What do we mean by **spatial** coherence?

a) The electric field oscillations at one point along the path on which the light is traveling are in synchronization with the electric field oscillations at a point that is ahead of or behind the first point.

b) The electric field oscillations at one point in a light beam are in synchronization with the electric field oscillations at a point whose position vector, relative to the first point, is transverse to the direction in which the light is traveling.

White light in air is normally incident on a thin film of n=1.25 transparent material on glass for which n=1.4 . The path difference for the two relevant reflections is 3 wavelengths-in-the-film-material of green light. Looking at the glass as nearly head-on as possible, one sees a bright green glare. A different white light source is then used and the green glare is no longer evident. What is different about the second light source?

a) **There is less spatial coherence of the green light of the relevant wavelength.**
b) **There is less temporal coherence of the green light of the relevant wavelength.**

White light in air is normally incident on a thin film of n=1.25 transparent material on glass for which n=1.4 . The path difference for the two relevant reflections is 3 wavelengths-in-the-film-material of green light. Looking at the glass as nearly head-on as possible, one sees a bright green glare. The same light is incident, on a different piece of glass with a different thickness of the same coating, at an angle of 35° relative to the normal. Again, the path difference for the two relevant reflections is 3 wavelengths-in-the-film-material of the same green light. This time, however, there is no green glare evident at any angle. Why?

a) **The light lacks sufficient temporal coherence for constructive interference.**

b) **The light lacks sufficient spatial coherence for constructive interference.**

A drop of gasoline is allowed to fall onto a puddle of water. It spreads out over the surface of the water and is illuminated by the sun. A person looking at the puddle sees a rainbow of colors. Name the phenomenon.

a) Diffraction.

b) Refraction.

c) Thin Film Interference.

d) Magnification.

e) None of the above.

A thin film of transparent material whose index of refraction *n* is between that of air and that of glass is put on some glass. What is the minimum thickness of the film required for maximum constructive interference of the reflected light in the case of light (in air) of wavelength lambda normally incident upon the coated surface of the glass?

a) $\lambda/4$

b) $n\lambda/4$

c) $(\lambda/n)/4$

d) $\lambda/2$

e) $n(\lambda/f)(\lambda/n)/2$

f) λ

g) $n\lambda$

h) λ/n

i) None of the above.

A person is looking straight down on a flat horizontal glass plate illuminated from directly below the plate by a monochromatic coherent light source. On top of the glass plate is another glass plate. The person sees a circular interference pattern that is dark the center. This means that, regarding the light reflected from the thin film of air between the plates:

a) The normally incident light is experiencing destructive interference.

b) The normally incident light is experiencing constructive interference.

A person is looking straight down on a flat horizontal glass plate illuminated from directly below the plate by a monochromatic coherent light source. On top of the glass plate is another glass plate. The person sees a circular interference pattern that is dark the center. What is the minimum increase in thickness that would have to be added to the layer of air in the center in order to make the center appear maximally bright?

a) $\lambda/4$

b) $n\lambda/4$

c) $(\lambda/n)/4$

d) $\lambda/2$

e) $n(\lambda/f)(\lambda/\mathrm{n})/2$

f) λ

g) $n\lambda$

h) λ/n

i) None of the above.

Is it possible for thin film interference to occur if the index of refraction of both of the media between which the thin film is sandwiched is the same as the index of refraction of the medium of which the thin film consists?

a) Yes

b) No

Is it possible for thin film interference to occur if the index of refraction of *only one* the media between which the thin film is sandwiched is the same as the index of refraction of the medium of which the thin film consists?

a) Yes

b) No

As regards the formation of an image by an optical system such as a plane mirror, what will serve as an object?

a) An emitter of light, such as, a candle.

b) A diffuse reflector of light.

c) Both a and b.

d) None of the above.

What is the difference between a real image and a virtual image?

a) A real image is formed by rays of light that converge onto the position of the image whereas a virtual image isn't.

b) A real image will appear on a piece of tissue paper, the way a power point slide on a screen does, if the tissue paper is held at the position of the image. A virtual image won't.

c) Both a and b above.

d) None of the above.

