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General Physics II, Final 2
PHYS1020AA, AB, AC, Class year 108
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ABSOLUTELY NO CHEATING! Dictionary and Calculators are NOT allowed.

Rules of the examine

1. You need to position your camera so we can see you.
2. Use a blank paper to write your answer to these problems. When you finish, you use your cell phone to take photos of your answer, then combine into one file (WORD or PDF), upload it into the e-learning TA Rajakar has created. The link is http://www.elearn.ndhu.edu.tw/moodle/index.php?lang=en_utf8
3. You need to mail your solution before 12:00, and you need to get a confirm letter for the TA within 30 min, then your examine is complete. If you have any difficulty in doing so, you can call me @890-3696
4. Your file name should be Name-Studentnumber.xxx; for example: John-King-123456789.xxx

Problems (5 Problems, total 100%)

You can take a photo of the problem first so you don't have to look at the problem on the screen **Please write your Student ID, name, phone number, and email on your answer sheet**

1. **Current and charge:** (20%) (a) In a section of wire of cross sectional area A, length Δx, where the charge carriers with charge q are moving with a drift velocity V_d. If n is the mobile charge per unit volume (carrier density), what is the current generated by the moving charge carriers? (b) If this is a copper wire with a carrier n=8.49×10^{28} electron/m^3, cross sectional area 3.31×10^{-6} m^2, and a 10A current running in it. What is the drift velocity of the carriers in the copper wire, knowing that an electron has 1.6×10^{-19} Coulomb?

2. **Maxwell's Equations:** (20%) Write down the 4 Maxwell's equations and briefly explain its meaning.

3. **Displacement current:** (20%)An ideal capacitor has two conducting plate that separated by a distance L, where two plates can have opposite charges (+q and -q). However, in a capacitor, current can flow through this device. Maxwell inserted one term $I_d = \epsilon_0 \frac{d\Psi_E}{dt}$ to solve the problem. Prove this term is indeed current (has the unit of Coulomb/sec).

4. **Capacitive reactance:** (20%) Refer to the figure to the right, if an AC source of frequency ω =50 Hz is connected to the points a and d. What is the capacitive reactance in this circuit?

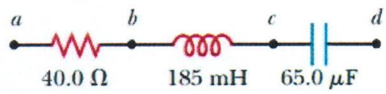
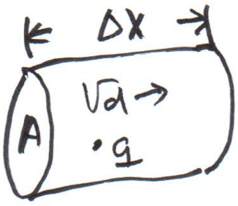


Figure P32.16 Problems 16 and 51.

5. **Single slit diffraction:** (20%) A parallel beam of blue light (wavelength 420 nm) is incident on a small aperture. After passing through the aperture, the beam is no longer parallel but diverges at 1° to the incident direction. What is the diameter of the aperture?
   Note: for small angle θ, $\sin\theta \cong \theta$; $1° = \pi/180 = 3.14/180 = 0.017$

1.

(a)



ΔQ = Total charge

$= (n A \Delta x) q$

$= (n A V_d \cdot \Delta t) q$ for a given time Δt

$\therefore I_{av} \doteq \frac{\Delta Q}{\Delta t} = \frac{n A V_d \Delta t q}{\Delta t} = n q V_d A$

(b) from (a) $I = n q V_d A$

$\rightarrow V_d = \frac{I}{n q A}$

$I = 10 A$

$A = 3.31 \times 10^{-6} m^2$, $n = 8.49 \times 10^{28}$ electron/m^3

$q = 1.6 \times 10^{-19}$ Coulomb

$$V_d = \frac{10 A}{(8.49 \times 10^{28})(1.6 \times 10^{-19} C)(3.31 \times 10^{-6} m^2)}$$

$\doteq 2.22 \times 10^{-4}$ m/sec

2 Maxwell's equations

1. $\oint \vec{E} \cdot d\vec{A} = \frac{q}{\epsilon_0}$ — You can calculate the electric field by constructing a Gaussian and the enclosed charge determines the field, this imply the possibility to isolate a single charge (positive or negative)

Gauss law Electricity

2. $\oint B \cdot dA = 0$ — this implies it is not possible to isolate a single pole of the magnet.

Gauss law magnetism

3 $\oint E \cdot ds = -\frac{d\phi_B}{dt}$ the possibility to create an E field by a changing magnetic flux. this connects Electricity and magnetism

Faraday's law

4 $\oint B \cdot ds = \mu_0 I + \mu_0 \epsilon_0 \frac{d\Phi_E}{dt}$

Ampere-Maxwell law — this determines the source of magnetis can be moving charge, or changing Electric flux ove time. and changing electric flux is a sort of current called displacement current.

3, $I_d = \epsilon_0 \frac{d\phi_E}{dt}$

from Gauss law $\Phi_E = EA$, E is electric field inside the capacitor
$= \frac{q}{\epsilon_0}$ A is the area of the plate

$\therefore I_d = \epsilon_0 \frac{d}{dt}\left[\frac{q}{\epsilon_0}\right] = \frac{dq}{dt} \equiv I$ $\therefore$ I_d has the same unit as current

4. The capacitance is C, with source $\omega = 50\ Hz$

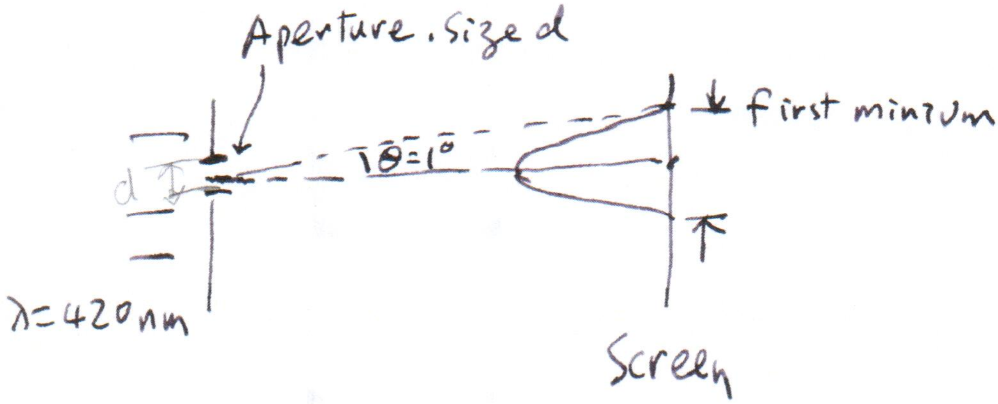
$C = 65\mu F$

$$\therefore X_C = \frac{1}{\omega C} = \frac{1}{2\pi(50\,Hz)(65\times10^{-6}\,F)}$$

$$= \frac{1}{2\pi\cdot(50\,\frac{1}{sec})(65\times10^{-6}\,F)}$$

$$= 49\,\Omega$$

5



The size on the screen of the aperture is the consequence of the diffraction. From the center to the first minimum is the observed size of the apenature,

The first minimum appears @

$d \sin\theta = n\lambda$, When $n=1$, and $\theta = \theta = 1°$

When angle is smalle, $\sin\theta \approx \theta = 2° = \frac{\pi}{180}$

↑ To account both sides of the image

$\therefore d\left(\frac{\pi}{180}\right) = 1 \cdot 420\,nm$

$= 420 \times 10^{-9}\,m$

$\therefore d = \dfrac{420 \times 10^{-19}}{\frac{\pi}{180}} = 24\,\mu m$

or $24 \times 10^{-6}\,m$