Equations

pV = nRT

pV^{γ} = constant (Q=0)

Q = $nC_v\Delta T$ (constant V)

$\gamma = C_p/C_v$

$C_p = C_v + R$

$C_v = \frac{3}{2}R$ (monatomic ideal gas)

ΔU=Q-W

R=8.3 J/molK

$$dS = \frac{dQ}{T}$$

$$W = \int pdV$$

$$e = \frac{W}{Q_H}$$

$$e_c = 1 - \frac{T_C}{T_H}$$

For H_2O:

L_f = 334 J/g

L_v = 2256 J/g

c = 4.2 J/gK (water)

= 2.1 J/gK (ice)

T_f = 273K

$$\frac{1}{4\pi\varepsilon_0} = k = 9\times 10^9 \text{ Nm}^2/\text{C}^2$$

1 nanoCoulomb = 1 nC = 10^{-9} C

$$\varepsilon_0 = 8.85\times 10^{-12} \text{ C}^2/\text{Nm}^2$$

$$F = \frac{k|qq_0|}{r^2} = q_0 E$$

$$U = \frac{kqq_0}{r} = q_0 V$$

$$\oint \vec{E}\cdot d\vec{A} = \frac{q_{enc}}{\varepsilon_0}$$

$$V = -\int \vec{E}\cdot d\vec{l}$$

$$E_x = -\frac{\partial V}{\partial x}$$

$$Q = CV$$

$$C_{pp} = \varepsilon A/d$$

$$\varepsilon = K\varepsilon_0$$

$$U_{cap} = \tfrac{1}{2}CV^2 = \tfrac{1}{2}Q^2/C$$

$$u = \tfrac{1}{2}\varepsilon E^2$$

$$C_{par} = C_1 + C_2$$

$$1/C_{ser} = 1/C_1 + 1/C_2$$

Inductance & LR Circuits

$$\mathcal{E} = -L\frac{di}{dt}$$

$$L_{coil} = N\Phi_B/i$$

$$U_{ind} = \tfrac{1}{2}LI^2$$

$$u = \frac{1}{2\mu_0}B^2$$

$$\tau = L/R$$

LC

$$\omega_0 = 1/\sqrt{LC}$$

AC Circuits

$$v = V\cos\omega t$$

$$V_{rms} = V/\sqrt{2}$$

$$V = IX$$

$$X = \begin{cases} R & \text{in phase} \\ \omega L & \text{v Leads i} \\ 1/(\omega C) & \text{v Chases i} \end{cases}$$

$$P = V_{rms}I_{rms}\cos\phi$$

Sources of B

$$\boxed{\mu_0 = 4\pi\cdot 10^{-7} \text{ Tm/A}}$$

Ampere: $\oint \vec{B}\cdot d\vec{l} = \mu_0(I_{enc} + \varepsilon_0\frac{d\Phi_E}{dt})$

$$\vec{B} = \frac{\mu_0}{4\pi}\frac{q\vec{v}\times\hat{r}}{r^2}$$

$$d\vec{B} = \frac{\mu_0}{4\pi}\frac{Id\vec{l}\times\hat{r}}{r^2}$$

Responses to B

$$\vec{F} = q\vec{v}\times\vec{B}$$

$$d\vec{F} = Id\vec{l}\times\vec{B}$$

Torque on current loop:

$$\vec{\tau} = \vec{\mu}\times\vec{B} \qquad \vec{\mu} = I\vec{A}$$

Resistors and Circuits

$$I = nqv_d A$$

$$\vec{J} = nq\vec{v}_d$$

$V = IR$ Ohm's Law

$R = \frac{\rho L}{A}$ cylindrical resistor

$$P = IV$$

$P_R = I^2R = V^2/R$ power in a resistor

$R_{eq} = R_1 + R_2 + \ldots$ in series

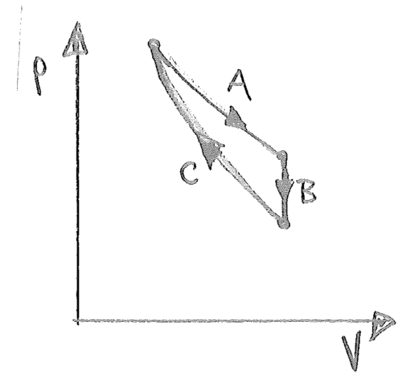
$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ in parallel