What minimum distance below eye level must a head-high plane vertical mirror extend in order for a person standing straight up in front of the mirror to be able to see his own feet? Assume the person to be more than a meter away from the mirror but less than 5 meters.

a) **About 2 cm down toward the floor from eye level.**

b) **About one quarter of the way down to the floor from eye level.**

c) **About one half of the way down to the floor from eye level.**

d) **All the way down to the floor.**

The law of reflection states that the angle of reflection is equal to the angle of incidence. In that statement, what is meant by the expression "angle of reflection?"

a) The angle of reflection is the angle between the image and the object.

b) The angle of reflection is the angle between the reflected ray and the normal.

c) The angle of reflection is the angle between the reflected ray and the surface of the mirror.

d) The angle of reflection is the angle between the reflected ray and the incident ray.

Completely unpolarized horizontally traveling light of intensity I_0 is normally incident on a vertical polarizer. The light that gets through is then normally incident on a horizontal polarizer. How does the intensity I_2 of the light that gets through both polarizers compare with I_0?

a) $I_2 = 0$

b) $I_2 = 0.25\, I_0$

c) $I_2 = 0.5\, I_0$

d) $I_2 = I_0$

e) None of the above.

Completely unpolarized, horizontally-traveling light is normally incident on an ideal polarizer whose polarization direction makes an angle of 25° with the vertical. How does the intensity I_1 of the light that gets through the polarizer compare with the intensity I_0 of the incident light?

a) $I_1 = I_0$

b) $I_1 = I_0 \cos 25°$

c) $I_1 = I_0 (\cos 25°)^2$

d) $I_1 = 0.5\, I_0$

e) None of the above

Completely horizontally-polarized, horizontally-traveling light is normally incident on an ideal polarizer whose polarization direction makes an angle of 25° with the vertical. How does the intensity I_1 of the light that gets through the polarizer compare with the intensity I_0 of the incident light?

a) $I_1 = I_0$

b) $I_1 = I_0 \cos 25°$

c) $I_1 = I_0 (\cos 25°)^2$

d) $I_1 = 0.5\, I_0$

e) None of the above

In an ongoing two-slit interference experiment involving initially unpolarized light, one slit is covered with a horizontal polarizer and the other with a vertical polarizer. What happens to the pattern of light on the screen?

a) **Both the interference pattern and the diffraction pattern go away. You see a bright dot on the screen, of the same shape as you get with no obstruction, but, of lesser brightness.**
b) **The diffraction pattern goes away but the interference pattern remains.**
c) **The interference pattern goes away but the diffraction pattern remains.**

Unpolarized light of intensity I_0 passes through an ideal vertical polarizer giving it an intensity I_1 and then an ideal polarizer at 15° with respect to the vertical giving it an intensity I_2.

In a separate experiment, vertically polarized light of the same intensity I_0 passes through the same two polarizers yielding I_1' and I_2' respectively. How does I_2' compare to I_2?

a) $I_2' = I_2$

b) $I_2' = 2\,I_2$

c) $I_2' = .5\,I_2$

d) None of the above

What is the appropriate polarization direction for polarized sunglasses?

a) Horizontal

b) Vertical

Completely unpolarized horizontally traveling light of intensity I_0 is normally incident on a vertical polarizer. The light that gets through is then normally incident on a second, and then a third polarizer. The polarization direction of the 3rd polarizer is horizontal. Does the intensity of the light, if any, that makes it through all three polarizers depend on the polarization direction of the second polarizer?

a) **Yes**
b) **No, because none makes it through all three polarizers.**

Completely unpolarized light of intensity I is normally incident upon a polarizer. The light passing through that polarizer is then normally incident upon a second polarizer. What is the maximum possible value of the intensity of the light that makes it through the second polarizer?

a) $I/4$

b) $I/2$

c) I

d) $2I$

e) $4I$

In the expression $I = I_o [\cos(\theta)]^2$, the angle θ is the angle between what and what?

a) The polarization direction of the first polarizer and the polarization direction of the second polarizer.

b) The polarization direction of the light and the polarization direction of the polarizer.

c) The direction in which the light is traveling and the direction of polarization of the light.

d) The polarization direction that the polarizer makes with the vertical.

e) The direction of polarization of the polarizer and the horizontal.

