Name _____

Hour _____

Question A:
 An 18 Ω resistor and a 6.0 Ω resistor are connected in series across an 18 V battery.
 a) Find the current through each resistor and the voltage drop across each resistor.
 b) Repeat Part *a* for the situation in which the same resistors are connected in parallel across the 18 V battery.

Question B:
 Three resistors are connected to a 12 V source in the circuit shown at right.
 a) Draw a circuit diagram of the circuit shown. Add an ammeter to measure current through the entire circuit and a voltmeter to measure the potential difference across the 4 Ω resistor.
 b) Calculate the reading shown on the ammeter.
 c) Calculate the reading shown on the voltmeter.
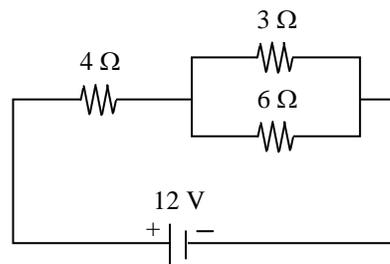
Question C:
 A 14 Ω coffee maker and a 16 Ω frying pan are connected in series across a 120 V source. A 23 Ω bread maker is also connected across the 120 V source and is in parallel with the series combination.
 a) Draw a circuit diagram of this situation. Include an ammeter to measure the current through the bread maker and a voltmeter to measure the potential difference across the frying pan.
 b) Calculate the reading shown on the ammeter.
 c) Calculate the reading shown on the voltmeter.

Question D:
 A 9.60 Ω electric heater and a 17.0 Ω toaster are connected in parallel across a 120 V source.
 a) Draw a circuit diagram of this situation. Include an ammeter to measure the current through the toaster and a voltmeter to measure the potential difference across the entire circuit.
 b) Calculate the reading shown on the ammeter.
 c) Calculate the power dissipated by the toaster.

Question E:
 A 200.0 µF capacitor and a 10.0 Ω resistor are connected in parallel to a 6.0 V battery, as shown in the schematic at right. The resistor is connected to Switch 1, which is originally closed, and the capacitor is connected to Switch 2, which is originally open. For this situation, determine . . .
 a) the current in the resistor.
 b) the charge stored on the capacitor.
 Switch 2 is then closed, and the circuit is allowed to stabilize. For this situation, determine . . .
 c) the current in the resistor.
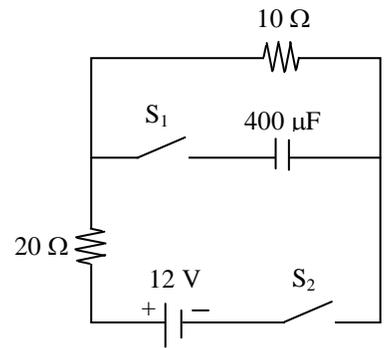 d) the charge stored on the capacitor.
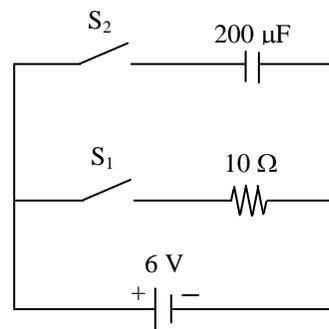
Question F:
 A 2500.0 µF capacitor and a 50.0 Ω lamp are connected in series to a 9.0 V power source. A switch in the circuit is closed, connecting the circuit.
 a) Draw a circuit diagram of this situation.
 b) Determine the current through the lamp immediately after the switch is closed.
 c) Determine the charge stored on the capacitor immediately after the switch is closed.
 d) Determine the current through the lamp after the circuit has reached steady state conditions.
 e) Determine the charge stored on the capacitor after the circuit has reached steady state conditions.
 f) Describe the changes in the light emitted by the lamp from the time when the switch is closed until the circuit reaches steady state conditions.
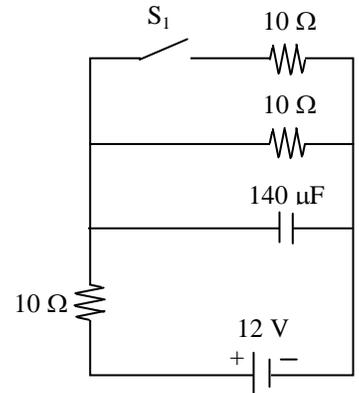
Question G:

