Physics 7B Third Exam August 20, 1992

You may use no books (except a Table of Integrals) and no papers except a card not larger than 3"×5". Exam totals 100 points.

(15)(1) In an oscillating LC circuit, the inductance is 3×10^{-3}H, and the capacitance is 2.7×10^{-6}F. At time $t=0$, the charge on the capacitor is zero and the current in the circuit is 2.0A. (a) Calculate the maximum charge that will appear on the capacitor; (b) After how many periods of oscillation will the energy stored in the capacitor be increasing at its greatest rate? (c) Calculate the greatest rate at which the energy in the capacitor increases. [a=b=c=5]

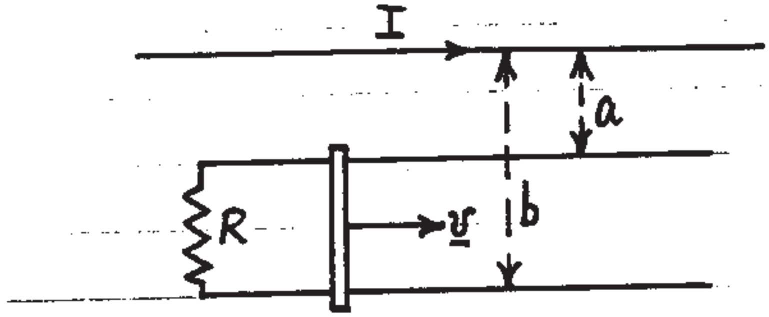
(15)(2) Given a series RLC circuit driven by an AC emf $\mathcal{E}(t)=\mathcal{E}_0\sin\omega t$, where $R=5\,\Omega$, $L=60\times10^{-3}$ H, $\omega=120\pi$ sec^{-1}, and $\mathcal{E}_0=300$ volts. (a) Calculate the value of C for which the average power in the circuit will be a maximum; (b) Calculate this maximum value of the average power; (c) Calculate the power factor when the average power is a maximum [a=b=c=5 points]

(20)(3) A length l of wire carries a current I and is formed into a flat circular coil of N turns. Show that the torque $\underline{\tau}$ exerted on the coil by an external magnetic field $\underline{B}$ (which is normal to the magnetic dipole moment vector of the coil) has magnitude

$$\tau=(Il^2B/4\pi N).$$

(continued →)

(25) (4) The figure below shows a copper rod moving with velocity $\underline{v}$ parallel to a long straight wire carrying a current I. The rod moves on rails connected to a resistor R as shown. Calculate the emf induced in the rod.



(25) (5) A straight wire segment of length l carries a current I. Show that the magnetic field $\underline{B}$, at a distance R from the wire along the perpendicular bisector of the wire, has the magnitude

$$B = \left(\frac{\mu_0 I}{2\pi R}\right)\frac{l}{[l^2+4R^2]^{1/2}}$$

$\epsilon_0 = 8.85\times10^{-12}\ C^2N^{-1}m^{-2}$; $\mu_0 = 4\pi\times10^{-7}\ T\,m\,A^{-1}$

$$\int\frac{dx}{(x^2+a^2)^{1/2}} = \ln\left[x+(x^2+a^2)^{\frac{1}{2}}\right]+C$$

$$\int\frac{x\,dx}{(x^2+a^2)^{1/2}} = (x^2+a^2)^{\frac{1}{2}}+C$$

$$\int\frac{dx}{(x^2+a^2)^{3/2}} = \frac{1}{a^2}\frac{x}{(a^2+x^2)^{1/2}}+C$$

$$\int\frac{x\,dx}{(x^2+a^2)^{3/2}} = \frac{-1}{(x^2+a^2)^{1/2}}$$

Physics 7B   Fourth Exam   August 21, 1992

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$R = 8.31\ J(K)^{-1}(mole)^{-1}$; $k_B = 1.38\times10^{-23}\ JK^{-1}$; $\epsilon_0 = 8.85\times10^{-12}\ C^2N^{-1}m^{-2}$; $\mu_0 = 4\pi\times10^{-7}\ TmA^{-1}$

(10)(1) Four moles of an ideal gas expand from volume V_1 to volume $2V_1$. The expansion is reversible and isothermal at 400 K. (a) Calculate the work done by the gas; (b) Calculate the entropy change of the gas. [a=b=5]

(15)(2) A certain non-ideal gas obeys the Van der Waals equation of state

$$\left(p+\frac{a}{V^2}\right)(V-b) = RT$$

where a and b are constants characteristic of the gas. One mole of this gas expands isothermally from volume V_i to volume V_f. Calculate the work done by the gas.

(25)(3) The spherical region $a<r<b$ carries a volume charge density $\rho(r) = Ar^{-1}$, where A is a constant (with units Cm^{-2}). At the center $(r=0)$ of the spherical region is a point charge $(+Q)$. Calculate the magnitude $E(r)$ of the electric field at a distance r (where $a<r<b$) from the center of the spherical region.

(25)(4) A long wire of circular cross section carries a current I distributed uniformly over its cross section. Show that the magnetic energy per unit length stored inside the wire is equal to $(\mu_0 I^2/16\pi)$.

(continued →)

(25)(5) A long copper wire (of circular cross section) carries a spatially uniform current I. Calculate the magnetic flux, per unit length of wire, passing through a plane surface S inside the wire, as shown in the drawing below.