$q = C\mathcal{E}(1 - e^{-t/RC})$ charging

$q = q_0 e^{-t/RC}$ discharging

Physics 161 Fall 2011 Final Examination
10 answer orange scantron (#0-9). Last name COMES FIRST. DO NOT CHEAT, or pretend to cheat, or appear to be cheating. 50 Questions. For 1-digit answers, enter 9 for 9 or greater. Round to the nearest even integer (e.g. 4.5 rounds to 4, 5.5 rounds to 6.) **Closed book, closed notes, calculator ok.**

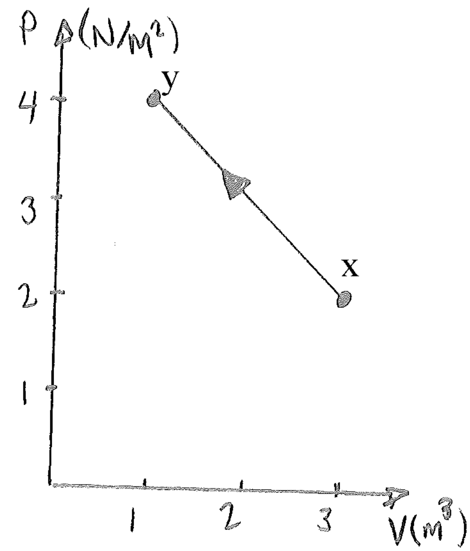
A monatomic ideal gas is taken around the cycle shown.
Each path may be isothermal, isobaric, isochoric, or adiabatic.



1. Which path is adiabatic?
2. Which path is isothermal?
3. Taken around the cycle in the direction shown, this is

a) an engine b) a refrigerator
c) not enough information to tell d) neither

A monatomic ideal gas is taken from point x to y on the pV diagram, by a straight line path.



4. Is work done ON the gas or BY the gas?
a) on the gas b) by the gas c) no work is done

5. What is the magnitude of the work done, to the nearest Joule?

6. If the temperature of the gas at x is 600K, what is the temperature at y?
a) 0K
b) 100K
c) 200K
d) 300K
e) 400K
f) 600K
g) 900K
h) 1200K
i) 1800K

7. Is heat added to the gas, or removed from the gas?
a) added b) removed c) no heat is transferred

8. What is the magnitude of the heat transferred, to the nearest Joule? (Use 9 for 9 or larger.)

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9. Which is true?
a) No reversible engine can exceed Carnot efficiency, but an irreversible one can
b) No irreversible engine can exceed Carnot efficiency, but a reversible one can
c) No engine can exceed Carnot efficiency

10. Which is true?
a) All real processes are reversible, because the laws of mechanics depend only on second derivatives with respect to time
b) No real processes are reversible, because thermodynamic reversibility requires heat flow with infinitessimal temperature differences
c) Some real processes are reversible, like heating, but phase changes are “irreversible”

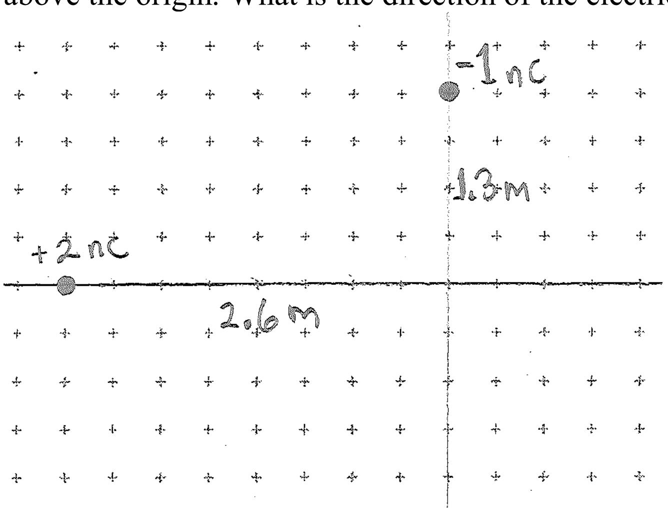
15 g of water at 40°C is mixed with 10 g of ice at 0°C in a perfect thermos. **Assume** 5 g of ice melts as the water cools to 0°C.

