

FOURTH MIDTERM

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Discussion Section # _____

REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!

Use the conversion constants and data given on the front page.

- (a) An electron is accelerated from rest through a potential of 500 volts. Calculate the radius of its circular path in the earth's magnetic field (assumed to be exactly 1.00 gauss).

$$\frac{mv^2}{2} = eU \quad ; \quad v = \sqrt{\frac{2eU}{m}} \quad ; \quad \frac{mv^2}{R} = qvB \Rightarrow R = \frac{mv}{qB} = \frac{1}{B} \sqrt{\frac{2mU}{e}} = \boxed{0.755 \text{ m}}$$

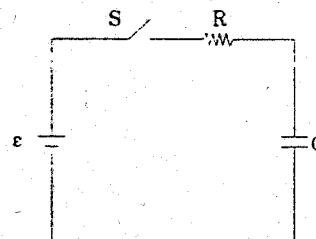
- (b) Calculate the cyclotron frequency, in Hz, for a proton in a magnetic field of 0.525 T.

$$\omega = \frac{eB}{m_p} \quad ; \quad f = \frac{1}{2\pi} \cdot \frac{eB}{m_p} = \boxed{8 \cdot 10^6 \text{ Hz}}$$

- (c) For the circuit shown calculate the current in the resistor 2.10 time constants after the switch is closed.

$\epsilon = 250 \text{ V}$
 $R = 350 \Omega$
 $C = 1.75 \mu\text{F}$

$$I_R = \frac{\epsilon}{R} e^{-\frac{t}{\tau}} = \boxed{8.75 \cdot 10^{-2} \text{ A}}$$



- (d) If a bolt of lightning has a current of $1.2 \times 10^5 \text{ A}$ and a radius of 3.75 cm, what is the average current density?

$$j = \frac{I}{A} = \frac{I}{\pi R^2} = \boxed{2.72 \cdot 10^7 \frac{\text{A}}{\text{m}^2}}$$

- (e) If copper has a density of $8.97 \times 10^3 \text{ kg/m}^3$ find the magnetic field needed to balance the weight of a copper rod whose diameter is 3.25 cm. The rod is carrying a current of 10,000 A and is horizontal. The magnetic field is horizontal and perpendicular to the rod.

$$mg = I\ell B$$

$$\rho A \ell g = I\ell B$$

$$B = \frac{\rho A g}{I} = \frac{\rho g \pi d^2}{4I} = \boxed{7.29 \cdot 10^{-3} \text{ T}}$$