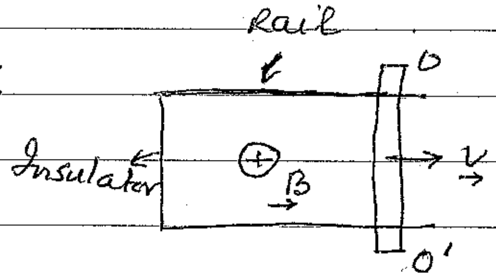
EXAM III - TEST QUESTIONS (PART 1) + ~~Supplement~~

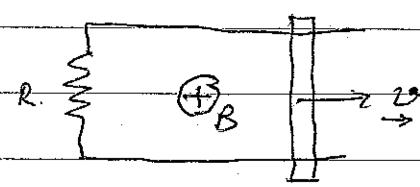
1. What is the difference between a Coulomb $\vec{E}$ field and a Non-Coulomb $\vec{E}$-field. Support your answers with examples.

2. What does the equation
$$\Sigma_c \vec{B} \cdot \Delta\vec{A} \equiv 0$$
tell you about the Elementary Generators of $\vec{B}$?

3. A copper bar of length l is sliding along two conducting rails at a velocity of $+v\hat{x}$ in a region where there is a constant field $-B\hat{z}$. What is the EMF developed between O' and O? Which pt. is +ive, O' or O? If the rails are frictionless do you need to apply a force to move the bar?



4. Repeat problem 3 but replace INSULATOR by a resistor R. What is the current in R?



5. In Prob 4, the resistor dissipates I^2R Joules/sec. Where does this Energy come from?

6. Repeat Prob. 3 with no rails, just Bar moving as shown. Now what causes the Emf?

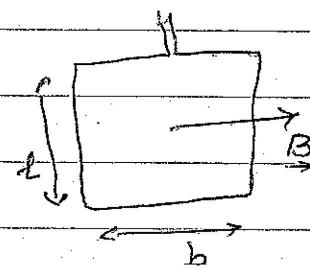
7. We are told that in order to establish a Current I in an Inductor L, the battery must do $\frac{1}{2}LI^2$ Joules of work. Where does this energy go?

7' Show that for a Solenoid $L = \mu_0 n^2 V$ [n = # of turns/meter, V = vol. of Solenoid]

8. What is the energy density of i) an $\vec{E}$ field ii) $\vec{B}$-field? Why?

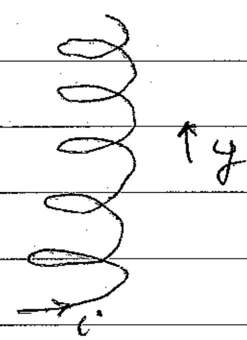
9. If in problem 8, $\eta_E = \eta_B$, what is the relationship between E and B (magnitudes).

10. Shown is a Coil of width b and length l suspended vertically in a $\vec{B}$-field. How would you make it work like a (i) motor, (ii) generator.



11. Show that in an ac Generator the emf is maximum (zero) when the flux of $\vec{B}$ through the Coil is zero (maximum).

12. A Solenoid has n turns per meter and radius R. The current i is increasing slowly as a function of time. Show that at a distance r from the axis of the Solenoid the non-Coulomb $\vec{E}_{NC}$ is



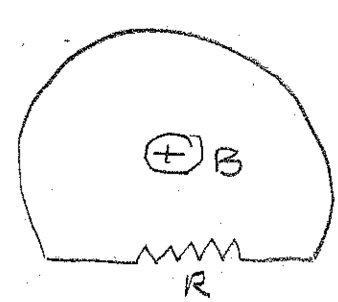
$$\vec{E}_{NC} = -\frac{\mu_0 n r}{2}\frac{\Delta i}{\Delta t}\hat{\phi} \quad \text{if } r<R.$$

$$= -\frac{\mu_0 n R^2}{2r}\frac{\Delta i}{\Delta t}\hat{\phi} \quad \text{if } r>R.$$

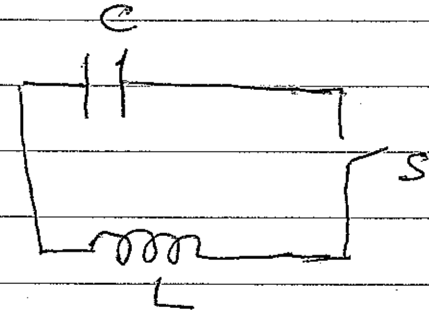
13. In Prob 12, what is the variation of the Emf in a loop if i) $r<R$ ii) $r>R$? Why?

14. Use the force $\vec{F}_B = q[\vec{v}\times\vec{B}]$ experienced by the Electrons in the rotating Coil in an ac generator to show that the Emf is maximum (zero) when the plane of the coil is parallel (perpendicular) to $\vec{B}$.

15. As shown a uniform $\vec{B} = -B\hat{z}$ is surrounded by the circuit. If $\vec{B}$ increase with time what is the sense of the non-coulombs $\vec{E}_{NC}$ generated.

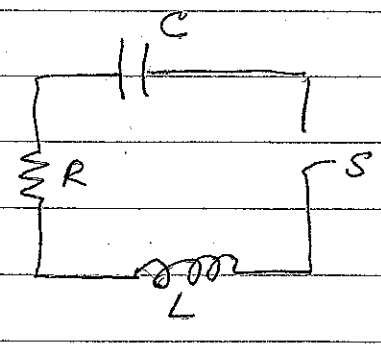


16 In the circuit shown we put a charge of $\pm Q_0$ on the capacitor and then close the switch. Show that, by analogy with a mass-spring oscillator, the charge on the capacitor will oscillate at an angular frequency of $\omega_0 = \frac{1}{\sqrt{LC}}$



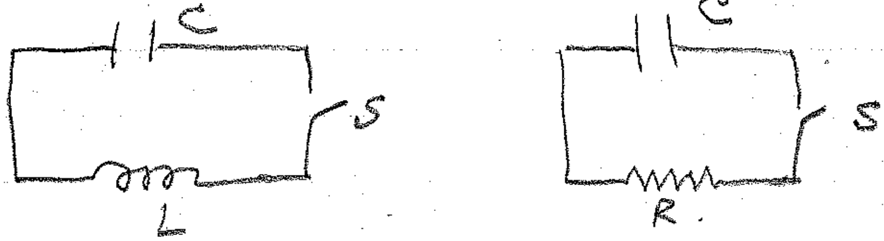
[Hint: L ⟺ Mass, $\frac{1}{C}$ ⟺ SPRING CONST].

17. Next, add a resistor to the circuit. Now what will happen to the charge on C when Q is closed.



18. A coil of wire of resistance R and area A is flipped in a $\vec{B}$ field from $\hat{n} \parallel \vec{B}$ to $\hat{n} \parallel -\vec{B}$. Show that during this experiment a charge $q = (2BA)/R$ travels around the coil. ~~where~~

19. Shown are two circuits



In both cases a charge Q_0 is put on the capacitor and then the switches are closed. What is the subsequent time variation of the charge on C? Why?

20. What is a bar magnet? Starting with the magnetic moment of an electron describe how you would conceptually "construct" a bar magnet.

21. According to Maxwell, one of the four field equations was "incomplete". Can you identify this equation and explain why he thought so?