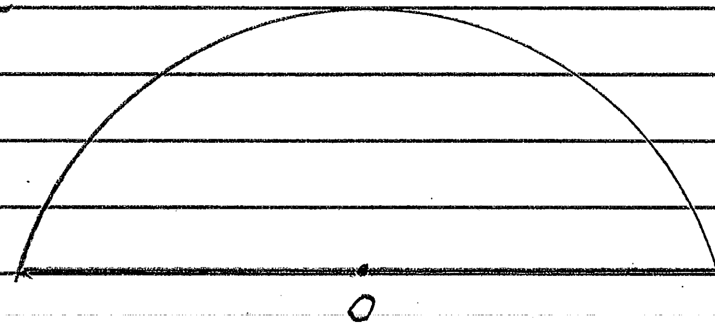
Test Questions – for FINAL

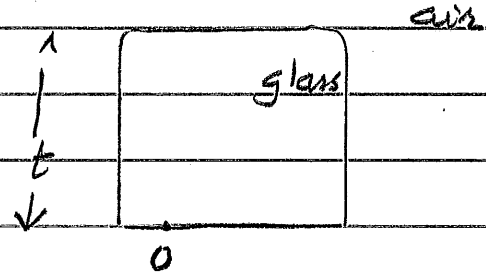
1. A hemispherical piece of glass of radius 10 cm is lying on a piece of paper and has a small black dot (O) at its center. Locate the image of O [support your answer with a diagram.



2. Show that a divergent lens or mirror can form only virtual images and that the image can never be further away from the lens (or mirror) than its focal point. (Provide ray Diagrams).

3. If you want to form an upright, enlarged image using a convergent lens (or mirror) where would you place the object? Why? (provide ray diagram)

4. Locate the image of the object O placed below a block of glass ($n_g = 1.5$) of thickness t.



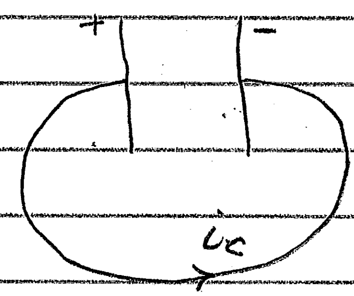
5. Complete the equation

$$D = \quad \sin\ (x - vt)$$

and precisely define the necessity for the factors that you introduce as well as their physical significance. Here x and t are space and time coordinates

6. Show that $\varepsilon_0 \dfrac{\Delta \phi_E}{\Delta t}$ where $\Delta \phi_E = \underline{E} \cdot \underline{A}$ has the dimensions of current.

7. The capacitor is fully charged when you connect a wire as shown. Show that the displacement current between the plates is equal to the conduction current in the wire.



8. What is a conservative force? Show that the Coulomb force is a conservative force.

$$\underline{F}_E = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}\ \hat{r}.$$

9. Show that when a sheet of charge having charge density σ is crossed the $\underline{E}$-field jumps by $\frac{\sigma}{\epsilon_0}$.

10. Show that when a thin sheet of thickness carrying a current density $\underline{J}$ is crossed the $\underline{B}$-field jumps by $\mu_0 J t$.

11. Prove that the energy densities of E and B fields are $\eta_E = \frac{1}{2}\epsilon_0 E^2$ and $\eta_B = \frac{B^2}{2\mu_0}$, respectively.

12. Show that the Intensity of a ~~x~~ periodic Electromagnetic wave can be written as $I = \frac{1}{2}\epsilon_0 c E_m^2 = \frac{c B_m^2}{2\mu_0}$ where E_m and B_m are the amplitudes

13. Light and Sound (in gases) are both waves, list 5 notable differences between them.

14. The speed of sound in a gas is given by $V_s = \sqrt{\frac{\gamma k_B T}{m}}$. Why is there a γ in this equation.

15. Prove that the intensity of a periodic sound wave is $I = \frac{1}{2} s_m^2 \omega^2 \frac{\gamma P_0}{V_s}$ where s_m is the amplitude and ω the angular frequency.

