Name:
Student Number:

Science One Physics Midterm #4

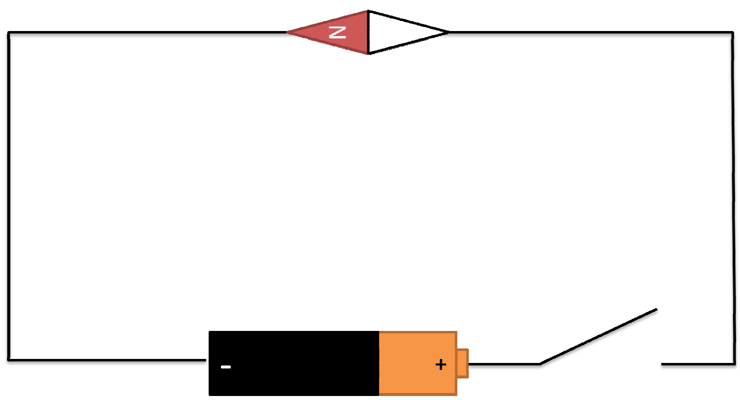
March 19, 2013

Questions 1-7: Multiple Choice: 1 point each
Question 8: Short answer: 2 points
Questions: Explain your work: 11 points total

Multiple choice answers:

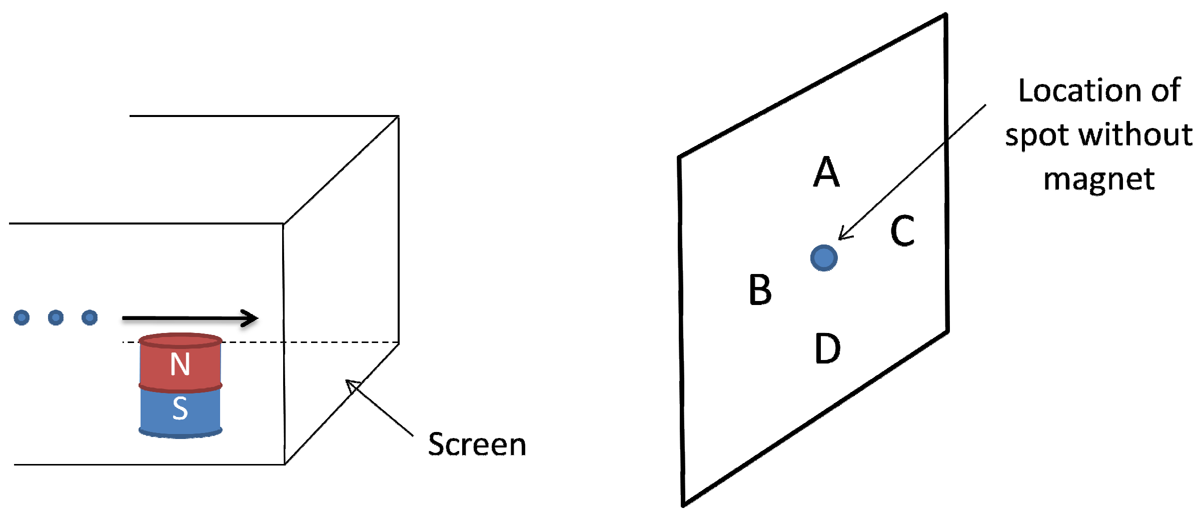
#1	
#2	
#3	
#4	
#5	
#6	
#7	

Formula sheet at the back (you can remove it)



Question 1: In the picture, a compass needle sits directly above a wire that passes 1cm below it (we are looking down from the top). When the switch is closed,

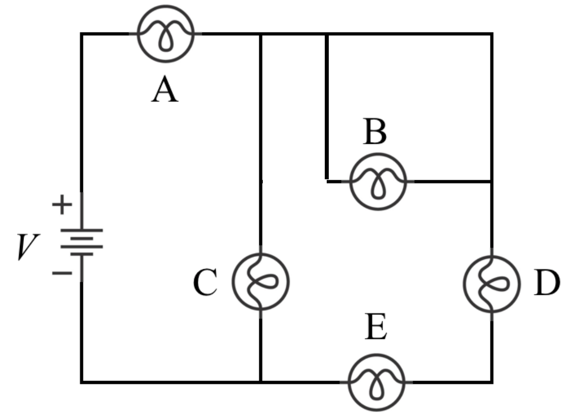
A) the compass needle will rotate clockwise.
B) the compass needle will rotate counterclockwise.
C) the compass needle will try to rotate so the N side points toward the wire.
D) the compass needle will try to rotate so the S side points toward the wire.
E) the compass needle will not rotate.



