PHY 2049C Final Exam. Summer 2015.
Name:

Remember, you know this stuff! Answer each questions to the best of your ability. Show ALL of your work (even for multiple choice questions) , you may receive partial credit. For short answer questions, UNDERLINE or circle your final answers (and *only* your final answers).

1. The trajectory of an electron initially at rest in an electromagnetic field which is constant everywhere and has **E** and **B** components which are at right angles to each other is
    a. A circle
    b. A helix (spring shape)
    c. A straight line
    d. There is not enough information to tell.

2. Waves with *higher* frequencies travel faster than waves with *lower* frequencies (True/False)

3. The *resistivity* of a material depends on its length and cross-sectional area (True/False)

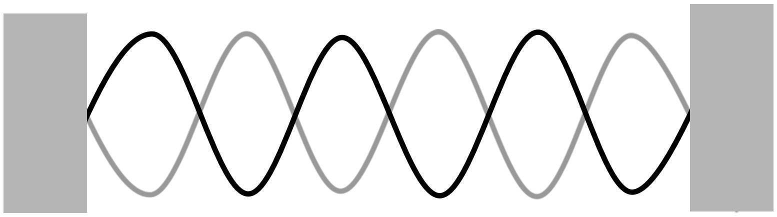
4. Two parallel wires carrying currents in opposite directions are attracted *toward* each other (True/False)

5. The flux through a cube of side, *a* placed in a uniform electric field of 470.0 V/m is
    a. 2820 Vm
    b. 0 Vm
    c. 3.186E14 Vm
    d. This cannot be determined without knowing the *direction* of the electric field.

6. A capacitor is charged by a battery. During the charging
    a. The magnetic field inside the capacitor plates is zero.
    b. The magnetic field inside the capacitor plates is proportional to the current in the wire charging the capacitor and the distance from the center of the plates.
    c. The magnetic field inside the plates is the same as the magnetic field around the wire
    d. The magnetic field is σ/ε_0.

7. A magnetic at rest in a stationary loop of wire induces a current in the wire which is proportional to the magnetic flux. (True/False)

8. You observe a standing wave on a 60 cm string of linear mass density $\mu = 0.10$ g/cm as shown in the figure below at t = 0 s (black) and t=0.02 s (light grey) which are within 1 period of each other.



a. Determine the frequency of the wave.
b. Determine the tension in the string.

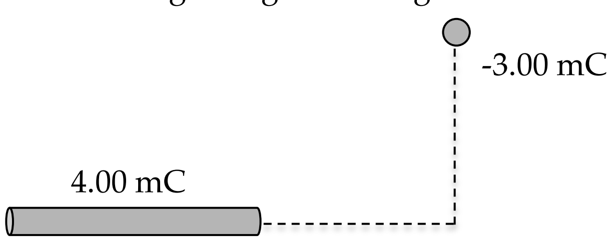
9. A train horn emits a sound with a frequency of 700Hz which is heard by a listener moving away from the train at 6.00 m/s. The listener hears a frequency of 730Hz.
    a. What is the speed of the train?
    b. Is the train moving toward or away from the listener?

10. An Electromagnetic wave propagates through an unknown dielectric material and the electric field component obeys the following wave-function:

$\mathbf{E}(x,t) = 5.0\text{N/C} \sin(5.0\text{E-}4\text{m}^{-1}x+4.0\text{E}11\text{s}^{-1}t)\mathbf{j}$

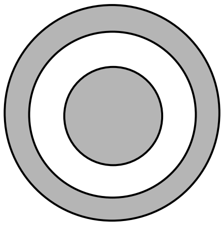
a. If the Poynting vector points in the **k** direction what is the direction of the magnetic field component?
b. What is the speed of the wave?
c. What is the permittivity of the material if $\mu = \mu_0 \sim 8.85\text{E-}12$ Nm/A?

11. A uniformly charged rod of length l = 1.00 m and total charge 4.00 mC lies along the +x-axis beginning at the origin. A -3.00 mC charge is at the point (1.0m,2.0m).



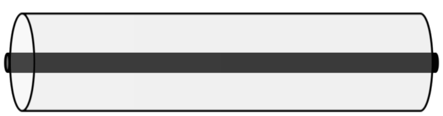
a. Determine the x and y components of the **E**-field at (0.0m, 2.0m).
b. Determine the magnitude and direction of the **E**-field at the point (0.0m,2.0m)

12. An insulating sphere of radius 0.05m and total charge Q = 6.0mC uniformly distributed over its volume, is surrounded by a conducting spherical shell of radius, 0.10m which is 0.03m thick.



