THE INTERNATIONAL UNIVERSITY (IU) – VIETNAM NATIONAL UNIVERSITY - HCMC

FINAL EXAMINATION – CLASS

Student Name:________________ Student ID:____________

Date: August 2017

Duration: 90 minutes

SUBJECT: PHYSICS 3	
Chair of Department of Physics: Signature: Full name: Phan Bảo Ngọc	Lecturer: Signature: Full name: Dương Hoài Nghĩa

INSTRUCTIONS: This is a closed book examination. Use of cell phones, laptops, dictionaries is not allowed.

1) A conducting rod of length d is free to slide on two parallel conducting bars. Two resistors R_1 and R_2 are connected across the ends of the bars (Fig.1). There is a uniform magnetic field B pointing into the page. An external agent pulls the bar to the right at a constant velocity v.

   a) Find the magnitude and the direction of the currents through the resistors. (*15 marks*)

   b) Find the applied force needed for the rod to maintain a constant velocity. (*10 marks*)

Fig. 1

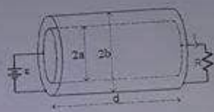

Fig. 2

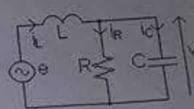

Fig. 3

2) A coaxial cable transmits DC power from a battery with emf ε to a load with resistance R. The cable consists of two concentric, long, hollow cylinders with radii a, b and length d (Fig.2). Assume that the internal resistance of the battery and the resistance of the cable can be neglected.

   a) Find the electric field in the cable and the capacitance of the cable. (*15 marks*)

   b) Find the magnetic field in the cable and the inductance of the cable. (*10 marks*)

3) Consider the circuits in Fig. 3 where $e = 200\sin(1000t)$ V, R = 100 Ω, L = 100 mH, C = 10 μF. Find the currents $i_R(t)$, $i_L(t)$, $i_C(t)$. (*25 marks*)

4) A plane electromagnetic wave, with wave length $\lambda = 1$ m travels in vacuum in the positive direction of the z axis. The electric field, of amplitude E = 100 V/m, oscillates parallel to the x axis.

   a) Find the amplitude of the magnetic field component. Parallel to which axis does the magnetic field oscillate? (*15 marks*)

   b) Find the Poynting vector and the time-averaged rate of the energy flow (*10 marks*)

END OF QUESTION PAPER

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1/

a/ $\mathcal{E} = \frac{d\phi_B}{dt} = B\frac{dA}{dt} = Bd\frac{dx}{dt} = Bdv$

i_1: To the right $\Rightarrow \frac{d\phi_B}{dt} > 0 \Rightarrow \vec{B_i} \uparrow\downarrow \vec{B} \Rightarrow$ Counter clockwise ; $i_1 = \frac{\mathcal{E}}{R_1} = \frac{Bdv}{R_1}$

i_2: $\quad$ " $\quad \Rightarrow \frac{d\phi_B}{dt} < 0 \Rightarrow \vec{B_i} \uparrow\uparrow \vec{B} \Rightarrow$ clockwise ; $i_2 = \frac{\mathcal{E}}{R_2} = \frac{Bdv}{R_2}$

b/

$\vec{F_B} = i\vec{L} \times \vec{B}$; $i = i_1 + i_2 = \frac{(R_1+R_2)Bdv}{R_1R_2}$

$\hookrightarrow$ $\vec{F_B}$ to the left $\Rightarrow \begin{cases} F_{applied} \text{ to the right} \\ |\vec{F_B}| = |\vec{F}_{applied}| \end{cases}$

$|\vec{F_B}| = \frac{(R_1+R_2)B^2d^2v}{R_1R_2}$

2/ a/ Gauss' Law: $\oint \varepsilon_0 \phi_E = q_{enc} \Rightarrow \varepsilon_0 2\pi r d E = q_{enc} \Rightarrow E = \frac{q_{enc}}{2\pi\varepsilon_0 r d}$

$(a < r < b)$

$V = \int E ds = \int_a^b E dr = \int_a^b \frac{q\,dr}{2\pi\varepsilon_0 d r} = \frac{q}{2\pi\varepsilon_0 d}\int_a^b \frac{1}{r}dr$

$= \frac{q}{2\pi\varepsilon_0 d} \ln\left(\frac{b}{a}\right)$

$q = CV \Rightarrow C = \frac{q}{V} = \frac{2\pi\varepsilon_0 d}{\ln\frac{b}{a}}$

b/ Ampere's Law $\Rightarrow \oint B ds = 2\pi r B = \mu_0 i \Rightarrow B = \frac{\mu_0 i}{2\pi r} = \frac{\mu_0 \mathcal{E}}{2\pi r R}$

$(a < r < b)$

Imagine a rectangular sheet with width d, stretching from a to b.