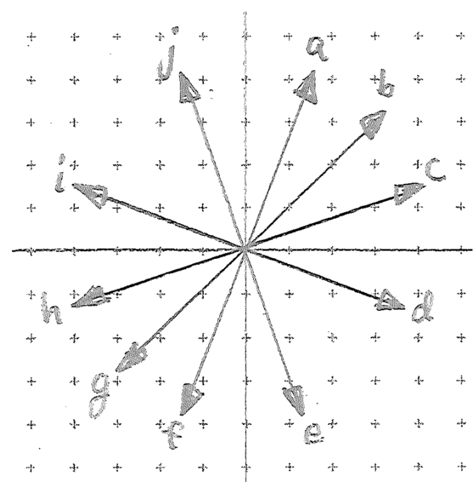
11. What is the magnitude of the entropy change of the ice that melts? (to the nearest J/K)

12. What is true of the entropy changes for the melting ice ΔS_{ice} and the cooling water ΔS_w?
a) both are negative (entropy of each decreases), so the sum < 0
b) both the positive (entropy of each increases), so the sum > 0
c) $\Delta S_{ice} <0$, $\Delta S_w >0$, the sum > 0
d) $\Delta S_{ice} >0$, $\Delta S_w <0$, the sum > 0
e) $\Delta S_{ice} <0$, $\Delta S_w >0$, the sum < 0
f) $\Delta S_{ice} >0$, $\Delta S_w <0$, the sum < 0
g) $\Delta S_{ice} =0$, $\Delta S_w >0$, the sum > 0
h) $\Delta S_{ice} =0$, $\Delta S_w <0$, the sum < 0
i) $\Delta S_{ice} >0$, $\Delta S_w <0$, the sum = 0

13. Is the assumption that "5g of ice melts" correct (to the nearest gram) ?
a) yes b) no, less ice melts c) no, more ice melts.

14. Two point charges are located as shown, +2 nC 2.6m to the left of the origin, and -1 nC 1.3 m above the origin. What is the direction of the electric field at the origin?



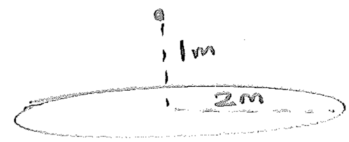


15. What is the magnitude of the field at the origin, to the nearest N/C?

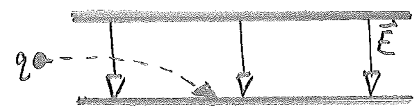
16. What is the potential at the origin, in volts? (Take V=0 at infinity.)

17. If these two charges are fixed in place, what would be the trajectory of a small positive point charge released from the origin?
a) it would follow the field lines and collide with the negative charge
b) it wouldn't move at all
c) it would move in a circular orbit around the negative charge
d) it would move in an elliptical orbit with one charge at each focus
e) it would move in a complex orbit, but never getting farther from the negative charge than 1.3 m
f) it would move in a complex orbit, but never getting closer to the positive charge than 2.6 m
g) both e&f are true
h) it would move in a complex trajectory, which might go to infinity

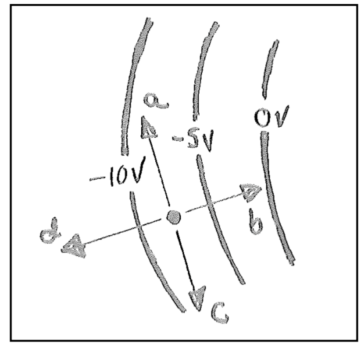
18. A ring of radius 2 m has total charge of +3.3 nC distributed uniformly. What is the electric field magnitude on the axis, a distance of 1 m above the center of the ring? (to the nearest N/C)(Hint: the only integral you need to solve this problem is $\int dq = q$.)



19. A parallel plate capacitor has an electric field of 4000 N/C; the plates are separated by 2 mm = 2×10^{-3} m. A point charge of 1 C enters the space between the plates, moving horizontally exactly halfway between the plates, with a kinetic energy of 4J. What is the kinetic energy of the charge just before it collides with one of the plates (to the nearest J)? Ignore gravity; enter 0 if insufficient information has been given.



20. A graph of equipotential lines is shown at right.
What is the direction of the E field? (Choose from the arrows.)



21. An electric field is given by $E_x = -x/2$, with x in meters and E in N/C. E_y and E_z are unknown. What is the potential difference between the origin and (x,y,z) = (4 m, 0, 0) (in V)? Enter zero if insufficient information has been given.

22. An electrical potential is given by V = 3x + 2, x in meters and V in volts. What is the magnitude of the electric field at the origin?