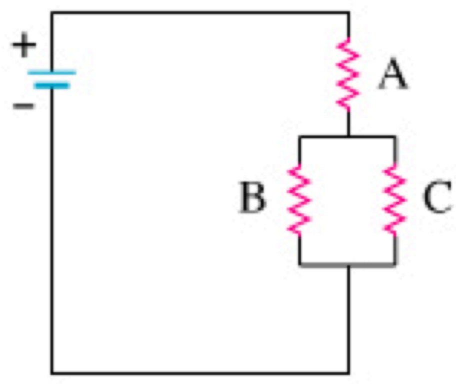
a. Determine the electric field at the **r** = .10m and **r** = 0.20m from the center of the sphere.
b. What is the charge on the inner and outer surfaces of the conducting spherical shell?

13. A coaxial cable consists of an essentially infinite wire of linear charge density, $\lambda = +1.2$ μC/m and a oppositely charged cylindrical shell of radius, 2E-3m.



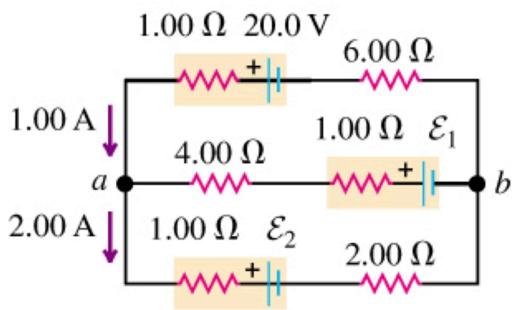
a. Find the potential difference between the wire and the cylindrical shell
b. Determine the capacitance per unit length.

14. The resistor network shown in the figure below is connected to a 12V ideal battery. R_A = 2.0 Ω ,R_B = 6.0 Ω, and R_C = 9.0 Ω.



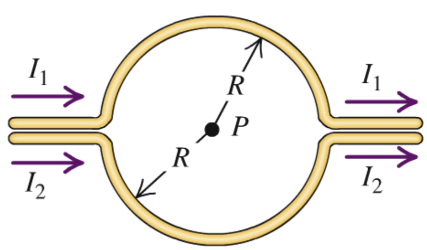
a. Determine the equivalent resistance.
b. Determine the total current in the circuit
c. Determine the potential difference across the 9.0 Ω resistor.

15. Determine unknown EMF's of the batteries, ε_1 ε_2.



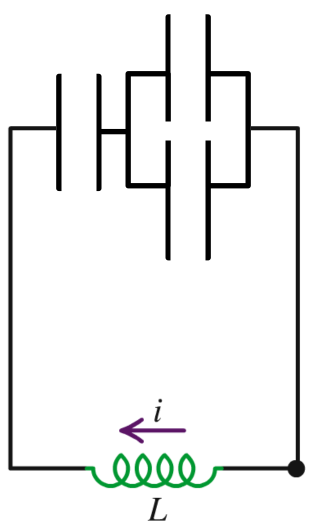
16. Determine the magnitude and direction of the net force on an electron of charge q_e = 1.60E-19 C and mass m_e = 911E-30 kg with traveling in the x-y plane with a velocity of 3E5 m/s at an angle of 20º from the +x-axis if a constant magnetic field of 0.75 T points along the –y-axis everywhere.

17. In the configuration below, I_1 is 3.4 A and the radius of the circle R = 0.2 m. If the magnitude of the magnetic field is 0.75 T and directed out of the page, determine the magnitude and direction of I_2.



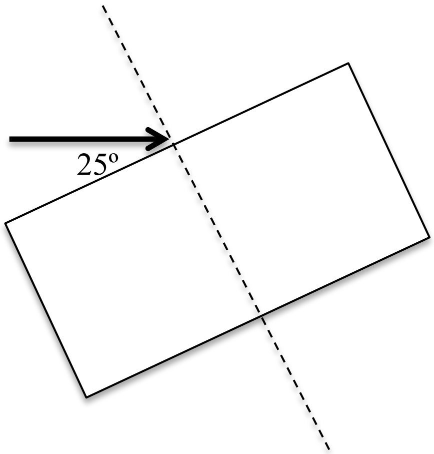
18. A 1.0 kg conducting bar slides vertically down two conducting wires separated by 0.3m. A constant magnetic field of 0.5T points in the +x direction. The wires have a total resistance of 100 Ω.
    a. What is the current induced in the wire as the bar falls?
    b. At what speed does the bar fall?

19. Three 20.0 μF are charged and connected to a 2.4mH inductor as shown in the figure below.



a. What is the equivalent capacitance of the network?
b. Determine the frequency of the LC circuit.
c. What percentage of the initial charge is on the equivalent capacitor 1.6 s after the switch is closed?

