PHYS-207 (3) (Kaldon-10776) **Name _____SAMPLE FINAL EXAM_____**
WMU - Summer 2000 ☐ **You Must Go Through "Check-Out" With Dr. Phil**
Final Exam - 200,000 points + 40,000 ☆ points

08/07/2000•Rev.3•a

State Any Assumptions You Need To Make – Show All Work – Circle Any Final Answers
Use Your Time Wisely – Work on What You Can – Be Sure to Write Down Equations
Feel Free to Ask Any Questions ☐☆2a ☐☆2b ☐☆2c ☐☆2e

Space Cowboys (50,000 pts.)

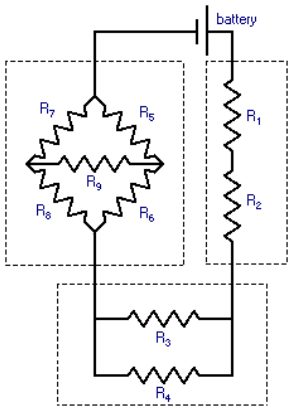
1.) (a) In the new movie, four aging actors (Clint Eastwood, Tommy Lee Jones, James Garner and Donald Sutherland) play aging astronauts. They take the Space Shuttle to fix a ex-Soviet "communications satellite" named ICON (ИКОН) – which strangely resembles a giant spark plug. Consider a gap between the tip and the endpiece of 2.00 meters (I said it was a *giant* spark plug). If this gap was in *air* instead of the vacuum of space, what would be the potential difference, ΔV, between the two conductors such that a spark would jump?

(b) If the potential difference comes from a 1917 F capacitor, then how much charge Q makes the jump across the gap? *Assume the capacitor is completely drained in the process.*

(c) How many *electrons* are transferred in (b)? *If you didn't get an answer to (b), assume Q = 1917 C.*

(d) If you look up *electric current* in Microsoft Bookshelf '95, you'll find the following circuit diagram. If all the resistors, R_i, have a resistance R, find the total resistance of the circuit in terms of R.

Microsoft Bookshelf '95



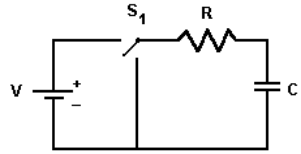
R1 and R2 are connected in series. R3 and R4 are connected in parallel. R5, R6, R7, R8, and R9 are neither series nor parallel. The three two-terminal subcircuits enclosed in broken lines are in series with the battery.

(e) If the total resistance of the circuit is 5.38 MΩ, and the battery has a voltage of 1385 volts, then find the current through R_1.

Now Starring… Your Favorite Star Problems! (50,000 points)

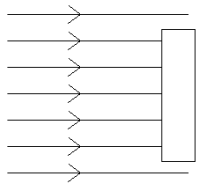
2.) ☆(a) A spherical insulator of radius R has a total charge Q evenly distributed throughout the sphere. Use Gauss' Law to find the magnitude of the E-field at a radius r, where $r < R$. *NOTE: You may evaluate the integrals by using the known equations for things like the surface area and volume of a sphere.*

☆(b) Consider an RC circuit as shown. Flip the switch S_1 to the left and the capacitor charges to $\pm Q_0$. For the charging capacitor, write a Kirchhoff's Law voltage loop equation. Remember that the definition of current is $I = dq/dt$. Show that $Q(t) = Q_0\left(1 - e^{-t/RC}\right)$.

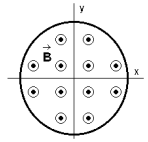


☆(c) The differential equation for an ideal LC circuit is $\frac{d^2Q}{dt^2} = -\frac{1}{LC}Q$, whose solutions are mathematically the same as the Simple Harmonic Oscillator in PHYS-205. Create this equation by starting with the knowledge that the change in the total energy stored in both the inductor and the capacitor is zero, $\frac{dU}{dt} = \frac{d}{dt}\left(\frac{Q^2}{2C} + \frac{1}{2}LI^2\right) = 0$ and remembering that $I = \frac{dQ}{dt}$.