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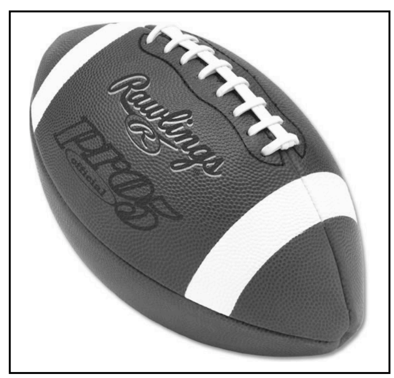
23. A football is made from 4 identical wedges of leather. If a point charge of Q lies at the exact center of the football, what is the flux of the electric field through each wedge?

a) $\frac{Q}{4\pi\varepsilon_0}$ b) $\frac{Q}{4\varepsilon_0}$ c) $\frac{Q}{4}$ d) $\frac{Q^2}{4}$ e) $\frac{4Q}{\varepsilon_0}$ f) $\frac{Q}{16}$ g) $\frac{Q^2}{16\varepsilon_0}$ h) 0

(Note: leather is non-conducting.)



24. If the area of each wedge is A, what is the electric field on each wedge?

a) 0 everywhere
b) $\frac{Q}{4A\varepsilon_0}$
c) $\frac{Q}{4A}$
d) $\frac{Q}{A\varepsilon_0}$
e) $\frac{Q}{4\pi A\varepsilon_0}$
f) it varies from place to place on the wedge

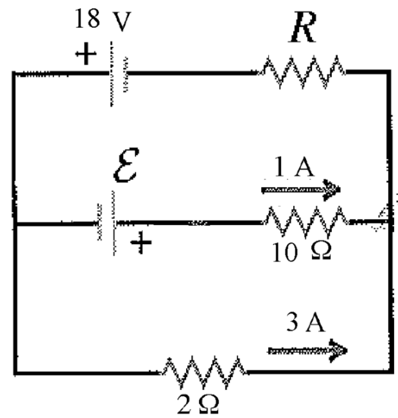
25. Suppose the football is now coated with bronze (a conductor.) The bronze has no net charge. What is true about the charge **on the inner surface**?

a) The charge density is zero everywhere
b) The total charge is zero, but some places will be + and some –
c) The total charge is Q, uniformly distributed
d) The total charge is Q, but nonuniformly distributed
e) The total charge is –Q, uniformly distributed
f) The total charge is –Q, but nonuniformly distributed

26. In the circuit at right, what is the current through resistor R, to the nearest ampere?

27. What is the resistance R, to the nearest ohm?

28. What is the unknown emf? (to the nearest V.)



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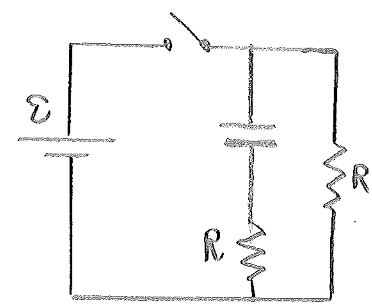
29. The battery emf is 20 V, and each resistor is 10 ohms. What is the current through the battery immediately after closing the switch, to the nearest ampere?

30. What is the current through the battery a long time after closing the switch, to the nearest ampere?



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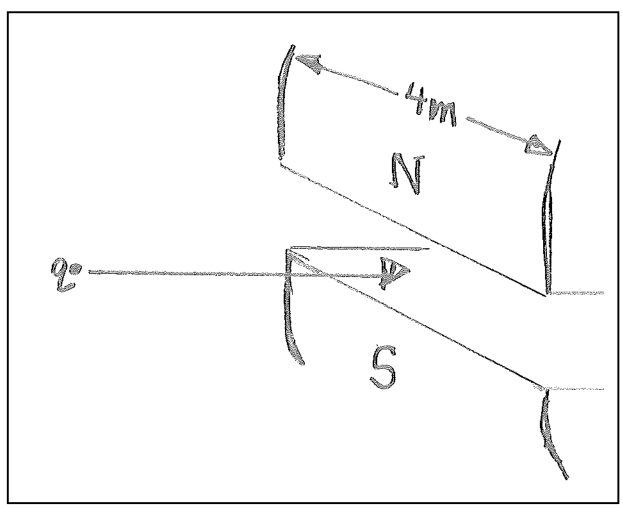
31. A large horseshoe magnet creates a square region of uniform B field of 10 T. The width of the square region is 4m; the field is directed downward. A charged particle enters the center of the region moving due EAST, horizontally. The magnitude of the charge is 1 μC; the particle mass is 1 mg = 10^{-6} kg. For what speeds will the particle exit the magnet moving due WEST, horizontally? (Ignore gravity).