Given that the light given off by the sun is completely unpolarized, what is the point of polarized sunglasses?

a) Sunlight is horizontally polarized when it undergoes specular reflection (as light reflects off a mirror), the kind of reflection that forms glare. The lenses in polarized sunglasses are oriented so that the polarization direction of the lenses is vertical. The lenses thus absorb most of the glare (and, as a side effect, half of the unpolarized light).

b) The purpose is to reduce the intensity of light about to enter one's eyes to one half of its value.

c) None of the above.

A physics professor has a polarizer and wants to determine the polarization direction of the polarizer so that she can draw a line on it, in the direction of polarization, for future reference. Assume that she is in a building like the Goulet Science Center on a sunny winter day. How can she determine the direction of polarization of the polarizer?

Three polarizers are lined up one behind the other. The polarization direction of the 1st polarizer is vertical. The polarization of the 3rd polarizer is horizontal. Unpolarized light approaching the polarizers along a path at right angles to the surfaces of all the polarizers hits the 1st polarizer first. What must the polarization direction of the 2nd polarizer be in order to minimize the intensity of the light that makes it through all three?

a) Horizontal.
b) Vertical.
c) Either horizontal or vertical.
d) It doesn't matter. No light makes it through all 3 for any polarization direction of the second polarizer.
e) 45° with respect to the vertical.
f) 45° with respect to the horizontal.
g) Answers e and f are the same and both are correct.

As regards the formation of an image by an optical system such as a plane mirror, what will serve as an object?

a) An emitter of light, such as, a candle.

b) A diffuse reflector of light.

c) Both a and b.

d) None of the above.

What is the difference between a real image and a virtual image?

a) **A real image is formed by rays of light that converge onto the position of the image whereas a virtual image isn't.**

b) **A real image will appear on a piece of tissue paper, the way a power point slide on a screen does, if the tissue paper is held at the position of the image. A virtual image won't.**

c) **Both a and b above.**

d) **None of the above.**

What minimum distance below eye level must a head-high plane vertical mirror extend in order for a person standing straight up in front of the mirror to be able to see his own feet? Assume the person to be more than a meter away from the mirror but less than 5 meters.

a) **About 2 cm down toward the floor from eye level.**
b) **About one quarter of the way down to the floor from eye level.**
c) **About one half of the way down to the floor from eye level.**
d) **All the way down to the floor.**

The law of reflection states that the angle of reflection is equal to the angle of incidence. In that statement, what is meant by the expression "angle of reflection?"

a) The angle of reflection is the angle between the image and the object.

b) The angle of reflection is the angle between the reflected ray and the normal.

c) The angle of reflection is the angle between the reflected ray and the surface of the mirror.

d) The angle of reflection is the angle between the reflected ray and the incident ray.

Consider a light ray incident upon a flat glass/air interface. Under what conditions will some of the light be reflected?

a) Some of the light will be reflected under any conditions.

b) Some of the light will be reflected if and only if the light is initially traveling in the air.

c) Some of the light will be reflected if and only if the light is initially traveling in the glass.

d) Some of the light will be reflected if and only if both of the following conditions are met: The light is initially traveling in the glass, and, the angle of incidence is greater than the critical angle.

e) Some of the light will be reflected if and only if both of the following conditions are met: The light is initially traveling in the glass, and, the angle of incidence is less than the critical angle.

The flat surface of a thick chunk of glass is facing a person, who in turn, is facing the glass. A ray of light from a position just to the right of the person is directed at the glass. It hits a point on the glass directly in front of the person. Some of the light passes through the interface. After it passes through the interface, the light is:

a) to the left of the normal (from the point of view of the person).

b) to the right of the normal (from the point of view of the person).

c) traveling along the normal.

d) There is no light on the other side of the interface.