$\phi_B = \int_a^b B d\,dr = d\int_a^b B\,dr = d\int_a^b \frac{\mu_0 i}{2\pi r}dr = \frac{\mu_0 i d}{2\pi}\ln\left(\frac{b}{a}\right)$

Inductance $L = \frac{\phi_B}{i} = \frac{\mu_0 d}{2\pi}\ln\left(\frac{b}{a}\right)$

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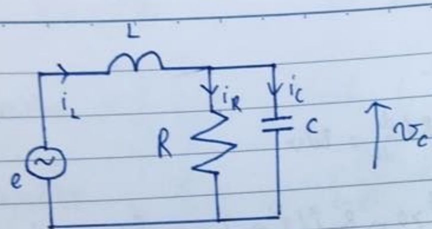
3| 

$e = 200\sin(1000t)$

$R = 100\ \Omega$

$L = 100\,mH \Rightarrow Z_L = 100\ \Omega$

$C = 10\,\mu F \Rightarrow Z_C = 100\ \Omega$

$$v_C = V_m \sin(1000t + \varphi) \Rightarrow i_C = \frac{V_m}{100}\sin(1000t + \varphi + 90^\circ)$$

$$i_R = \frac{V_m}{100}\sin(1000t + \varphi)$$

Junction Rule: $i_L = i_C + i_R = \frac{\sqrt{2}}{100} V_m \sin(1000t + \varphi + 45^\circ)$

↳ $v_L = \sqrt{2}\, V_m \sin(1000t + \varphi + 135^\circ)$

~~Loop~~ We have: $e = v_L + v_C$

$$\Rightarrow 200\sin(1000t) = V_m \sin(1000t + \varphi) + \sqrt{2}\, V_m \sin(1000t + \varphi + \dots$$

$$= V_m \sin(1000t + \varphi + 90^\circ)$$

$$\Rightarrow V_m = 200;\ \varphi = -90^\circ$$

$$\Rightarrow \begin{cases} i_C = 2\sin(1000t) \\ i_R = 2\sin(1000t - 90^\circ) \\ i_L = 2\sqrt{2}\sin(1000t - 45^\circ) \end{cases}$$

4| ~~What the fuck??~~

a| Travel on the z axis & Efield oscillates parallel to x axis $\Big\}\Rightarrow$ B field oscillate parallel to y axis

$$B_m = \frac{E_m}{c} = \frac{100}{3\times10^8} = \frac{1}{3\times10^{-6}}\ (T)$$

b| what the actual fuck??

$\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B} \Rightarrow S = \frac{E^2}{\mu_0 c} = \frac{1}{\mu_0 c}100^2\sin^2(\omega t - kx)$; $\omega = 2\pi f = 2\pi\dots$

~~$\Rightarrow S = \frac{1}{\mu_0 c}100^2\sin^2$~~ ; $k = \frac{2\pi}{\lambda}$

$\Rightarrow S = \frac{1}{\mu_0 c}100^2\sin^2(2\pi c t - 2\pi)$; Direction: along the z-axis.

$$I = \frac{100^2}{2c\mu_0} = 13.263\ W$$

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5| $\vec{E} = E_0 \sin(\omega t - kx)\vec{a}_y$

=> ~~#~~ E field propage along x-axis, oscillate parallel to y-axis.

$\Rightarrow \vec{B} \Rightarrow \vec{B} = \frac{E_0}{c}\sin(\omega t - kx)\vec{a}_{\cancel{y}z}$

Poynting vector: $\vec{S} = \frac{1}{\mu_0}\vec{E}\times\vec{B} \Rightarrow \vec{S} = \frac{1}{\mu_0 c}E_0^2\sin^2(\omega t - kx)\vec{a}_x$