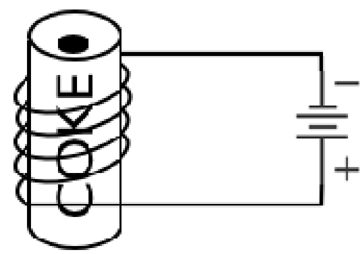
Question 2: In a cathode ray tube, a beam of electrons is sent towards a screen, resulting in a bright spot on the screen. If we now place a magnet under the beam as shown, what will be the final position of the dot on the screen? Choose A, B, C, D, or

E) The dot will stay in the original location

Question 3: Five identical light bulbs are connected to a potential as shown in the figure. What is the order from the brightest bulb to dimmest?



a) A = D = E > B = C
b) A > B > C = D > E
c) B > A > C > D = E
d) A > C = D > E > B
e) A > C > E = E > B

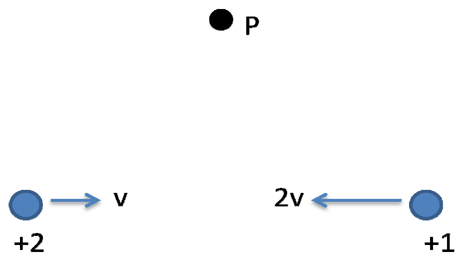


Question 4: The circuit initially has a huge current running through it. A pop can is placed in the middle of the coil. Choose the best answer that describes what happens when the coil is detached from the voltage source so that the current rapidly drops to zero.

a) The pop can shoots upwards.
b) The pop can shoots downwards.
c) The pop can gets crushed.
d) The pop can balloons outwards.
e) Nothing.

Question 5: You use a battery to fully charge a parallel plate capacitor. You then disconnect the capacitor from the battery and double the distance between the plates. What happens to the electric field between the plates and the capacitance?

a) The electric field doubles and the capacitance halves.
b) The electric field doubles and the capacitance doubles.
c) The electric field stays the same and the capacitance halves.
d) The electric field stays the same and the capacitance doubles.
e) The electric field halves and the capacitance halves.
f) The electric field halves and the capacitance doubles.



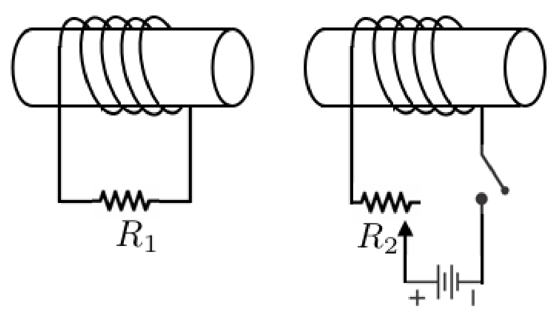
Question 6: The charges shown approach each other with the indicated speeds. The net magnetic field at the point P is

a) zero.
b) into the page.
c) out of the page.
d) None of the above.

Question 7: A narrow copper wire of length *L* and radius *b* is attached to a wide copper wire of length *L* and radius 2*b*, forming one long wire of length 2*L*. This long wire is attached to a battery and current runs through it. If the drift speed in the wide section of the wire is *v*, then the drift speed in the narrow section is:

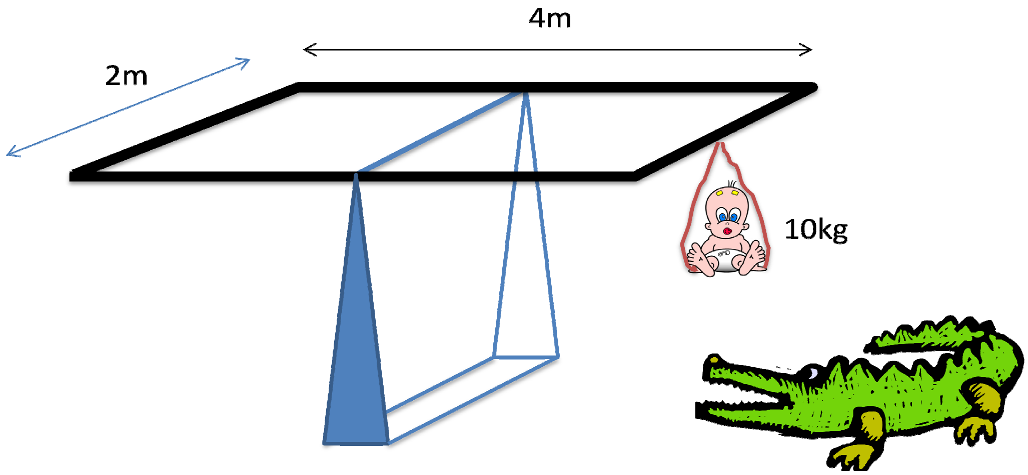
a) $v/4$
b) $v/2$
c) v
d) $2v$
e) $4v$

Question 8: Find the direction of the current through the resistor R_1 when the following steps are taken in the order given. Circle the correct answers.



