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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER I
SESSION 2017/2018

COURSE NAME	:	ELECTROMAGNETIC FIELDS AND WAVES
COURSE CODE	:	BEB 20303
PROGRAMME	:	BEV / BEJ
EXAMINATION DATE	:	DECEMBER 2017/ JANUARY 2018
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS

THIS QUESTION PAPER CONSISTS OF **NINE (9)** PAGES

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Q1 (a) Consider two nested cylindrical conductors as shown in **Figure Q1(a)** of height, h and radii, a and b respectively. A charge $+Q$ is evenly distributed on the inner cylinder and $-Q$ on the outer cylinder. The region in between the cylinders is filled with dielectric material constant ε_r. Derive the capacitance, C of the system in terms of a, b and h. You may ignore the edge effects.

(7 marks)

(b) Three dielectrics are placed in between a parallel-plate capacitor as shown in **Figure Q1 (b).** Each plate has an area, $A = 0.004$ m^2 and the plates are separated by a distance $d = 0.006$ m. The dielectrics constant are given as $\varepsilon_1 = 2.4$, $\varepsilon_2 = 2$ and $\varepsilon_3 = 4$. Compute the capacitance of the system.

(3 marks)

(c) The centre of the dielectric spherical shell is located at (0, 4, -5). It carries volume charge density $\rho_v = 2$ nC/m^3 with inner radius, $a = 1$ m outer radius $b = 3$ m. A point charge with $Q_l = 5$ nC is located at the center of the spherical shell as shown in **Figure Q1 (c).** In addition, an infinite long wire is located along the z-axis carries line charge density, $\rho_l = -12$ n C/m. Calculate the total electric field, $\vec{E}$ at (0, 6, 4).

(15 marks)

Q2 (a) Consider an infinite sheet located at $z = 0$ with current density of **K** A/m as shown in **Figure Q2 (a).**

(i) Identify the magnitude and direction of the current density, **K,**

(1 mark)

(ii) Explain the generation of magnetic field intensity **H** above and below the infinite sheet with an aid of diagram.

(5 marks)

(iii) By applying Ampere's circuit law to the given Amperian path in **Figure Q2 (a),** shows that the magnetic field intensity, **H** from the infinite sheet due to the current density **K** A/m is given by,

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$$\mathbf{H} = \frac{1}{2}\mathbf{K} \times \hat{n}$$

(9 marks)

(b) **Figure Q2 (b)** shows two infinite sheets at $z = 0$ and $z = -4$ carrying current densities of $10\hat{x}$ A/m and $-20\hat{x}$ A/m respectively. Determine,

(i) magnetic field intensity, **H**, at (-1,-1,-1),

(5 marks)

(ii) magnetic flux density, **B** at (0,-3,2).

(5 marks)

Q3 (a) A conducting bar is moving at a velocity, $\boldsymbol{v} = 15\,\hat{y}$ m/s on two conducting rails separated by distance L as shown in **Figure Q3(a)**. If the $\boldsymbol{B} = -6\hat{z}\ mWb/m^2$.

(i) State the type of V_{emf} induced in **Figure Q3(a)**.

(1 mark)

(ii) State whether the current is flowing in clock wise or anti clock wise direction.

(1 mark)

(iii) Calculate the voltage, V_{emf} induced in the bar.

(4 marks)

(iv) What is effect of the V_{emf} if the L in **Figure Q3(a)** increase.

(1 mark)

(v) If V_{emf} = 5V is required, by putting the bar in the same condition as above, determine the suitable value of L.

(2 marks)

(b) A circular loop with N turns is placed within a time-varying magnetic field as shown in **Figure Q3 (b).** Force is applied at the loop and it changes its shape to be elliptic as shown in **Figure Q3 (b).** Explain how this will affect the V_{emf} generated.

(4 marks)

(c) An inductor is formed by 10 turns of a thin conducting wire into a rectangular loop centered at the origin as shown in **Figure Q3 (c)**. In the presence of a magnetic field given by

$$\boldsymbol{B} = 50x^2\,(2\hat{z} + 3\,\hat{y})\cos 10^3\, t\,,$$

(i) determine the voltage across the resistor, R.

(10 marks)

(ii) calculate the current induced, I in the inductor, if the resistor value is,

R = 100 ohm.

(2 marks)

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Q4 (a) Electromagnetic (EM) waves such as radio waves, TV signal, radar beam and so on propagate into the space to deliver information. The propagation characteristics of EM wave are influenced by relative permittivity, ε_r relative permeability, μ_r and conductivity, σ . These parameters are dependent on the medium used. Elaborate the plane wave propagation characteristic of the followings:

(i) Free space

(4 marks)

(ii) Lossless dielectric

(4 marks)

(iii) Good conductor

(4 marks)

(b) The electric field in free space is given by

$$\boldsymbol{E} = 50\cos(10^8\, t + \beta x)\hat{z} \qquad V/m$$

(i) Find the direction of wave propagation.

