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UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
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SEMESTER II
SESSION 2019/2020

COURSE NAME	:	ELECTROMAGNETIC FIELDS AND WAVES / ENGINEERING ELECTROMAGNETICS
COURSE CODE	:	BEB20303/BEF22902
PROGRAMME	:	BEJ
EXAMINATION DATE	:	JULY 2020
DURATION	:	3 HOURS
INSTRUCTION	:	ANSWER ALL QUESTIONS **OPEN BOOK EXAMINATION**

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FINAL EXAM BEB20303/BEF22902 EMT 1920S2 (50 Marks) 03 Hour.

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Q 1 (Electrostatic)

Please answer all questions.

Q1 (a): The electrostatic field is conservative as it has the the following characteristics EXCEPT that: *

- Its circulation is identically zero.
- it is the gradient of a scalar potential.
- Its curl is identically zero.
- The potential difference between any two points is zero.

Q1 (b): *

A capacitor is made with seven metal plates and separated by sheets of Mica having a thickness of 0.3 mm and a relative permittivity, ε_r of 6. The area of one side of each plate is 500 cm^2. A potential difference of 400 V is maintained across the terminals of the capacitor. Calculate the capacitance, C

$C = 0.0531\ \mu F$	$C = 0.531\ \mu F$
Option 1	Option 2
$C = 5.31\ \mu F$	$C = 53.1\ \mu F$
Option 3	Option 4

Q1 (c): *

A homogeneous dielectric with a relative permittivity, ε_r of 2.5 fills Region 1 (x < 0) while Region 2 (x > 0) is a free space. If $\mathbf{D}_1 = 12\hat{\mathbf{x}} - 10\hat{\mathbf{y}} + 4\hat{\mathbf{z}}$ nC/m², determine $\mathbf{D}_2$.

$\mathbf{D}_2 = 12\hat{\mathbf{x}} - 4\hat{\mathbf{y}} - 1.6\hat{\mathbf{z}}\ nC/m^2$

Option 1

$\mathbf{D}_2 = 12\hat{\mathbf{x}} + 4\hat{\mathbf{y}} - 1.6\hat{\mathbf{z}}\ nC/m^2$

Option 2

$\mathbf{D}_2 = 12\hat{\mathbf{x}} - 4\hat{\mathbf{y}} + 1.6\hat{\mathbf{z}}\ nC/m^2$

Option 3

$\mathbf{D}_2 = 12\hat{\mathbf{x}} + 4\hat{\mathbf{y}} + 1.6\hat{\mathbf{z}}\ nC/m^2$

Option 4

Q1 (d): A perfect conductor could not contain an electrostatic field inside it. How does this behaviour will affect the properties of a conductor? *

- Electric field is zero
- Volume charge density is zero
- Potential difference between any points is zero
- Current is Zero
- Magnetic field is zero
- magnetic flux line is zero

Q1 (e): Which of the followings are NOT true true about equipotential surface? *

- Every point on the equipotential surface has the same potential difference.
- The field lines and equipotential surface are orthogonal with each other.

No work is done when the charge moves along an equipotential line.

No work is done when the charge moves between the lower to higher potential lines.

Q1 (f): Predict the outcomes when we rub a glass rod with a silk cloth. *

- Both glass rod and silk acquire negative charge.
- Both glass rod and silk acquire positive charge
- Glass rod acquires negative charge while silk acquires positive charge.
- Glass rod acquires positive charge while silk acquires negative charges.

Q1 (g): Two point charges, Q1 and Q2 each with a charge of 1 nC and 2 nC are separated at a distance apart. Which of the following statements are true? *

- The force on Q1 is repulsive.
- The force on Q2 is the same in magnitude as that on Q1.
- As the distance between them decreases, the force on Q1 increases linearly.
- The force on Q2 is along the line joining them.

Q1 (h): "The total electric flux through any closed surface surrounding the charge is equal to the amount of charge enclosed." This statement is associated with ________________. Fill in the blank. *

- Conservative nature of E
- Gauss Law
- Biot-Savart Law
- Faraday Law
- Ampere Law
- Stokes Theorem
- Divergence Theorem

Q1 (i): "Two identical, small spheres of mass 2.0 g are fastened to the ends of a 0.60 m long light, flexible, insulating fishing line. The fishing line is suspended by a hook in the ceiling at its exact centre. The spheres are each given an identical electric charge.They are in static equilibrium, with an angle of 30 between the string halves, as shown. Calculate the magnitude of the charge on each sphere. *