A 400.0 μF capacitor, a 10.0 Ω lamp and a 20.0 Ω resistor are connected to a 12.0 V battery, as shown in the schematic at right. Switch 1 and Switch 2 are both initially closed and the circuit is in steady state conditions. For this situation, calculate . . .

  a) the current through the 20 Ω resistor.
  b) the electric potential difference over the 10 Ω lamp.
  c) the charge stored on the capacitor.

Switch 1 is then opened while Switch 2 remains closed.

  d) What effect, if any, does this have on the 10 Ω lamp?

Switch 2 is then opened and Switch 1 is again closed.

 e) What effect, if any, does this have on the 10 Ω lamp?

Question H:

A 140.0 μF capacitor and three 10.0 Ω resistors are connected to a 12.0 V battery as shown in the schematic at right. One 10.0 Ω resistor is connected to Switch 1 which is originally closed. For this situation, calculate . . .

  a) the potential difference across the capacitor.
  b) the charge stored on the capacitor

Switch 1 is then opened and is left open for a long time.

  c) Calculate the new amount of charge stored on the capacitor.

Question I:

A battery with emf 9.0 V and internal resistance 1.5 Ω is connected to a resistance R, as shown at right.
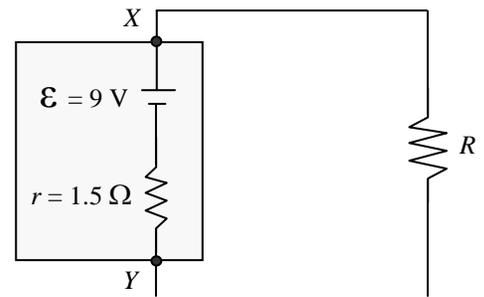
  a) If the resistance R is 20.0 Ω, calculate the current in the circuit.
  b) Calculate the terminal voltage, V_{XY}, of the battery.
  c) If the resistance R is 30.0 Ω, calculate the current in the circuit.
  d) Calculate the new value of terminal voltage, V_{XY}, of the battery.
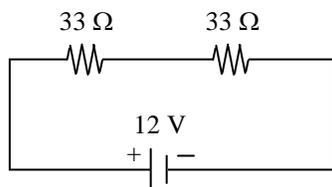
Question J:

A battery with emf 12.0 V and internal resistance 3.5 Ω is connected to a resistor of 45.0 Ω.

  a) Draw a circuit diagram of this situation.
  b) Determine the current in the circuit.
  c) Determine the terminal voltage of the battery.
  d) Determine the power dissipated in the 45.0 Ω resistor.
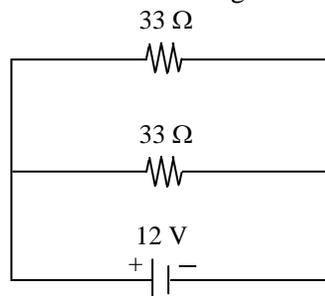
Question K:

Two 33 Ω resistors are connected to a 12.0 V battery as shown in the diagrams below. Determine the equivalent resistance of the circuit for . . .