(2 mark)

(ii) Calculate the phase constant, β and the time it takes to travel a distance of $\lambda/2$.

(5 marks)

(iii) Sketch the wave at $t = 0$, $t = T/4$ and $t = T/2$.

(6 marks)

– END OF QUESTIONS –

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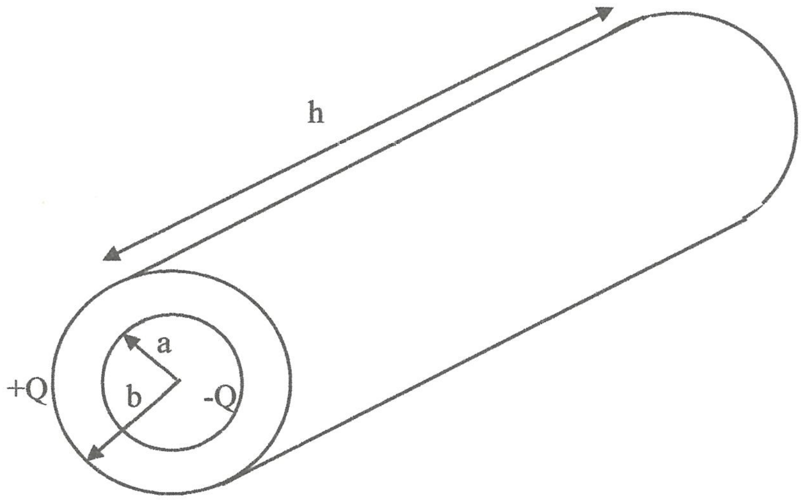

Figure Q1 (a)

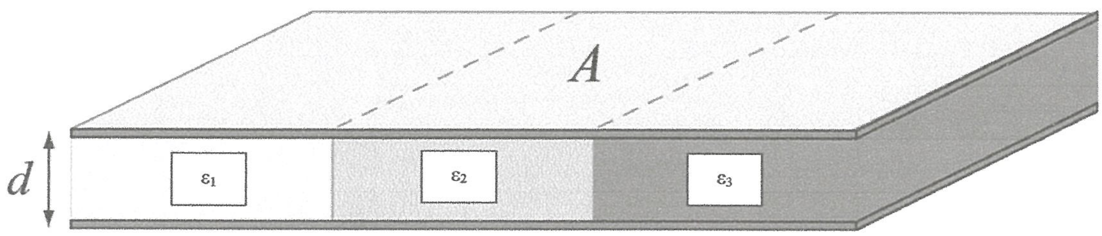

Figure Q1 (b)

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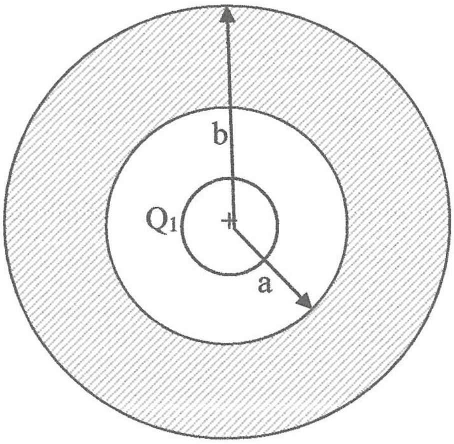

Figure Q1(c)

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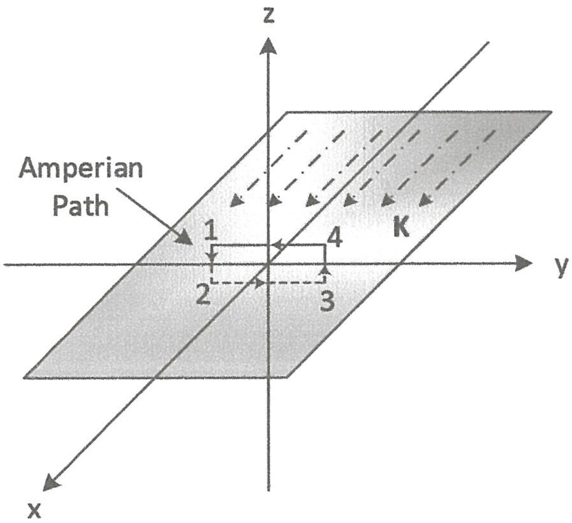

Figure Q2 (a)