A ray of light traveling in air encounters the smooth surface of a pool of water. Some of the light goes through. In this case, the normal is a vertical line passing through the point where the light hits the water.

a) True

b) False

A ray of light traveling in a pool of water encounters the smooth surface of water. (The light is not normally incident upon the surface.) Some of the light goes through the surface and into the air. Inside the water, the ray makes a smaller angle with the normal than it does when it is in the air.

a) True

b) False

You are out of the water, looking at a rock on the bottom of a swimming pool that is full of water. Where does the rock appear to be?

a) Farther below the surface of the water than it really is.

b) Closer to the surface of the water than it really is.

c) At the same distance below the surface that it really is.

A ray of light hits the interface between the transparent medium it is in and another transparent medium. The ray experiences total internal reflection. How does the index of refraction of the medium the light is in compare with that of the other medium?

a) The medium the light is in has a smaller index of refraction.

b) The medium the light is in has a larger index of refraction.

c) They are both the same.

Do parallel rays that enter a concave lens diverge after passing through the lens?

a) Yes

b) No

What do rays emanating from a point on an object do before they pass through any lenses?

a) They converge.

b) They are parallel to each other.

c) They diverge.

Is it possible for a converging lens alone to form a virtual image of a real object?

a) Yes

b) No

Is it possible for a diverging lens alone to form a real image of a real object?

a) Yes

b) No

Rays from a real object pass through a converging lens. After the rays pass through the lens, are the rays necessarily converging?

a) Yes

b) No

Which of the following statements about a concave lens is true?

1) It is a converging lens.

2) It is a diverging lens.

3) It has a positive focal length.

4) It has a negative focal length.

a) 1 and 3

b) 2 and 4

c) 1 and 4

d) 2 and 3

e) Only one of the statements is true.

A system of one or more thin spherical lenses forms an image. What does it mean for the image distance to be negative?

a) The image is inverted.

b) The image is virtual.

c) The image is behind the lens (when light hits the front of the lens).

d) The premise of the question is flawed. The image distance can't be negative.

e) None of the above.

A single lens, acting alone, forms an image of an actual light bulb. What does it mean for the object distance to be negative?

a) **The object is inverted.**
b) **The object is virtual.**
c) **The object is behind the lens (when light hits the front of the lens).**
d) **Both b and c above.**
e) **The premise of the question is flawed. The object distance can't be negative.**
f) **None of the above.**

The second lens (counting from an actual object) of a two-lens system forms an image of the object. What does it mean for the object distance, *for that lens*, to be negative?

a) **The object is inverted.**
b) **The object is virtual.**
c) **The object is behind the lens (when light hits the front of the lens).**
d) **Both b and c above.**
e) **The premise of the question is flawed. The object distance can't be negative.**
f) **None of the above.**

The lens equation reads $1/f = 1/o + 1/i$. Is this equivalent to $f = o + i$?

a) Yes

b) No

The lens equation reads $1/f = 1/o + 1/i$. Is it possible to find an f and an o that would yield an infinite i ?

a) Yes

b) No

An object is placed between the focal point of a lens, and the lens itself. The focal length of the lens is –22 cm. The object is 6 cm from the focal point. What is *o*?

- **a) –28 cm**
- **b) –22 cm**
- **c) –16 cm**
- **d) –6cm**
- **e) 6 cm**
- **f) 16 cm**
- **g) None of the above.**

Consider a sewing needle that is on one side of (call it in front of) a lens of focal length 14.7 cm, and assume that the needle remains on that one side of the lens and that the needle is always aligned perpendicular to the principal axis of the lens with one end on the principal axis of the lens. How many correct answers are there to the question: How far must the needle be from the plane of the lens in order to form an image that is 11.8 cm from the plane of the lens?

a) 0
b) 1
c) 2
d) 3
e) 4

A charge distribution lies along a segment of the positive x axis. On that segment, the linear charge density λ is $\frac{b}{x'}$ where b is a constant having units of Coulombs. What is the charge on an infinitesimal length dx' of the charged segment?

a) $\frac{b}{x'}dx'$
b) $q\ dx'$
c) λ
d) b
e) $b\ dx'$

In Coulomb's Law for the Electric Field, $E = \frac{k|q|}{r^2}$ what does the r stand for?

a) Radius

b) The separation of the charged particle and the point in space at which the electric field is being calculated.

c) The separation of the two charged particles.

d) None of the above.