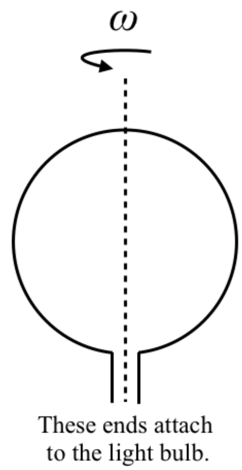
Step:	Current is to the
a) The switch is closed	left/ right/ none
b) The variable resistor, R2, is decreased	left/ right/ none
c) The circuit containing R2 is moved to the right	left/ right/ none
d) The switch is opened	left/ right/ none

Question 9:



A uniform 0.1T magnetic field points to the right. How much current do we need in the rectangular loop to keep the baby from being eaten? Indicate the direction of the current on the diagram. *Note: the baby is also afraid of heights and is likely to make an unpleasant whining noise if he goes any higher.* **(3 points)**

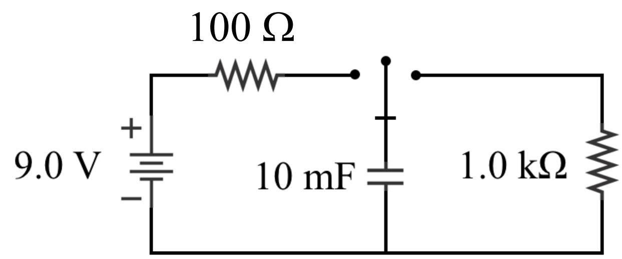
Question 10: Suppose you have 10 m of wire and you want to use the Earth's magnetic field to make a generator that can light a light bulb from the Science One storage room.



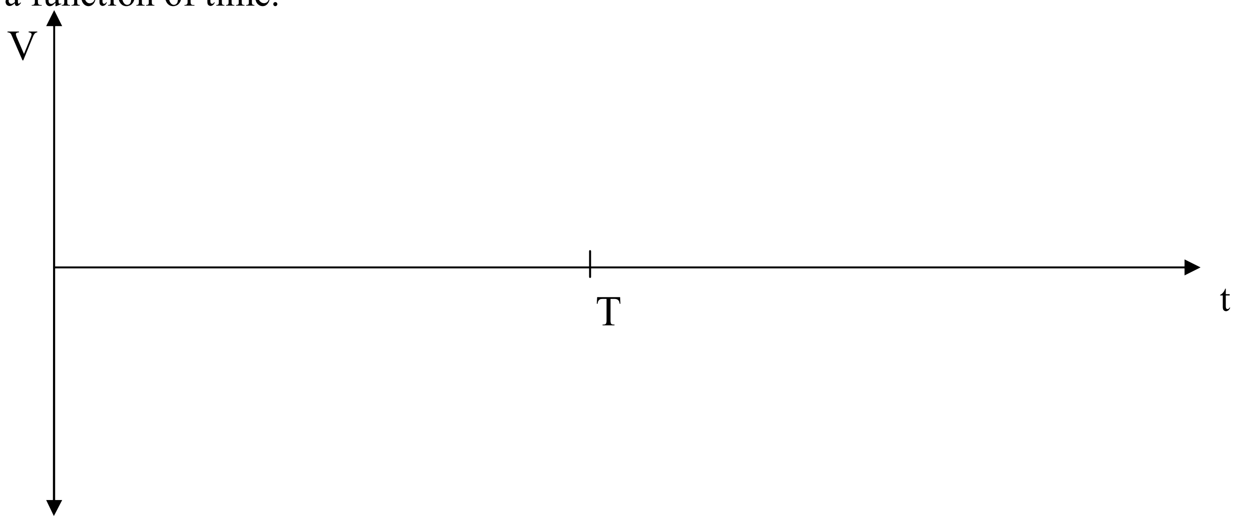
The light bulb needs 1 V across it to light. The strength of the magnetic field in Vancouver is about 50 μT (micro = 10^{-6}). You can assume the wire has no resistance and take resistance of the bulb to be 10 Ω.