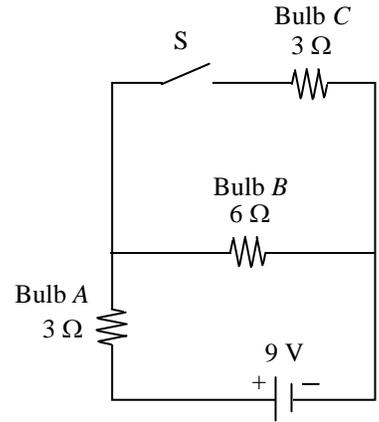 a) Arrangement A
  b) Arrangement B

Arrangement A

Arrangement B

Question L:

Lightbulbs of fixed resistance 3.0 Ω and 6.0 Ω, a 9.0 V battery, and a switch *S* are connected as shown in the schematic diagram at right. The switch *S* is closed.

a) Calculate the current in bulb *A*.
b) Which lightbulb is brightest? Justify your answer.
c) Switch *S* is then opened. Determine whether the brightness of each lightbulb increases, decreases, or remains the same. Explain your reasoning for each lightbulb.
    i. Bulb *A*
   ii. Bulb *B*
  iii. Bulb *C*

Bulb *C*
3 Ω

S

Bulb *B*
6 Ω

Bulb *A*
3 Ω

9 V

AP Physics: Chapter 19 & 20
Electromagnetism

Question A:

An electron travels with a velocity of 2.0×10^7 m/s into a magnetic field of .5 T as shown in the diagram at right.
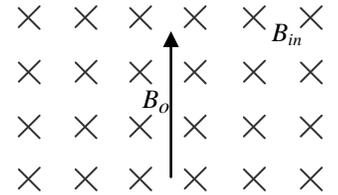
a) Calculate the magnitude and determine the direction of the magnetic force acting on the electron.
b) Calculate the magnitude and determine the direction of the electric field that could be added to the region in order to allow the electron to move at a constant velocity.

B_{in}

B_o

3 Ω
1 Ω

.4 m

.8 m
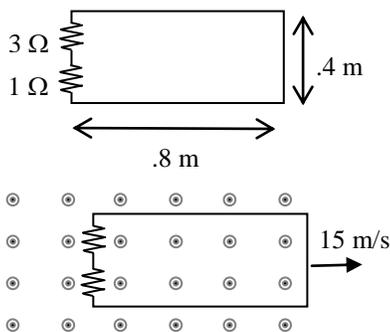
15 m/s

Question B:

A rectangular wire loop contains two resistors and has dimensions of .40 m by .80 m, as shown in the diagram at left. The loop is then placed in a uniform magnetic field directed out of the page and pulled with a constant velocity of 15 m/s to the right. As the wire loop exits the magnetic field, a current of .50 A is induced in the wire loop.

a) Calculate the strength of the magnetic field.
b) Determine the direction of the induced current through the resistors as the loop exits the magnetic field.
c) Calculate the magnitude of the force required to pull the wire loop out of the magnetic field with a constant velocity.
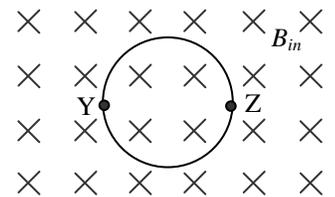
Question C:

A wire loop of area .17 m^2 is placed in a uniform magnetic field of .085 T, directed out of the page. As shown in the diagrams below, the wire loop is initially orientated so that it is perpendicular to the plane of the page and parallel to the plane of the magnetic field. During a time of .045 sec, the wire loop is rotated so that it is parallel to the plane of the page and perpendicular to the plane of the magnetic field.
  a) Calculate the magnitude of the induced emf in the wire loop during this transition.
  b) Determine the direction of the induced current through the resistor of the wire loop.
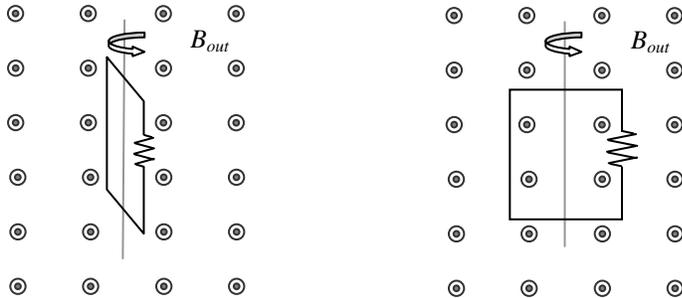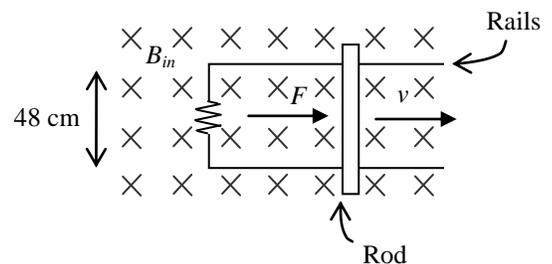
Question D:

A circular wire loop is placed in a uniform magnetic field of .086 T, directed into the page. The initial radius of the loop is .15 m.
  a) Suppose the wire loop is stretched at Points Y and Z, causing it to close completely to an area of zero in a time of .035 sec. Calculate the induced emf and determine the direction of the induced current in this situation.
  b) Suppose the wire loop remains undisturbed, but the strength of the magnetic field is increased to .159 T in a time of .035 sec. Calculate the induced emf and determine the direction of the induced current in this situation.

Question E:

A force of .35 N is applied to a conducting rod so that the rod slides with a constant velocity over a frictionless pair of parallel conducting rails, as shown in the diagram at right. The rails are connected by a wire of length 48 cm and a resistance of .50 Ω. There is a uniform magnetic field of .25 T directed into the page.
  a) Calculate the magnitude and determine the direction of the induced current.
  b) Calculate the electrical power dissipated in the .50 Ω resistor.
  c) Calculate the velocity of the conducting rod.
  d) Calculate the mechanical power delivered by the force as it moves the rod. How does this power compare to the answer for Part b above? Explain your answer.
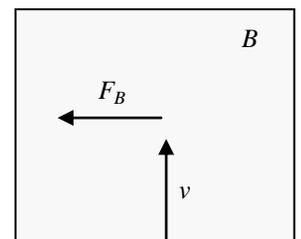
Question F:

In a television set, electrons travel at a velocity of 6.0 x 10^7 m/s. A strong magnet moved near the television set exerts a force of 6.2 x 10^{-12} N on a single electron, distorting the picture. Calculate the strength of the magnetic field.

Question G:

Some radioactive decay reactions release alpha particles, which have the same charge as two protons and a mass of 6.64 x 10^{-27} kg. A magnetic field of .075 T is used to exert a magnetic force of 3.6 x 10^{-15} N on a moving alpha particle, as shown in the diagram at right.
  a) Calculate the velocity of the alpha particle as it moves through the magnetic field.
  b) Determine the direction of the magnetic field required to cause this force.
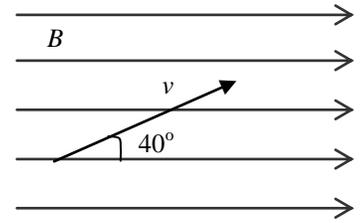
Question H:
 A particle accelerator of 22,000 V accelerates a proton. The proton then enters a magnetic field of .35 T.
 a) Calculate the kinetic energy of the proton after being accelerated by the particle accelerator.
 b) Calculate the velocity of the proton after being accelerated by the particle accelerator.
 c) Calculate the magnetic force exerted on the proton by the magnetic field.

Question I:
 A proton travels with a velocity of 3.0×10^6 m/s at an angle of $40°$ through a magnetic field as shown at right. Determine the magnetic force exerted on the proton if the magnetic field strength is .50 T.

Question J:
 At the Fermilab particle accelerator in Illinois, electromagnets accelerate protons around a large circular chamber of radius 1.0 km at a velocity of 3.14×10^7 m/s. Determine the strength of the magnetic field.