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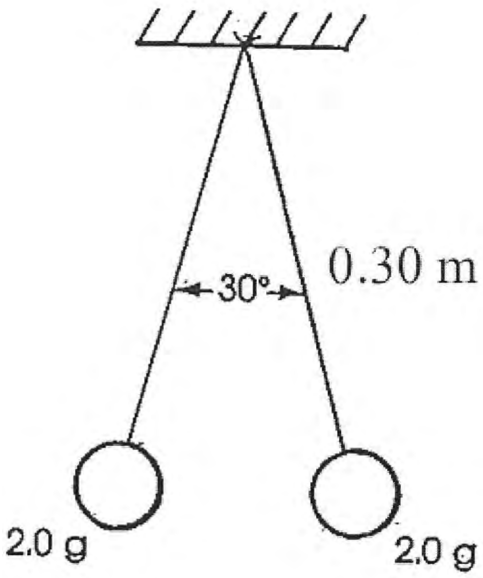


- 1.2 x 10 -7 C
- 2.2 x 10 -7 C
- 3.2 x 10 -7 C
- 4.2 x 10 -7 C
- 5.2 x 10 -7 C

Q 2 (Magnetostatic)

Q2 (a): The magnitude of H vector due to an infinite straight current-carrying filamentary conductor can be expressed in terms (as a function) of one of the following coordinates: *

- r
- z
- φ
- 0

Q2 (b): The direction of H vector due to an infinite straight current-carrying filamentary conductor is: *

- Radial
- Circumferential
- Parabolic
- Elliptical

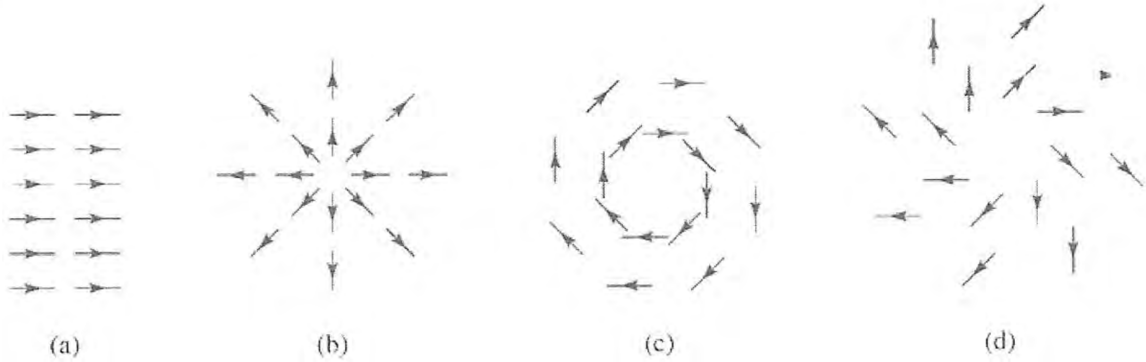
Q2 (c): A finite conductor with a length of 3 m is laid along x-axis currying a current of 3 A in (x roof) direction and magnetic flux density of 0.08 (z roof) (T), the conductor experiences a magnetic force of: *

- - 0.92 N (z roof)
- - 0.52 N (z roof)
- - 0.82 N (x roof)
- - 0.62 N (y roof)
- - 0.72 N (y roof)
- - 0.22 N (z roof)

Q2 (d): Maxwell's third and fourth equations for static fields in point form can be described in words as: *

curl of a magnetic field intensity vector equals to current density., divergence of magnetic flux density vector equals to zero.