If you make the wire into a big circular loop that can be rotated, what is the minimum angular velocity at which you have to spin your loop in order to light the bulb? **(3 points)**

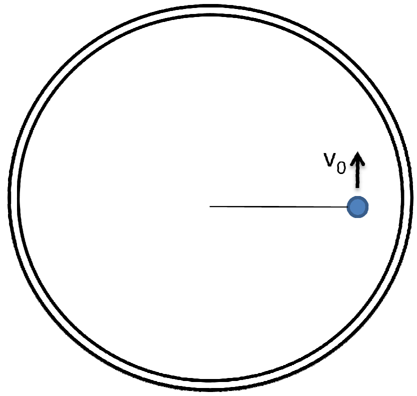
Question 11: The circuit shown has a switch with three possible positions: left, right, and middle. The switch is initially in the middle position, which isn't connected to anything. **(3 points)**



a) At t = 0 the switch is flipped to the left and remains there until the voltage across the capacitor stops changing significantly. The switch is then flipped to the right (at time T). Plot the voltage across the capacitor (potential difference between top and bottom) as a function of time.



b) It turns out that the capacitor is actually the Not-Explodatron 9000, a device that, once charged, needs at least 7 V potential difference at all times, or the world will explode. How long after time T does humanity have to realize the folly of moving the switch to the right and move it back to the left?



Question 12:

A positively charged object of mass M swings around at speed v_0 on a rope of length C. Suddenly a big solenoid appears around the swinging object as shown in the figure. At time t=0, the current in the solenoid starts increasing, resulting in a uniform magnetic field into the page with strength B = H t for t > 0. The object is observed to start swinging faster, but then at some time T starts spiraling towards the middle.

a) Explain why this occurs. (*there is no gravity, friction, or air drag in this problem).* **(2 points)**
b) Determine the time T in terms of v_0, R, M, and H. (**Happy Bonus Points^{TM}**)
(*Hint: something from the formula sheet may be useful)*

FORMULA SHEET

$PV = nRT = Nk_bT$ $R = 8.31$ J/(mol K) $k = 1.38 \times 10^{-23}$ J/mol/K
$\Delta E = Q + W$ $\Delta E = n\, C_V \Delta T$ $C_V = 3/2R$ (ideal monotomic gas)
$W = -\int PdV$

PV^{γ} = constant $\gamma = 1 + C_V/R$

$T = (2/3k_b)E_{avg}$
$P = (2/3)(N/V)E_{avg}$

$\mathbf{F} = m\mathbf{a}$
$F_r = -dU/dr$ $W = -\Delta U = -\int \mathbf{F \cdot dr}$

$\mathbf{F} = q\mathbf{E}$ $U = q\,V$
$E_r = -dV/dr$ $\Delta V = -\int \mathbf{E \cdot dr}$

$E = kq/r^2$ $E = \eta/(2\varepsilon_0)$ $E = 2kp/r^3$ $p = qs$
$\text{Flux} = Q_{enc}/\varepsilon_0$

$k = 9 \times 10^9$ N m^2/C^2 $\varepsilon_0 = 8.85 \times 10^{-12}$ C^2/(N m^2)

$\mathbf{F} = q\mathbf{E} + q\,\mathbf{v} \times \mathbf{B}$ $\mathbf{F} = I\,\mathbf{l} \times \mathbf{B}$ $\boldsymbol{\tau} = \boldsymbol{\mu} \times \mathbf{B}$ $\mu = I\,A$

$\mathbf{B} = \mu_0/(4\pi)q\,\mathbf{v} \times \mathbf{r} / r^3$ $\mathbf{B} = \mu_0/(4\pi)I\,\mathbf{ds} \times \mathbf{r} / r^3$ $B = (\mu_0 / 2\pi)\, I/d$ $B = \mu_0\,(N/L)\,I$

$V = IR$
$C = Q/V$
$P = IV$

$R = \rho LA$
$\sigma = n_e e^2\tau/m = 1/\rho$
$v_d = e\,\tau\,E/m$
$I = e\,n_e\,Av_d$

$Q(t) = Q_0\exp(-t/RC)$

$\varepsilon = |d\Phi_m/dt|$
$\Phi = \mathbf{B \cdot A} = BA\cos(\theta)$

$\oint \vec{E} \cdot d\vec{s} = -d\Phi_m/dt$