16 A wave $y_i = A_i \sin(kx - \omega t)$ travelling on a string arrives at $x=0$ where velocity changes from v to v' and it gives rise to a reflected wave $y_r = A_r \sin(kx + \omega t)$ and a transmitted wave $y_t = A_t \sin(k'x + \omega' t)$.

i) are these waves longitudinal or transverse?

ii) What is the relationship between ω' and ω?

iii) We are told that the amplitudes are related by the equations

$$\frac{A_r}{A_i} = \frac{v - v'}{v + v'}, \quad \frac{A_t}{A_i} = \frac{2v'}{v + v'}$$

(iv) The energy transported per second by a wave is

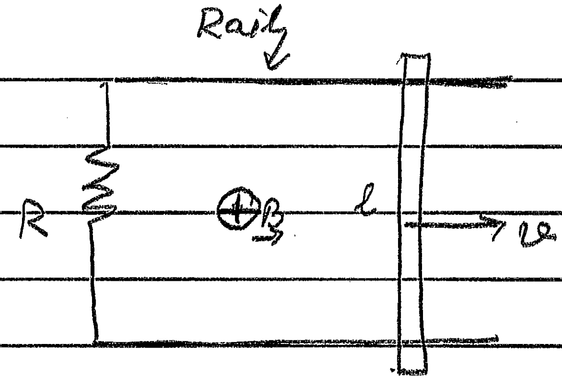
$$P = \frac{1}{2} A^2 \omega^2 \frac{T}{v}$$

where T is the Tension in the string. Show that if $v' \gg v$ very little energy goes into the transmitted wave.

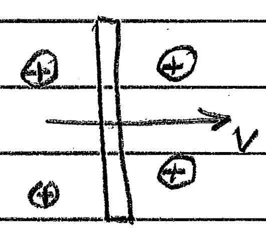
(v) Show that on reflection there is no change of phase if $v' \gg v$.

17. A mass M is subjected to a force $\vec{F} = C x \hat{x}$ where C is a positive quantity. Will it exhibit linear harmonic oscillations? Justify your answer.

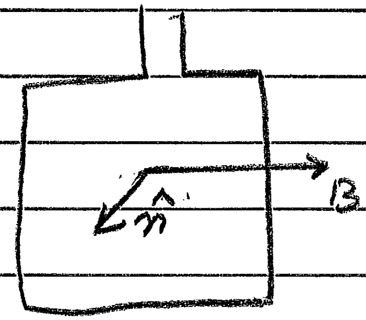
18. A copper bar of length l is sliding along the rails at a const. velocity of $v\hat{x}$ in a region where there is a uniform $\underline{B}$ field $-B\hat{z}$ (see figure). What is the current in R? Why? If I is the current, the resistor dissipates I^2R Joules/sec. Where does this energy come from?



19. Repeat problem 18 with no rails. Just a copper bar of length l moving at $v\hat{x}$ in a field of $-B\hat{z}$. What is the emf now? Why?

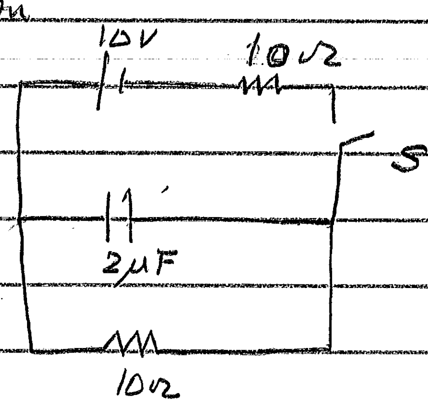


20. Shown is a coil of wire of width b and length l suspended vertically in a $\underline{B}$ field. It is free to rotate about the vertical. How would you make it work like a (i) motor and (ii) generator.

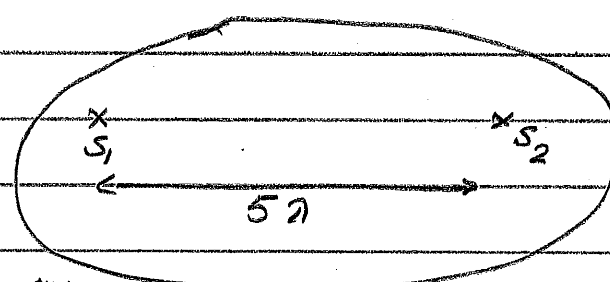


21. WRITE DOWN Maxwell's EQUATIONS and in Each Case precisely define the meaning of the terms on the two sides of the equations.

22. In the circuit shown what is the current in the circuit i) immediately after S is closed ii) a long time later



23. Two Coherent sources of Sound are separated by 5λ. The waves start from S_1 & S_2 in step. How many maxima would you encounter if you walk once on the path shown.