Q2 (e): V.B≠0 (non-vanishing) in: *



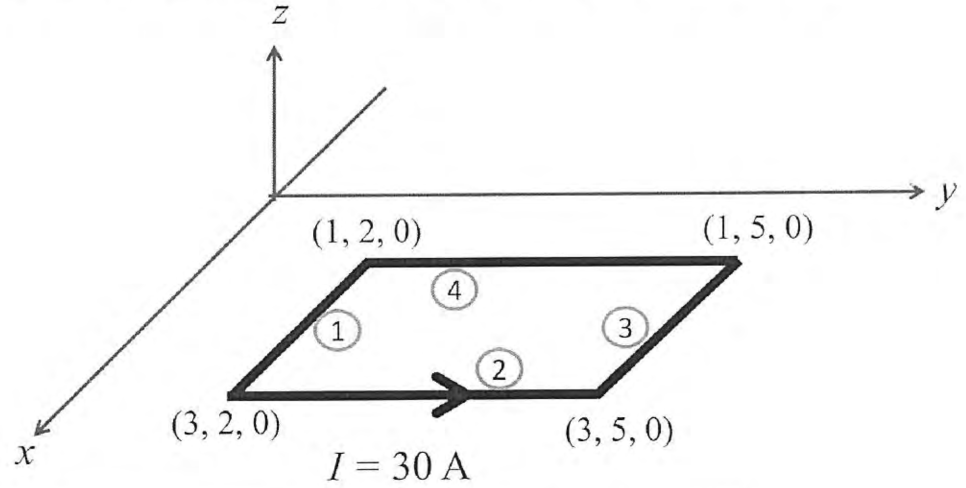
- a
- b
- c
- d

Q2 (f): State whether the following statement is true or false. A rectangular loop is placed in a non-parallel B with respect to its plane, all four arms of the loop experiences non-zero forces. *

- True
- False

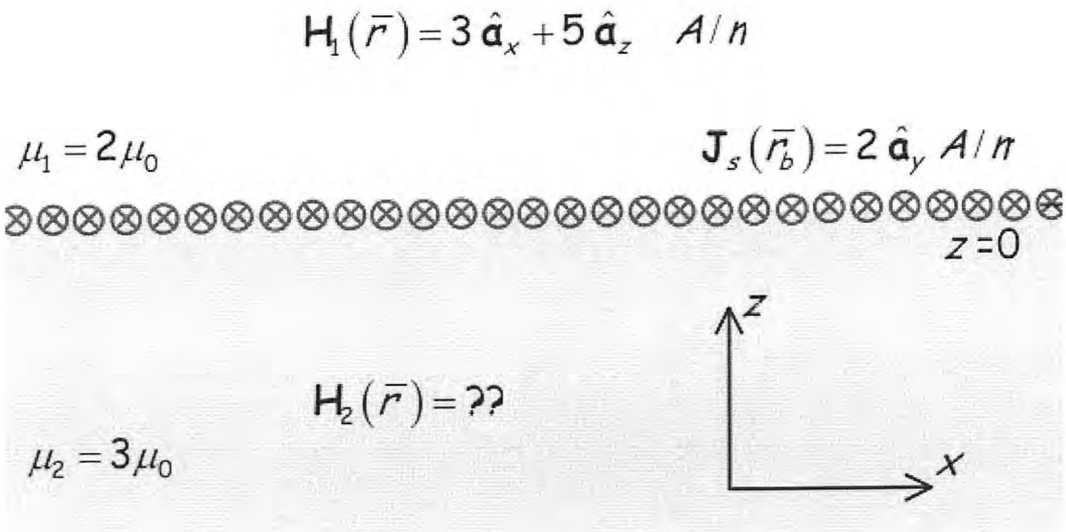
Q2 (g): Write the final answer. *

A rectangular loop as shown below lies in the xy–plane at $z = 0$. Find the total force exerted on the rectangular loop located in free space if the magnetic flux density, $\vec{B}$ is given by: $\vec{B} = -3x\hat{x}+5y\hat{y} - 2z\hat{z}$ (T). The loop is bounded by x=1, x=3, y–2, y–5, all in cm.



-36 (z roof) mN

Q2 (g)(i): Consider two magnetic materials, separated by a boundary as shown in the following Figure. What is scalar component the magnetic field in region 2? *