a) The particle would never do this
b) For speeds more than 10 m/s
c) For speeds less than 10 m/s

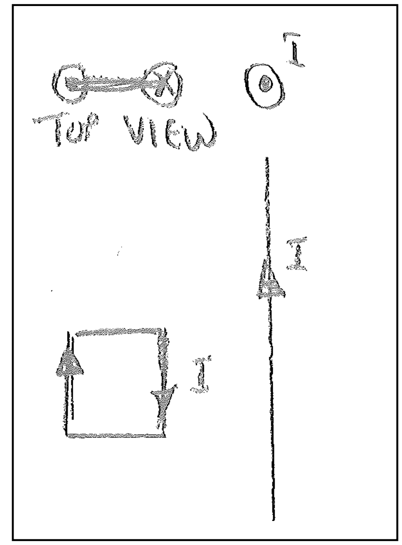


32. Suppose the charge enters the field moving East, but at an angle of 25° above horizontal and a speed of 11 m/s. Assuming this charge does not hit the magnet, what is its motion? (Ignore gravity)

a) it exits the magnet moving WEST, horizontally.
b) it exits the magnet moving WEST, but 25° above horizontal.
c) it exits the magnet moving WEST, but 25° below horizontal.
d) it exits the magnet on the South side, horizontally.
e) it exits the magnet on the North side, horizontally.

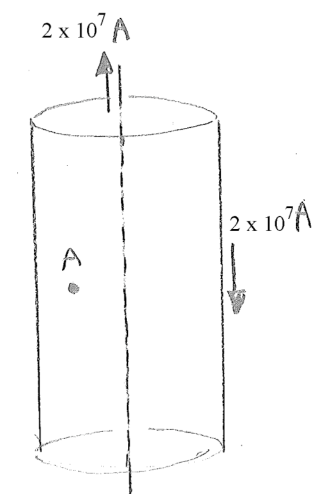
33. A square loop carries current I, near a long wire also carrying current I.
What is the direction of the **force** on the loop?
a) toward the wire b) away from the wire
c) there is no force on the loop, just a torque
d) there is neither force nor torque on the loop

34. The loop is replaced with a compass. **In the top view**, what direction does the North end of the compass needle point? (Ignore Earth's B field.)
a) up b) down c) away from the wire d) toward the wire



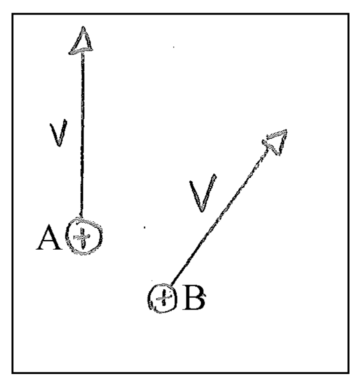
35. A long wire carries current $2x10^7$ A upward. A thin cylindrical shell carries current $2x10^7$ A downward. What is the magnitude of the magnetic field at point A, 1 m from the wire (to the nearest T)?

36. What is the answer to Q35 if the direction of the shell current is changed from downward to upward?

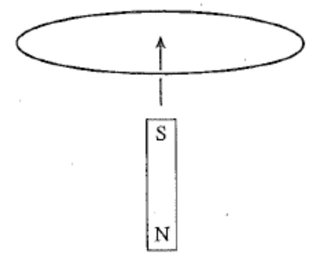


37. Two identical charges move as shown. They have the same speed.
What is true about the **magnetic** forces these particles exert on each other?
I. They are equal in magnitude
II. The force on B is toward A and the force on A is toward B
III. The force on B is greater than the force on A
IV. The force on A is greater than the force on B

a) I only
b) II only
c) III only
d) IV only
e) I & II are both true
f) all are true
g) none are true



38. A bar magnet is pushed toward a wire loop as shown as shown. Which is true at the instant shown:



a) There will be no current in the loop, because magnetic forces do not act on stationary charges
b) There will be no current in the loop, because the magnetic flux through the loop does not change until the magnet is actually in the loop
c) There will be a clockwise current in the loop (viewed from above)
d) There will be a counterclockwise current in the loop (viewed from above)

39. Which of the following is also true:
a) There will be no force and no torque on the loop
b) There will be no force on the loop, but there will be a torque
c) The loop will be attracted to the magnet
d) The loop will be repelled by the magnet