Three charged particles lie on the x axis: one at the origin, one to the left of the origin (that is, at a position having a negative x value), and another to the left of that one. A person is asked to determine the electric field due to the trio, at a point on the positive y axis. The person determines the distance r that each particle is from the point on the y axis in question and then calculates the value of $E = \frac{k|q|}{r^2}$ for each of the three particles in turn. Then the person adds the three values thus determined and gives the sum as the total electric field at the point on the y axis in question. Is this procedure correct?

a) Yes.

b) No.

In calculating the electric field due to a charged line segment, one considers each bit of the line segment to be a point charge.

a) True.
b) False.

The author of your textbook states that, conceptually, the outward electric flux through a closed surface is the net number of electric field lines poking outward through that surface. Are electric field lines real physical entities?

a) Yes.
b) No.

The average electric flux through a rectangle is the dot product between the area vector for that rectangle and the average electric field vector on the flat rectangular region.

a) True.
b) False.

Would it be reasonable to say that each electric field line in an electric field diagram represents a certain amount of flux?

a) Yes.
b) No.

A person creates a 3-D electric field line model for a region in space in the vicinity of a distribution of charge. Another person creates her own model for the same distribution of same amount of charge but this person shows four times as many field lines. Does that mean that the flux a particular closed surface will be greater in the latter case?

a) Yes.
b) No.

A person creates a 3-D electric field line model for a region in space in the vicinity of a distribution of charge. Another person creates her own model for the same distribution of same amount of charge but this person shows four times as many field lines. In which case is a single electric field line supposed to represent more flux (more than in the other case)?

a) In the model with the smaller number of electric field lines.
b) In the model with the greater number of electric field lines.

Wanda creates an electric field line model of the electric field due to a positive point charge. Larry argues that one can’t associate an amount of flux with each field line because if you enclose the point charge with a sphere centered on the point charge, a bigger sphere would have more area and hence, more actual flux, but, the number of field lines through it (in the model) would be the same as for a smaller sphere.

a) Larry is right.
b) Larry is wrong.

Wanda creates an electric field line model of the electric field due to a positive point charge. Larry argues that one can't associate an amount of flux with each field line because if you enclose the point charge with a sphere centered on the point charge, all points on the surface of a smaller field would be at locations where the electric field is greater (than at points on the surface of a bigger sphere) so there would be more actual flux through the smaller sphere, but, the number of field lines (in the model) through it would be the same as for a larger sphere.

a) Larry is right.
b) Larry is wrong.

Consider an imaginary surface in the shape of a closed box. There is no matter inside the box. Beside the imaginary box is a positively-charged glass rod. What can you say about the net outward flux through the box?

a) It is less than zero.
b) It is greater than zero.
c) It is zero.

Consider an imaginary closed surface in the shape of a tuna fish can. A person establishes that the net outward flux through the surface is greater than zero. What can you say about the net charge inside the closed surface?

a) It is less than zero.

b) It is greater than zero.

c) It is zero.

(Demo using board of nails and wire loop held with plane of loop parallel to board at each of 2 locations. The nails represent electric field lines.) In which case is the electric flux through the loop greater?

a) In the first case.
b) In the second case.
c) Neither.

(Demo using board of nails and wire loop held with plane of loop perpendicular to board at each of 2 locations.) In which case is the electric flux through the loop greater?

a) In the first case.
b) In the second case.
c) Neither.

(Demo. Put model of positive point charge in box.) What can you say about the net flux through the box for the actual case that is represented by the model?

a) It is less than zero.

b) It is greater than zero.

c) It is zero.