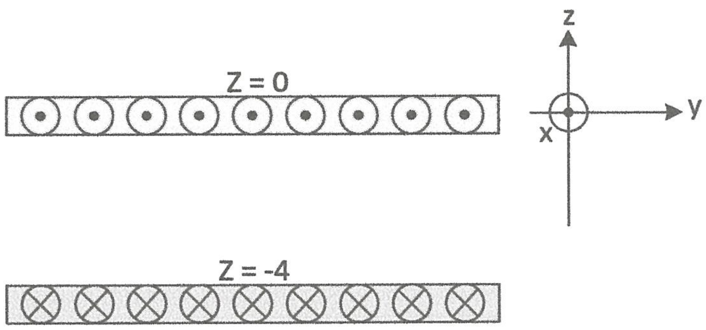

Figure Q2 (b)

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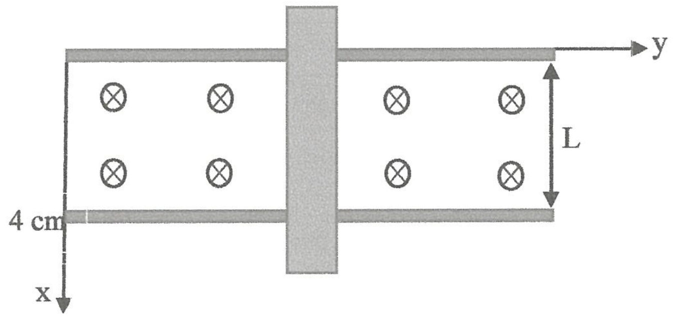

Figure Q3 (a)

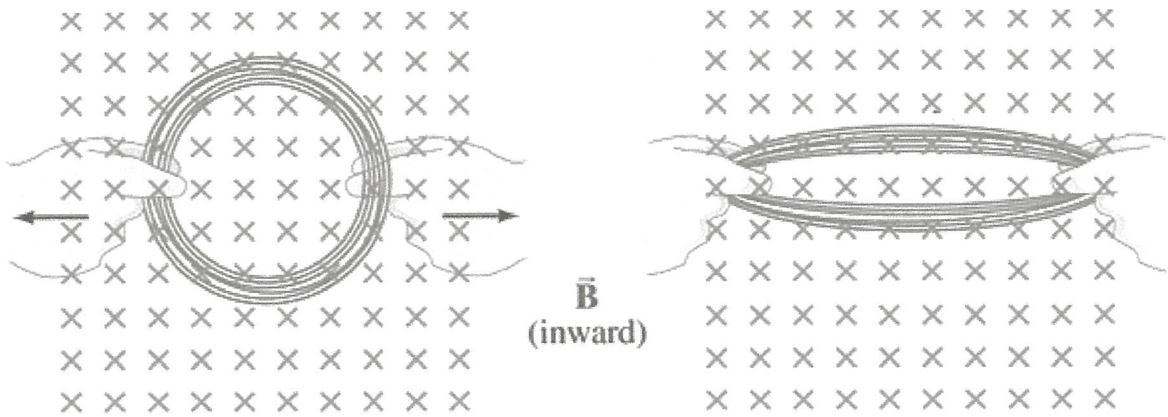

Figure Q3 (b)

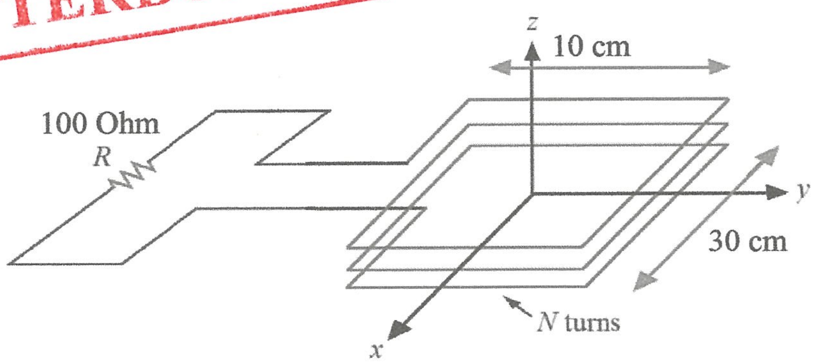

Figure Q3 (c)