	0	1	10/3	2/4	2	4	5
Hx	○	◉	○	○	○	○	○

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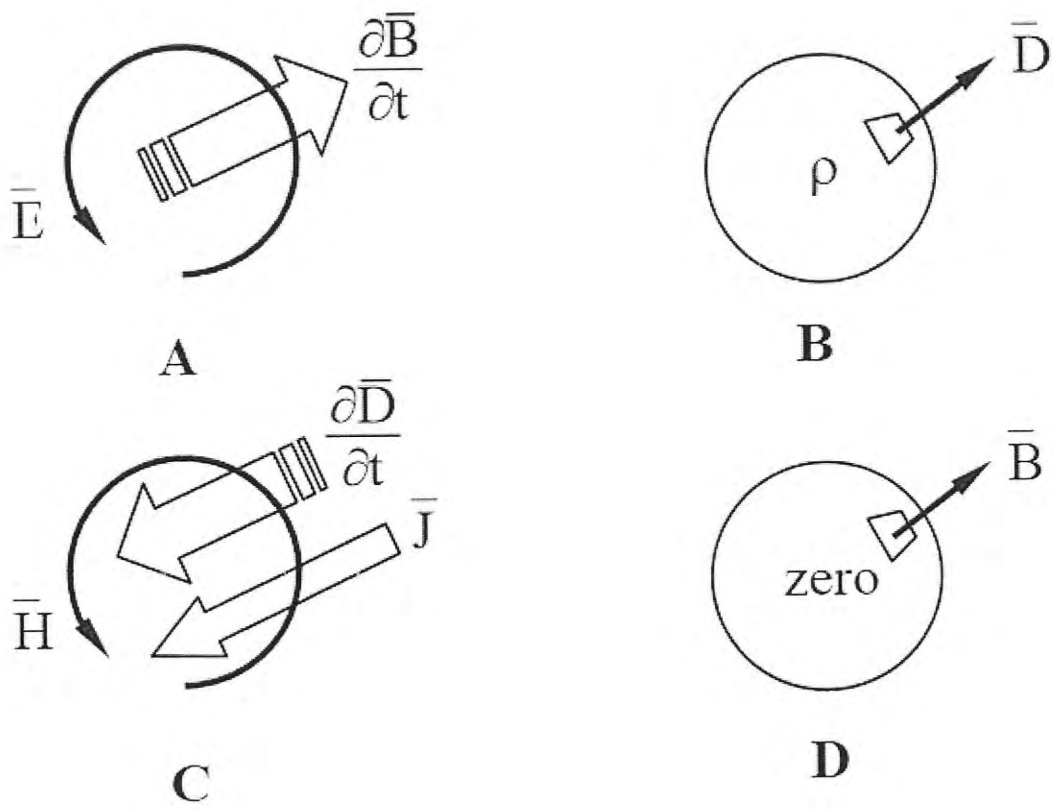
	0	1	10/3	2/4	2	4	5
Hy	◉	○	○	○	○	○	○
Hz	○	○	◉	○	○	○	○

Analyse the Figure below and decide which one best describe the Gauss Law for magnetic field. *



○ A
○ B
○ C
◉ D

Q 3 (Time-Varying Fields)

Q3 (a)(i): *

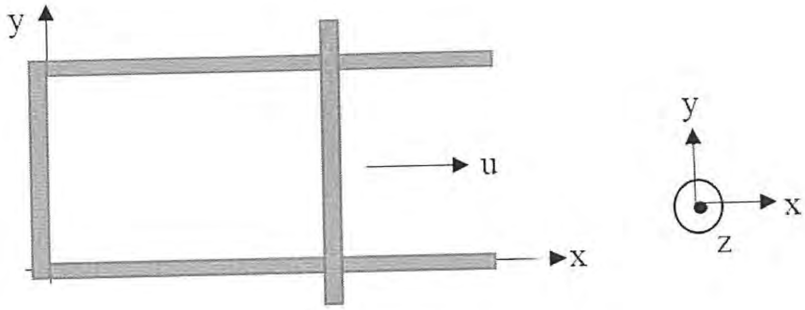


Figure Q3 (a)

It is given a sliding bar as shown in **Figure Q3 (a)**, the width of the rails is 40 cm and the location of the bar, x is dependent on the time, t by $x(t) = 2t$. If the magnetic flux density is $\boldsymbol{B} = 4x^2\hat{z}\ Wb/m^2$. State the type of the induced electromotive force when the bar is moving at a fix velocity, $\boldsymbol{u}$.

motional EMF

Q3 (a)(ii): What is the velocity and direction of the moving bar? *

example of answer: 10, Y direction

2, X direction

Q3 (a)(iii): Explain how you use the Lenz' Law to determine the direction of the current flow in the loop *

According to Lenz's law, the induced current, I should flows such as to produce a magnetic field that opposes the change in magnetic flux density. In this case, the magnetic field is in the + z direction, hence the generated current should produce a magnetic field in the - z direction. Hence the current should flow in the clockwise direction in the loop

Q3 (a)(iv): Compute the formula of generated Vemf

- ○ 4.3 * x^2
- ○ 5.5 * x^2
- ○ 1.2 * x
- ○ 4.7 * x
- ◉ 3.2 * x^2

Q3 (a)(v): Compute the generated Vemf when the sliding bar is moved to 30 cm?