24. In the doppler effect the observed frequency f' is related to the emitted frequency f by

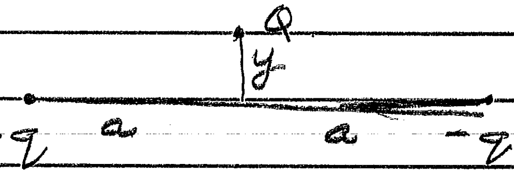
$$\frac{f'}{f} = 1 \pm \frac{V_{Det}}{V_{sound}}$$

if the detector moves but

$$\frac{f'}{f} = \frac{1}{1 \mp \frac{V_{source}}{V_{sound}}}$$

if the source moves. What accounts for this difference.

25. Two equal negative charges are located at $-a$ and $+a$. The force on a positive charge Q located at y would be



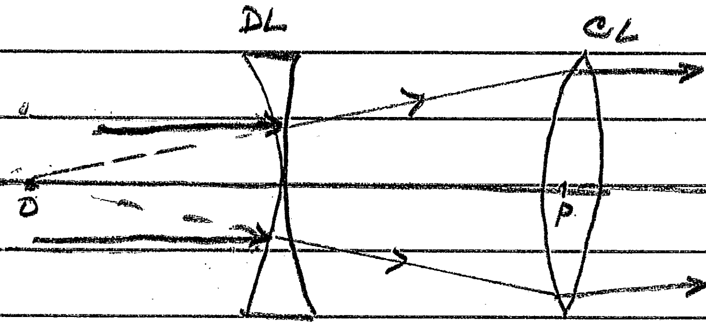
$$F = -\frac{2kqQ\,y}{(a^2+y^2)^{3/2}}\hat{y}$$

What will be the motion of Q if $y \ll a$. Why?

26. Show that when light from two coherent sources forms an interference pattern on a screen, the bright spots are equally spaced and equally intense.

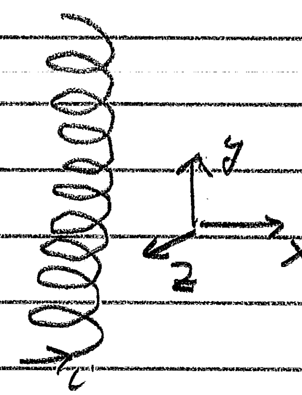
27. How would your observation change if the two sources in Prob 26 are identical but incoherent? Why?

28. The picture shows the path of light through a DL - CL combination. Prove that OP = f the focal length of the CL.



29 What is total internal reflection? Could you get total internal reflection for a ray of light going from air ($n = 1$) to water ($n = 1.33$)

31 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

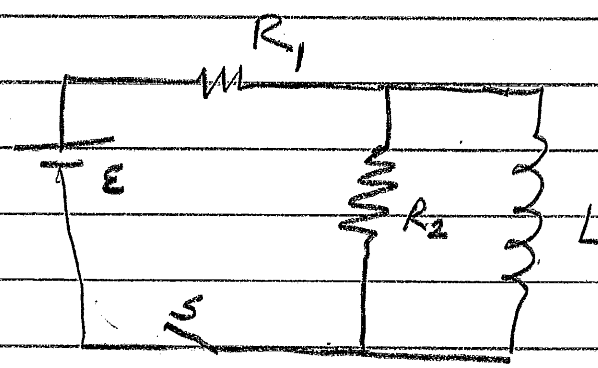


$$\vec{E}_{NC} = -\frac{\mu_0 n r}{2}\frac{\Delta i}{\Delta t}\hat{\phi} \quad \text{if } r<R$$

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

32 In prob. 31 what is the variation of the emf in a loop if i) $r<R$ and ii) $r>R$? Why?

33 In the circuit shown what is the current i) immediately after S is closed ii) a long time later.



34 When a wire is fixed at both ends (or a tube closed at both ends) the normal modes obey

$$n \frac{\lambda_n}{2} = L \quad n = 1, 2, 3 \ldots$$

However, if one end is open and the other closed they follow

$$(2n-1) \frac{\lambda_n}{4} = L \quad n = 1, 2, 3$$

What accounts for this difference?

35 What is the difference between interference and diffraction?

36. In the experiment with a simple pendulum why is it necessary to use small amplitudes?

37. The right rear view mirror of your car carries the warning "objects are nearer than they appear" what kind of mirror is this? (Support your answer with a diagram) why?