Cross Section of Cathode Ray Tube
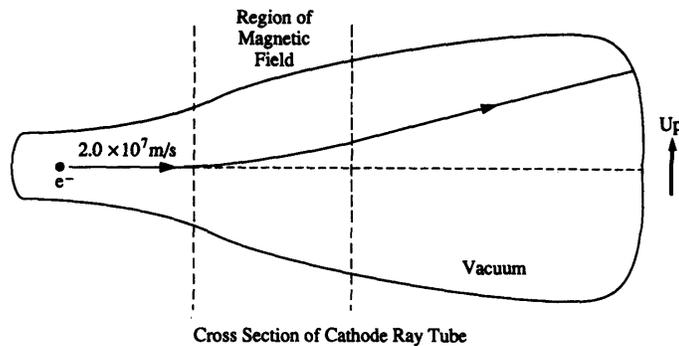
Question K:
 The figure above shows a cross section of a cathode ray tube. An electron in the tube initially moves horizontally in the plane of the cross section at a speed of 2.0×10^7 meters per second. The electron is deflected upward by a magnetic field that has a field strength of 6.0×10^{-4} Tesla.
 a) What is the direction of the magnetic field?
 b) Determine the magnitude of the magnetic force acting on the electron.
 c) Determine the radius of curvature of the path followed by the electron while it is in the magnetic field.
 An electric field is later established in the same region as the magnetic field such that the electron now passes through the magnetic and electric fields without deflection.
 d) Determine the magnitude of the electric field.
 e) What is the direction of the electric field?

Surface of Earth (North into the page)
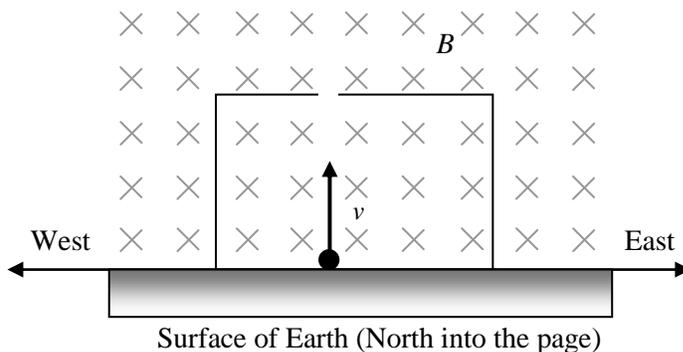
Question L:

A proton of mass m_p and charge e is in a box that contains an electric field E, and the box is located in Earth's magnetic field B. The proton moves with an initial velocity vertically upward from the surface of the Earth. Assume that gravity is negligible.

a) Determine the direction of the electric field inside the box so that there is no change in the trajectory of the proton while it moves upward in the box. Explain your answer.

b) Determine the speed v of the proton while in the box if it continues to move vertically upward. Express your answer in terms of the fields and the given quantities.

The proton now exits the box through the opening at the top.

c) Sketch the path of the proton after it leaves the box.

d) Determine the magnitude of the acceleration a of the proton just after it leaves the box, in terms of the given quantities and fundamental constants.

.08 m

B

I   I   .16 m
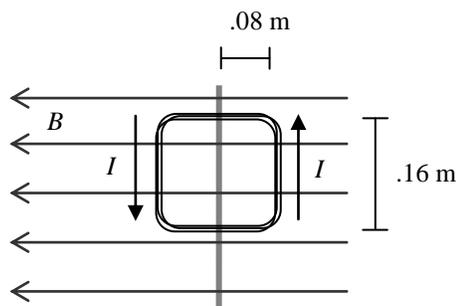
Question M:

A wire loop is created with 3 loops of wire within a magnetic field of .0065 T, as shown in the diagram at left. A current of .50 A moves through the wire, which has a length of .16 m and a distance of .08 m from the axis.

a) Calculate the magnetic force exerted on each side of a single wire in the loop.

b) Calculate the total torque exerted on each side of the wire loop.

c) Determine the direction of the magnetic force exerted on the right side of the wire loop.

d) Determine the direction of the magnetic force exerted on the left side of the wire loop.

