Name ____________________
Physics 51M Section ___ Box # _____
Problem Set 11
9 December 2019

Collaborators:

HRK E6.44 In the circuit shown in Fig 36-22, the switch has been in position *a* for a long time. It is now thrown to *b*. (a) Calculate the frequency of the resulting oscillating current. (b) What will be the amplitude of the current oscillations?

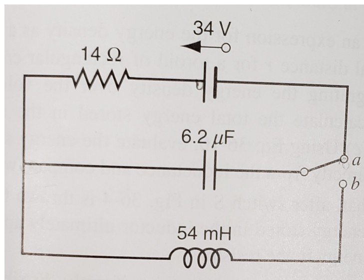

FIGURE 36-22. Exercise 44.

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*[HRK E34.26] A stiff wire bent into a semicircle of radius a is rotated with a frequency f in a uniform magnetic field, as suggested in Fig. 34-51. What are (a) the frequency and (b) the amplitude of the emf induced in the loop?

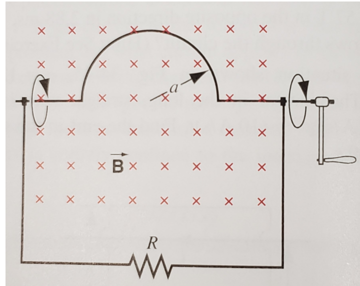

FIGURE 34-51. Exercise 26.

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HRK P38.4 A long, cylindrical conducting rod with radius R is centered on the x axis as shown in Fig. 38-26. A narrow saw cut is made in the rod at $x = b$. A conduction current i, increasing with time and given by $i = \alpha t$, flows toward the right in the rod; α is a (positive) proportionality constant. At $t = 0$, there is no charge on the cut faces near $x = b$. (a) Find the magnitude of the charge on these faces, as a function of time. (b) Use Eq. 1 in Table 38-1 to find E in the gap as a function of time. (c) Sketch the lines of $\vec{B}$ for $r < R$, where r is the distance from the x axis. (d) Use Eq. IV in Table 38-1 to find $B(r)$ in the gap for $r < R$. (e) Compare the above answer with $B(r)$ in the rod for $r < R$.

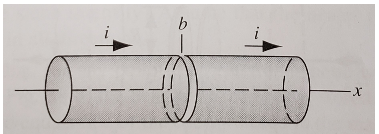

FIGURE 38-26. Problem 4.

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A parallel plate capacitor has circular plates of radius R and separation d. The capacitor is connected to a battery of voltage V and then disconnected so that the charge ought to remain constant. The air is humid, however, and therefore slightly conducting; thus the stored charge leaks back across the air gap between the capacitor plates at rate i_{leak}. Assume that this leakage current is uniformly distributed across the area of the plates. Find the magnetic field everywhere between the plates.

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In lecture we derived the wave equation for E using Maxwell's equations in free space. Use a similar procedure to derive a wave equation for B . Show that Maxwell's equations require that B must be transverse to the direction of propagation. (You may want to remember the vector calculus identity $\vec{\nabla} \times (\vec{\nabla} \times \vec{C}) = \vec{\nabla}(\vec{\nabla} \cdot \vec{C}) - \nabla^2 \vec{C}$ for any $\vec{C}$.)

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HRK E38.16 The electric field associated with a pane electromagnetic wave is given by $E_x = 0, E_y = 0, E_z = E_0 sink(x - ct)$, where $E_0 = 2.34 \times 10^{-4}$ V/m and $k. = 9.72 \times 10^6\ m^{-1}$. The wave is propagating in the $+x$ direction. (a) Write expressions for the components of the magnetic field of the wave. (b) Find the wavelength of the wave.

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(a) Consider an electromagnetic wave in a vacuum with electric field $\vec{E} = E_0 \hat{y} sin(kx - \omega t)$. What is the propagation direction of this electromagnetic wave? (b) Consider an electromagnetic wave with electric field $\vec{E} = E_0 (\hat{-z}) sin(ky + \omega t)$. What is the propagation direction of this electromagnetic wave? (c) Consider the electric field $\vec{E} = E_0 \hat{y}[sin(kx - \omega t) + sin(kx + \omega t)]$. Show that this electric field satisfies the wave equation $\frac{\partial^2 \vec{E}}{\partial x^2} + \frac{\partial^2 \vec{E}}{\partial y^2} + \frac{\partial^2 \vec{E}}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 \vec{E}}{\partial t^2}$
provided $\frac{\omega}{k} = c$.

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