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FORMULA

$Q=\int \rho_\ell d\ell,$

$Q=\int \rho_s dS,$

$Q=\int \rho_v dv$

$\bar{F}_{12}=\dfrac{Q_1Q_2}{4\pi\varepsilon_0 R^2}\hat{a}_{R_{12}}$

$\bar{E}=\dfrac{\bar{F}}{Q},$

$\bar{E}=\dfrac{Q}{4\pi\varepsilon_0 R^2}\hat{a}_R$

$\bar{E}=\int\dfrac{\rho_\ell d\ell}{4\pi\varepsilon_0 R^2}\hat{a}_R$

$\bar{E}=\int\dfrac{\rho_s dS}{4\pi\varepsilon_0 R^2}\hat{a}_R$

$\bar{E}=\int\dfrac{\rho_v dv}{4\pi\varepsilon_0 R^2}\hat{a}_R$

$\bar{D}=\varepsilon\bar{E}$

$\psi_e=\int\bar{D}\bullet d\bar{S}$

$Q_{enc}=\oint_S\bar{D}\bullet d\bar{S}$

$\rho_v=\nabla\bullet\bar{D}$

$V_{AB}=-\int_A^B\bar{E}\bullet d\bar{\ell}=\dfrac{W}{Q}$

$V=\dfrac{Q}{4\pi\varepsilon r}$

$V=\int\dfrac{\rho_\ell d\ell}{4\pi\varepsilon r}$

$\oint\bar{E}\bullet d\bar{\ell}=0$

$\nabla\times\bar{E}=0$

$\bar{E}=-\nabla V$

$\nabla^2 V=0$

$R=\dfrac{\ell}{\sigma S}$

$I=\int\bar{J}\bullet dS$

$d\bar{H}=\dfrac{Id\bar{\ell}\times\bar{R}}{4\pi R^3}$

$Id\bar{\ell}\equiv\bar{J}_s dS\equiv\bar{J}dv$

$\oint\bar{H}\bullet d\bar{\ell}=I_{enc}=\int\bar{J}_s dS$

$\nabla\times\bar{H}=\bar{J}$

$\psi_m=\int_s\bar{B}\bullet d\bar{S}$

$\psi_m=\oint\bar{B}\bullet d\bar{S}=0$

$\psi_m=\oint\bar{A}\bullet d\bar{\ell}$

$\nabla\bullet\bar{B}=0$

$\bar{B}=\mu\bar{H}$

$\bar{B}=\nabla\times\bar{A}$

$\bar{A}=\int\dfrac{\mu_0 Id\bar{\ell}}{4\pi R}$

$\nabla^2\bar{A}=-\mu_0\bar{J}$

$\bar{F}=Q(\bar{E}+\bar{u}\times\bar{B})=m\dfrac{d\bar{u}}{dt}$

$d\bar{F}=Id\bar{\ell}\times\bar{B}$

$\bar{T}=\bar{r}\times\bar{F}=\bar{m}\times\bar{B}$

$\bar{m}=IS\hat{a}_n$

$V_{emf}=-\dfrac{\partial\psi}{\partial t}$

$V_{emf}=-\int\dfrac{\partial\bar{B}}{\partial t}\bullet d\bar{S}$

$V_{emf}=\int(\bar{u}\times\bar{B})\bullet d\bar{\ell}$

$I_d=\int J_d.d\bar{S}, J_d=\dfrac{\partial\bar{D}}{\partial t}$

$\gamma=\alpha+j\beta$

$\alpha=\omega\sqrt{\dfrac{\mu\varepsilon}{2}\left[\sqrt{1+\left[\dfrac{\sigma}{\omega\varepsilon}\right]^2}-1\right]}$

$\beta=\omega\sqrt{\dfrac{\mu\varepsilon}{2}\left[\sqrt{1+\left[\dfrac{\sigma}{\omega\varepsilon}\right]^2}+1\right]}$

$\bar{F}_1=\dfrac{\mu I_1 I_2}{4\pi}\oint_{L1}\oint_{L2}\dfrac{d\bar{\ell}_1\times(d\bar{\ell}_2\times\hat{a}_{R_{21}})}{R_{21}^{\,2}}$

$|\eta|=\dfrac{\sqrt{\mu/\varepsilon}}{\left[1+\left(\dfrac{\sigma}{\omega\varepsilon}\right)^2\right]^{\frac{1}{4}}}$

$tan2\theta_\eta=\dfrac{\sigma}{\omega\varepsilon}$

$tan\theta=\dfrac{\sigma}{\omega\varepsilon}=\dfrac{\bar{J}_s}{\bar{J}_{ds}}$

$\delta=\dfrac{1}{\alpha}$

$\varepsilon_0=8.854\times10^{-12}\ \text{Fm}^{-1}$

$\mu_0=4\pi\times10^{-7}\ \text{Hm}^{-1}$

$\int\dfrac{dx}{(x^2+c^2)^{3/2}}=\dfrac{x}{c^2(x^2+c^2)^{1/2}}$

$\int\dfrac{xdx}{(x^2+c^2)^{3/2}}=\dfrac{-1}{(x^2+c^2)^{1/2}}$

$\int\dfrac{dx}{(x^2\pm c^2)^{1/2}}=ln\left(x+\sqrt{x^2\pm c^2}\right)$

$\int\dfrac{dx}{(x^2+c^2)}=\dfrac{1}{c}tan^{-1}\left(\dfrac{x}{c}\right)$

$\int\dfrac{xdx}{(x^2+c^2)}=\dfrac{1}{2}ln(x^2+c^2)$

$\int\dfrac{xdx}{(x^2+c^2)^{1/2}}=\sqrt{x^2+c^2}$

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