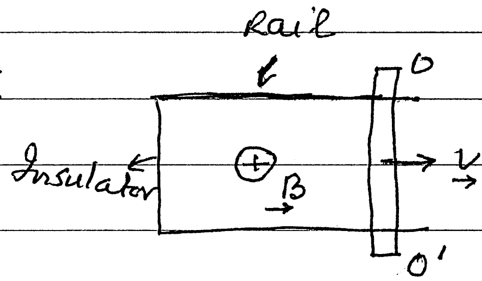
EXAM III - TEST QUESTIONS (PART 1).

COVENANT: $III > (II+5)$ buys $+15!$
[5 VISITS MANDATORY].

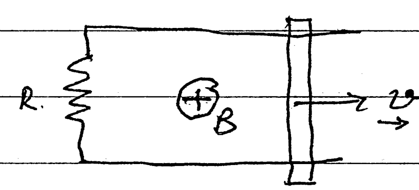
1. What is the difference between a Coulomb $\vec{E}$ field and a Non-Coulomb $\vec{E}$-field

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.



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

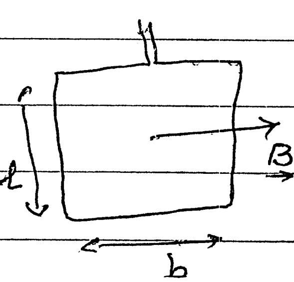
6. Repeat Prob. 3 with no rails, just Bar moving as shown. Now what causes the Emf?

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?

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

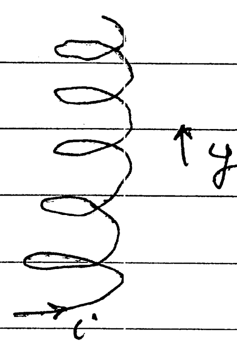
9. If in problem 8, $\eta_E = \eta_B$, what is the relationship between E and B (magnitudes).

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

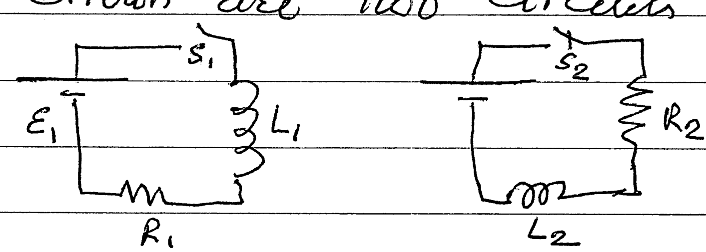


$$\vec{E}_{NC} = -\frac{\mu_0 n r}{2}\frac{\Delta i}{\Delta t}\hat{\phi} \quad \text{if } r < R.$$

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

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

14. Shown are two circuits

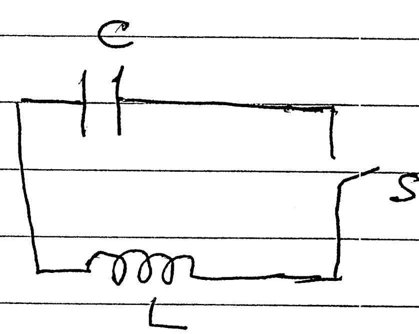


$L_1 = 10mH$, $L_2 = 20mH$
$R_1 = 1 k\Omega$, $R_2 = 2 k\Omega$.

If both switches are closed at $t=0$, in which circuit will the current reach 1mA first if i) $\mathcal{E}_1 = \mathcal{E}_2 = 10V$; ii) $\mathcal{E}_1 = 20V$, $\mathcal{E}_2 = 15V$? Why?

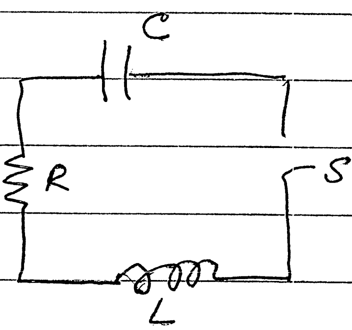
15. Show that $\frac{L}{R}$ and RC both have dimensions of time. Why do we need both L and R (in RL circuit) and C and R in (RC circuit) to define the characteristic time τ?

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: $L \Leftrightarrow$ Mass, $\frac{1}{C} \Leftrightarrow$ SPRING CONST].

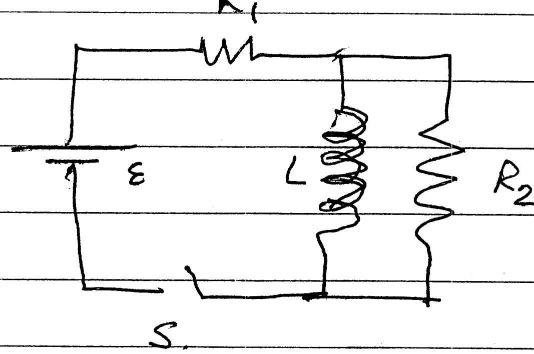
17. Next, add a resistor to the circuit. Now what will happen to the charge on C when Q is closed.



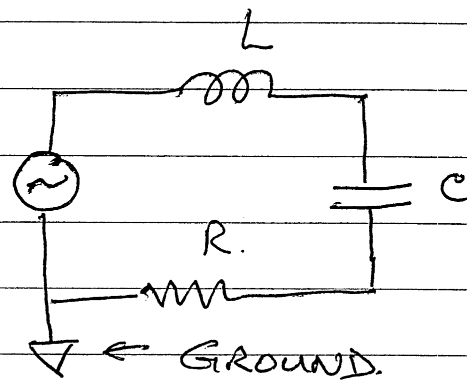
18. A coil of wire of area A is flipped in a $\vec{B}$ field from $\hat{n} \parallel \vec{B}$ to $\hat{n} \parallel -\vec{B}$. Show that during this experiment a charge $q = (2BA)/R$ travels around the coil whose

R is the resistance of the coil.

19. In the circuit shown S is closed at $t=0$. What is the current in the circuit i) immediately after $t=0$, ii) a long time later. Why?



20. In the circuit shown where would you attach the oscilloscope to measure the current? Why?



21. In a series L, C, R circuit we are told that the current phasor at $t=0$ is represented by $i_m \hat{x}$. Draw the corresponding voltage phasors across R, C, L.

22. Use the drawing of Prob 21 to calculate i) the impedance and (ii) the phase angle between the total voltage "vector" and the current "vector".

23. In Prob 22 if the current is $i = i_m \sin \omega t$ and the voltage is $\mathcal{E} = \mathcal{E}_m \sin(\omega t + \phi)$ show that the average power absorbed is

$$\langle P_w \rangle = \frac{i_m \mathcal{E}_m}{2} \cos\phi$$

$$= \frac{\mathcal{E}_m^2}{2R} \cos^2\phi$$

Hint: $i_m = \frac{\mathcal{E}_m}{Z}$, $Z = \sqrt{R^2 + (\omega L - \frac{1}{\omega C})^2}$, $\tan\phi = \frac{\omega L - \frac{1}{\omega C}}{R}$.
from P. 22

24. In Prob 20 the generator frequency can be varied. Why does the current become very small both at very low and very high frequencies?

25. Use the ideas of Probs. 20-24 to describe the phenomenon of resonance.

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