20. A 632 nm laser light is incident upon an acrylic brick of index of refraction of 1.525. The light is incident at an angle of 25° from the edge of the brick.



a. At what angle from the surface normal does the light travel through the brick?
b. At what angle from the surface normal does the light exit the acrylic brick?

Extra Credit: Write a problem which is of comparable difficulty to the questions on this test and related to the material covered in this course and answer it. Make sure to show all of your work. Your question must not be the same as any questions on this test with *just* the numbers changed.

Formula Sheet

$e = 1.602 \times 10^{-19}$ C

$F = \frac{1}{4\pi\varepsilon_0}\frac{|q_1 q_2|}{r^2}$

$E = k\frac{q}{r^2}$

$E = \frac{q}{\varepsilon_0 A} = \frac{\sigma}{\varepsilon_0}$

$k = \frac{1}{4\pi\varepsilon_0} = 8.99 \times 10^9 \text{ N} \cdot \text{m}^2 / \text{C}^2$

ε_0 can be found above

$\vec{E} = \frac{\vec{F}}{q_0}$

$U = -\vec{p} \cdot \vec{E}$

$\Phi_E = \int \vec{E} \cdot d\vec{A}$

$\oint \vec{E} \cdot d\vec{A} = \frac{Q_{encl}}{\varepsilon_0}$

$\vec{\tau} = \vec{p} \times \vec{E}$

$U = \frac{1}{4\pi\varepsilon_0}\frac{qq_0}{r}$

$U = \frac{q_0}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$

$W_{a\to b} = -(U_b - U_a) = -\Delta U$

$V = \frac{U}{q_0} = \frac{1}{4\pi\varepsilon_0}\frac{q}{r}$

$V = \frac{1}{4\pi\varepsilon_0}\int \frac{dq}{r}$

$V = \frac{U}{q_0} = \frac{1}{4\pi\varepsilon_0}\sum_i \frac{q_i}{r_i}$

$\vec{E} = -\left(\hat{i}\frac{\partial V}{\partial x} + \hat{j}\frac{\partial V}{\partial y} + \hat{k}\frac{\partial V}{\partial z}\right)$

$Q = CV$

$V_a - V_b = \int_a^b \vec{E} \cdot d\vec{l}$

$C = \frac{\varepsilon_0 A}{d}$

$\frac{1}{C_{eq}^{series}} = \frac{1}{C_1} + \frac{1}{C_2} + \cdots$

$C_{eq}^{para} = C_1 + C_2 + \cdots$

$R_{eq}^{series} = R_1 + R_2 + \cdots$

$\frac{1}{R_{eq}^{para}} = \frac{1}{R_1} + \frac{1}{R_2} + \cdots$

$U = \frac{Q^2}{2C} = \frac{1}{2}CV^2 = \frac{1}{2}QV$

$u = \frac{1}{2}\varepsilon_0 E^2$

$C = \kappa C_0$

$I = \frac{dq}{dt} = n|q|v_d A$

$\rho(T) = \rho_0[1 + \alpha(T - T_0)]$

$V=IR$

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

$\rho = \frac{E}{J} = \frac{RA}{L}$

$\sum I_{jnct} = 0 \quad \sum V_{loop} = 0$

$q = Q_0 e^{-t/RC}$

$q = CV(1 - e^{-t/RC})$

$P = VI = I^2 R = \frac{V^2}{R}$

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

$\Phi_B = \int \vec{B} \cdot d\vec{A}$

$\oint \vec{B} \cdot d\vec{A} = 0$

$r = \frac{mv}{qB}$

$\vec{F} = I\vec{L} \times \vec{B}$

$\vec{\tau} = \vec{\mu} \times \vec{B}, \quad \mu = IA$

$U = -\vec{\mu} \bullet \vec{B}$

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

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

$\mu_0 = 4\pi \times 10^{-7}$ T•m/A

$c = \frac{1}{\sqrt{\varepsilon_0 \mu_0}}$

$\varepsilon = \oint \vec{E} \cdot d\vec{l} = -\frac{d\Phi_B}{dt}$

$B_{\text{some wire}} = \frac{\mu_0 i}{2\pi r}$

$B_{\text{some loop}} = \frac{\mu_0 i}{2r}$

$F_{cent} = m\, v^2/r$

$\sin\theta = y/r$

$\cos\theta = x/r$

$\tan\theta = y/x$

$K = 1/2\, mv^2$

$S = 2\,\pi\, r$, $A = \pi\, r^2$

$A = 4\,\pi\, r^2$, $V = 4/3\,\pi\, r^3$

$A = 1/2\, b\, h$

$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$

$v_x = v_{x0} + a_x t$

$v^2 = v_0^2 + 2ad$

$x = x_0 + v_{x0}t + 1/2\, a_x t^2$

$C = \sqrt{A^2 + B^2}$