Question N:

For each situation below, a current carrying wire induces a magnetic field. Sketch the direction of the induced magnetic field around each wire.

a) I_{out}

b) I_{in}

c) $\xrightarrow{\quad I \quad}$

d) $\xleftarrow{\quad I \quad}$

e) $\downarrow I$

f) $\uparrow I$
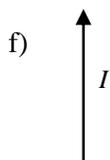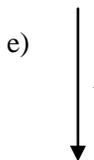
Question O:
  The magnetic field induced by a long wire in a household circuit is 3.4×10^{-4} T at a distance of .50 cm from the wire. Determine the current in the wire.

Question P:
  Wire A is attached to the lab table, and a current flows through it as shown in the diagram at right. Wire B is free to move, and a current also flows through it, as shown in the diagram. When current flows through both wires, which direction will Wire B move: towards Wire A or away from Wire A? Explain your answer.
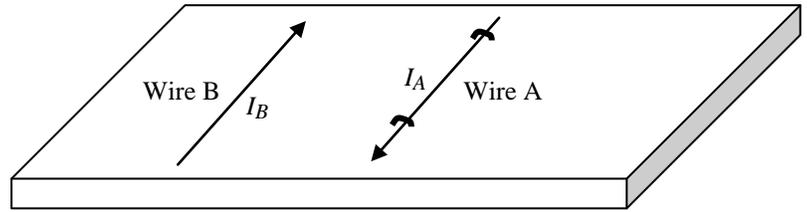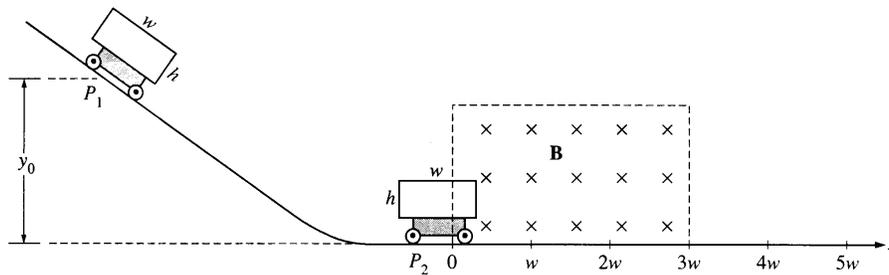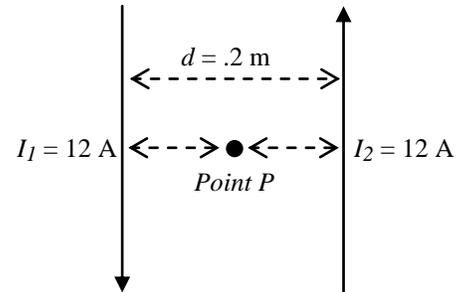
Question Q:
  For the situation described in Question #P, both wires have a length of 2.0 meters and carry a current of 1.5 Amps. They are separated by a distance of .15 m.
  a) Determine the strength of the magnetic field induced by Wire A at the location of Wire B.
  b) Determine the magnetic force exerted on Wire B by Wire A.

Question R:
  Two long straight wires carry identical currents of 12 Amps and are separated by .20 meters as shown at right. Point P is located halfway between them.
  a) Determine the strength of the magnetic field induced by each wire at Point P.
  b) Determine the strength of the net magnetic field at Point P.

Question S:
  A rectangular conducting loop of width w, height h, and resistance R is mounted vertically on a nonconducting cart as shown above. The cart is placed on the inclined portion of a track and released from rest at position P_1 at a height y_0 above the horizontal portion of the track. It rolls with negligible friction down the incline and through a uniform magnetic field B in the region above the horizontal portion of the track. The conducting loop is in the plane of the page, and the magnetic field is directed into the page. The loop passes completely through the field with a negligible change in speed. Express your answers in terms of the given quantities and fundamental constants.
  a) Determine the speed of the cart when it reaches the horizontal portion of the track.
  b) Determine the following for the time at which the cart is at position P_2, with one-third of the loop in the magnetic field.
       i. The magnitude of the emf induced in the conducting loop
       ii. The magnitude of the current induced in the conducting loop
  c) Determine the direction of the current when it is at Position P.