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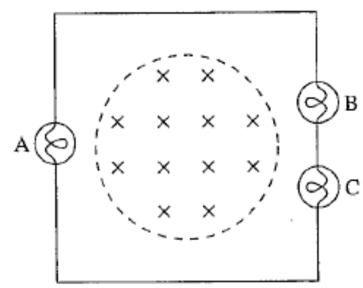
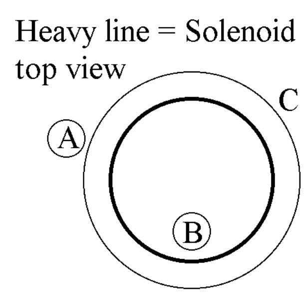
40. A wire of negligible resistance is used to connect three identical light bulbs, as shown. A magnetic field exists only within the dotted circle; it is increasing linearly with time. What is true:



a) none of the bulbs will light, as there is no B field where the square loop or bulbs are
b) all bulbs will light, but A will be brighter than B&C
c) all bulbs will light, but B&C will be brighter than A
d) all bulbs will light equally brightly

---

41. A long solenoid is perpendicular to the page; the current in the solenoid is increasing linearly with time. Assume the B field = 0 outside the solenoid. Around which loops is there an induced emf?
a) A only
b) B only
c) C only
d) only A & B
e) only A & C
f) only B & C
g) A, B & C
h) none



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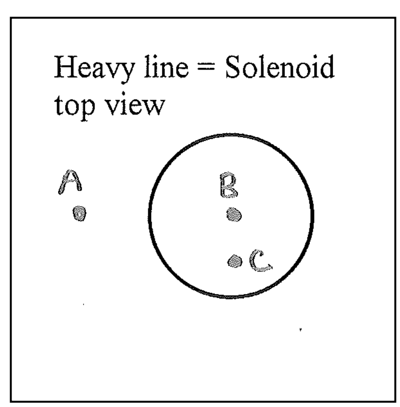
42. With the same solenoid, at which points is the induced electric field zero? B is on the axis of the solenoid. Choose from same answers above.



43. A circular parallel plate capacitor has a steady current *discharging* it. The capacitor has a radius of 2 cm. What is the ratio of the magnetic field inside the capacitor at a distance of 1 cm from the center, to the magnetic field 1 cm from the wire that is discharging the capacitor?

a) 0, there is no B field in the capacitor
b) ¼
c) ½
d) 1
e) 2
f) 4

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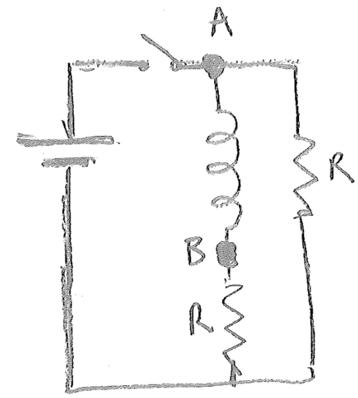
44. The battery emf = 40 V. The inductor L = 20 H. Both resistors are 2 Ohms. What is the current through the **inductor** immediately after closing the switch (to the nearest ampere)?



45. What is the current through the inductor 1 s later? (Assume the voltage across the inductor does not change during this time, a pretty good approximation here.)

46. After a long time, the switch is opened. Just after opening, what is the voltage difference between points A & B?

a) they are at the same potential
b) A is at a higher potential, by 20 V
c) A is at a higher potential, by 40 V
d) A is at a higher potential, by 80 V
e) B is at a higher potential, by 20 V
f) B is at a higher potential, by 40 V
g) B is at a higher potential, by 80 V

---

47. In a series LRC circuit, driven by a sinusoidal voltage, the voltage amplitudes across the capacitor, inductor, and resistor are 8 V, 11 V, and 4 V respectively. What is the total voltage amplitude provided by the source, to the nearest V? (Use 9 for 9 or greater.)

48. If the resistor is 2 Ohms, what is the average power provided by the AC voltage source (to the nearest Watt. Choose 9 for 9 or greater, *or if insufficient information has been given.*)

49. To bring this circuit into resonance, what could you do?

a) increase the driving frequency
b) decrease the driving frequency
c) neither would work
d) it's already in resonance

50. Another way to bring the circuit into resonance would be to

a) decrease the inductance and decrease the capacitance
b) increase the inductance and decrease the capacitance
c) decrease the inductance and increase the capacitance
d) increase the inductance and increase the capacitance

Happy Holidays!