(Demo. Put model of positive point charge in box.) What can you say about the net charge in the box for the actual case that is represented by the model?

a) It is negative.

b) It is positive.

c) It is zero.

What do the differential and the circle on the integral sign tell you about the integral $\oint \vec{\mathbf{E}} \cdot \vec{\mathbf{dA}}$?

a) **That the integral is over a closed surface.**
b) **That the integral is about a closed loop.**
c) **That the integral is about a circle.**
d) **None of the above.**

Given a specified unsymmetrical charge distribution and an imaginary closed surface enclosing all or a specified part of the charge distribution and asked to find the net outward electric flux through the surface, which is the better way to proceed?

a) Find the electric field at each point on the surface, and integrate $\oint \vec{\mathbf{E}} \cdot \vec{\mathbf{dA}}$.

b) Calculate the total amount of charge enclosed by the imaginary surface and divide the result by ϵ_o.

c) Neither. The net electric flux is zero.

Gauss's Law for the magnetic field is a statement of the fact that electric charge has no analog in magnetism. That is, there is no such thing as a magnetic monopole.

a) True.
b) False.

Magnetic flux plays the same role in Gauss's Law for the magnetic field that electric flux plays in Gauss's Law for the electric field.

a) True.

b) False.

Gauss's Law for the magnetic field involves the exact same kind of integral over the same kind of area as occurs in Gauss's Law for the electric field. The only difference is that in the former case the integral involves the magnetic field whereas in the latter case the integral involves the electric field.

a) True.
b) False.

Gauss's Law involves an integral over a surface whereas Ampere's Law involves an integral along a curve.

a) True.
b) False.

Ampere's Law is a statement of the fact that charge flow causes magnetic field.

a) True.
b) False.

What is electric current?

a) Charge speed.

b) Charge flow rate.

In applying Ampere’s Law, one uses an imaginary loop.

a) True.

b) False.

In applying Ampere's Law one addresses the question as to what the charge flow rate about the amperian loop is.

a) True.
b) False.

When we talk about the current through the amperian loop in the case of Ampere’s Law, we are talking about charge flow along a line or curve that “pokes through” the surface for which the amperian loop is the perimeter.

a) True.

b) False.

The perimeter (edge) of a tabletop forms what we mean by a closed loop in the context of Ampere’s Law whereas the surface of an inflated balloon forms a closed surface in the context of Gauss’s Law.

a) True.

b) False.

The top surface of a pond would be an example of an open surface whereas the outer surface of a football would be an example of a closed surface.

a) True.

b) False.

Which one of the following laws involves an imaginary loop?

a) Ampere’s Law

b) Coulomb’s Law

c) The Biot-Savart Law

d) Gauss’s Law for the Electric Field

e) Gauss’s Law for the Magnetic Field

Which one of the following laws involves an imaginary surface?

a) Ampere’s Law

b) Coulombs Law

c) The Biot-Savart Law

d) Gauss’s Law for the Electric Field

e) None of the above.

In applying the Biot-Savart Law to calculate the magnetic field at an empty point in space, call it point P, due to a straight current-carrying wire segment; what is the direction of $\vec{d\ell}$?

a) From the source current element toward point P.

b) From point P toward the source current element.

c) In the positive x, y, or z axis direction, depending on which axis the wire is on.

d) In the direction of the current.

e) In the direction opposite to that of the current.

In applying the Biot-Savart Law to calculate the magnetic field at an empty point in space, call it point P, due to a straight current-carrying wire segment; what is the direction of $\vec{r}$?

a) From the source current element toward point P.

b) From point P toward the source current element.

c) In the positive x, y, or z axis direction, depending on which axis the wire is on.

d) In the direction of the current.

e) In the direction opposite to that of the current.

A bar magnet that is aligned vertically, north pole up, has a constant horizontal velocity relative to you. Despite the absence of any unpaired charge, you observe that there is, in your reference frame, an eastward-directed electric field directly above the bar magnet. Which way is the magnet moving?

a) Northward.

b) Southward.

c) Eastward.

d) Westward.