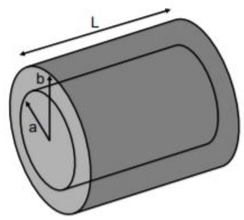
Name ____________
Physics 51M Section ___ Box # _____
Problem Set 7
4 November 2019

Collaborators:

(a) Calculate the capacitance per unit length $\frac{C}{L}$ of a cylindrical capacitor (two concentric conducting cylindrical shells, inner radius a and outer radius b) as shown in the figure. Ignore the end-caps of the cylinders. (b) Commercial RG-58 "BNC" coaxial cable (same geometry as part (a) above) has an inner cylinder diameter of $0.8mm$, and an outer diameter of $5mm$. Calculate the capacitance per unit length of RG-58 cable, and compare it to the commonly quoted value of 33 $pF/foot$. Comment on your result.



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The current density across a cylindrical conductor of radius R varies according to the equation $j = j_0(1 - \frac{r}{R})$, where r is the distance from the axis. Thus the current density is a maximum j_0 at the axis $r = 0$ and decreases linearly to zero at the surface $r = R$. (a) Calculate the current in terms of j_0 and the conductor's cross-sectional area $A = \pi R^2$. (b) Suppose that, instead, the current density is a maximum j_0 at the surface and decreases linearly to zero at the axis, so that $j = j_0 \frac{r}{R}$. Calculate the current. Why is the answer different from part (a)?

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* A dielectric slab of thickness b is inserted between the plates of a parallel-plate capacitor of plate separation d. Show that the capacitance is given by $C = \frac{K_e \epsilon_0 A}{k_e d - b(k_e - 1)}$.

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HRK E31.48 A capacitor (capacitance C) with an initial stored energy U_0 is discharged through a resistor of resistance R. (In parts (a) and (b) below, calculate a final numerical value assuming $C = 1.0\mu F, U_0 = 0.50J$, and $R = 1M\Omega$.)
(a) What is the initial charge on the capacitor? (b) What is the current through the resistor when the discharge starts? (c) Determine $\triangle V_C$, the voltage across the capacitor, and $\triangle V_R$, the voltage across the resistor, as functions of time. (d) Express the rate of generation of internal energy in the resistor as a function of time.

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HRK E32.32 A metal wire of mass m slides without friction on two horizontal rails spaced a distance d apart, as in Fig 32-36. The track lies in a vertical uniform magnetic field $\vec{B}$. A constant current i flows from generator G along one rail, across the wire, and back down the other rail. Find the velocity (speed and direction) of the wire a s a function of time, assuming it to be at rest at $t = 0$.

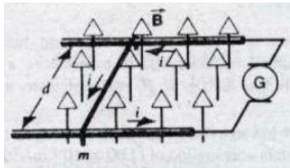

FIGURE 32-36. Exercise 32.

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HRK P32.5 Bainbridge's mass spectrometer, as shown in Fig. 32-39, separates ions having the same velocity. The ions, after entering through slits S_1 and S_2, pass through a velocity selector composed of an electric field produced by the charged plates P and P', and a magnetic field $\vec{B}$ perpendicular to the electric field and the ion path. Those ions that pass undeviated through the crossed $\vec{E}$ and $\vec{B}$ fields enter into a region where a second magnetic field $\vec{B}'$ exists, and are bent into circular paths. A photographic plate registers their arrival. Show that $\frac{q}{m} = \frac{E}{rBB'}$, where r is the radius of the circular orbit.

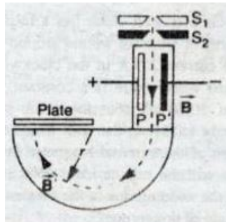

FIGURE 32-39. Problem 5.

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