(d) Consider a flat slab of glass (n = 1.55). Parallel light rays (in air) come in perpendicular to the surface. Complete the sketch, showing what happens to the light rays as they travel through the glass. What would be the "focal length" of a flat slab of glass?



☆(e) Find the magnetic flux, $\Phi_B = \int \vec{B} \cdot d\vec{A}$, in a circular area of radius a in the xy plane, centered on the origin, for a magnetic field $\vec{B} = b\,r\,\hat{k}$, where b is an arbitrary constant.



Zing! (50,000 points)

3.) (a) The Stanford Linear Accelerator, SLAC, is a real machine that takes electrons and accelerates them for most of a mile up to 99.99% the speed of light ($c = 2.998 \times 10^8$ m/s). Consider an electron (q = -e, $e = 1.602 \times 10^{-19}$ C, $m_e = 9.11 \times 10^{-31}$ kg) in a constant electric field that starts from rest and ends up at a speed with $\beta = 0.9999$ ($\gamma = 70.71$) after traveling in the $+x$ direction a distance of 1150 meters. Express the final relativistic kinetic energy in terms of Joules and in electron volts (eV).

(b) Find the accelerating potential, ΔV, needed in (a). *If you didn't get an answer in (a), use a kinetic energy of $K = 50.0$ MeV $= 50.0 \times 10^6$ eV.*

(c) If an electron traveling at a constant speed of 99.99% the speed of light traveled a distance of 1150 meters in the lab rest frame, what distance would the electron have seemed to cover from its point of view? *Note: this is not a trick question, so the answer is not "zero".*

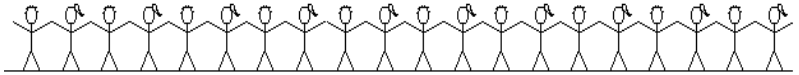
(d) Electrons traveling at 99.99% the speed of light in vacuum are shot into a pool of water, where you might see a pretty blue glow called Cerenkov radiation, because the electrons are traveling faster than the local speed of light in the water (n = 1.33). Show that the electrons *are* traveling faster than the speed of light in water.

(e) A large solenoid with 1500. turns, 2.00 meters length and a cross-sectional area of 1.00 m² is needed in the lab to generate a uniform *B*-field of 5.00 T. What is the current *I* running through the wires of the solenoid?

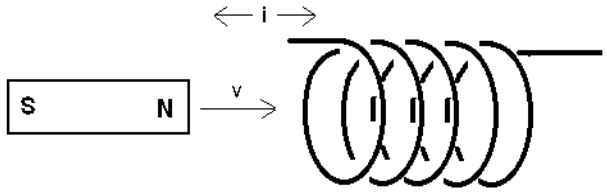
Survivor—Physics: Where We Vote Off A Physics Student Each Week… (50,000 points)

4.) (a) A man's human hand has dimensions of 10.0 cm × 18.0 cm and is 2.00 cm thick on average. Since the human body is mostly water ($\kappa = 80.0$), let's assume that this hand forms the inside of a dielectric filled parallel plate capacitor. Find the capacitance, C, of the hand. (Increasingly, biometrics like this are being used to identify people in security systems.)

(b) A human chain is formed by having twenty people holding hands as shown. If the average person has a resistance of 655,000 Ω, and the person on the left and the person on the right stick their free hand into the two slots of an electrical outlet (125 V.D.C.), then what current flows through each person?



(c) A permanent magnet is moved into the center of a coil as shown. Does the current flow from the induced *emf* go into the coil at the left side or out of the coil on the left side?



(d) Two charges, $q_1 = 3.21 \times 10^{-4}$ C and $q_2 = 5.48 \times 10^{-4}$ C , are placed 0.457 m away from each other. Find the magnitude of the electric force, F_E, between them, and indicated whether it is attractive or repulsive.

(e) A proton, $q = +e$, experiences an electric field of $E = 1710$ N / C. Find the magnitude of the electric force, F_E, on the proton and indicated whether it points parallel or anti-parallel to the E-field.