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0.387

0.495

0.36

1.41

0.288

Q3 (b)(i)

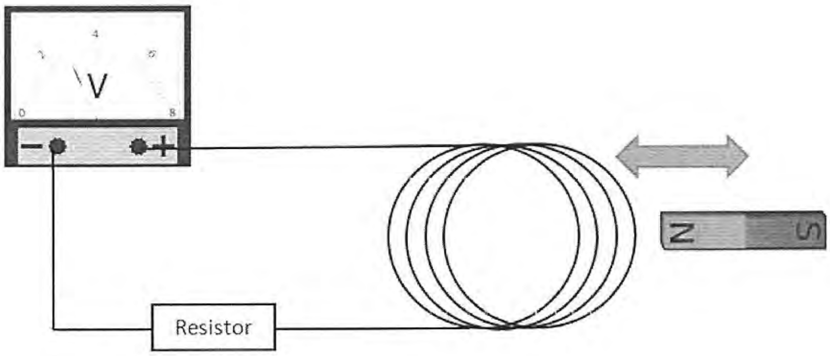

Figure Q3 (b)

A student has created a loop with turns, $N = 5$. He moves the magnetic bar in and out the loop and observes that there is a deflection at the voltmeter. If the area of the loop is 4 cm^2 and magnetic flux density produced by the magnetic bar is $\boldsymbol{B} = -5\, t\, \hat{x}$ Tesla. Determine the reading of the voltmeter.

0.01 V

0.35 V

0.035

0.11 V

0.101 V

Q3 (b)(ii): If the voltmeter is replaced by a light-emitting diode (LED) which its operating voltage is 2 V, calculate the minimum number of turns, N in order to light up the LED.

500

20

1500

1000

Q3 (b)(iii): Outline THREE(3) methods to ensure the current in the loop does not exceed the maximum allowable current of the LED.

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1. Increase the value of the resistor.
2. Reduce the number of the turn in loop.
3. Reduce the area of the loop.
4. Replace the magnet bar with those has weaker magnetic strength
5. Reduce the speed of the magnet bar moving

Q3 (b)(iv):

If the number of turns, $N = 100$, loop area is 4 cm^2 and $\boldsymbol{B} = -5\, t\, \hat{x}$ Tesla, compute the maximum value of resistance so that the current in the loop will be less than 20 mA.

- 50 ohm
- 20 ohm
- 30 ohm
- 40 ohm

Q 4 (Propagation)

Q4 (a): Which of the following statements is not true of electromagnetic (EM) spectrum in general? *

- The EM spectrum is divided into frequency and wavelength ranges according to application and natural occurrence.
- The EM spectrum consists of different types of EM waves, such as gamma rays, X-rays, ultraviolet radiation, visible light, infrared, microwaves, and radio waves.
- The EM spectrum is arranged according to its frequency, from high to low frequency and wavelength, from short to long wavelength. At high-frequency, the wavelength is short.
- The high-frequency or short-wavelength EM waves are more energetic and are more able to penetrate than the low-frequency waves. Therefore, the more details it can resolve in probing a material.
- As frequency increases, the appearance of EM energy is not dangerous to human beings
- The practical difficulties of using EM energy for communication purposes also increase as frequency increases.

Q4 (b): The electric field component of a wave in a certain medium is given below. Sketch the waveform of electromagnetic wave (EM) at t = 0, if the wave is classified as a Transverse Electromagnetic (TEM) wave. Please upload your answer in the form of either pdf or image file (Maximum file size is 1 GB). *

$$\vec{E} = 10^{-4}\cos\left(2\pi 10^{8} t - \frac{4\pi}{3} z + \frac{\pi}{6}\right)\hat{x} \quad \text{V/m}$$

ABC

Q4 (c): Which of the following statements are incorrect, if the magnetic field component of a wave is given by *

$$\vec{H} = \frac{1}{2} e^{-\frac{1}{10}x} \sin\left(10^{6} t - 2x\right)\hat{z} \quad \text{A/m}$$

- The attenuation constant is 0.1 Np/m.
- The phase constant is -2 rad/m.
- The angular frequency is 10,000,000 rad/s.
- The wave is travels along the positive x-direction.
- The wave is polarized in the z-direction.

Q4 (d): What is the major factor for determining whether a medium is free space, lossless dielectric, lossy dielectric, or good conductor? *

$$\alpha$$

Attenuation constant

$$\sigma, \varepsilon, \mu$$

Constitutive parameters

$$\tan\theta$$

Loss tangent

$$\Gamma$$

Reflection coefficient

Q4 (e): A loss tangent is a measure of the power loss in a medium. Which of the following is not true? *

$$\tan\theta = \frac{\sigma}{\omega\varepsilon} = 0$$

○ Free space

$$\tan\theta = \frac{\sigma}{\omega\varepsilon} >> 1$$

○ Good conductor

$$\tan\theta = \frac{\sigma}{\omega\varepsilon} << 1$$

◉ Lossless dielectric

$$\tan\theta = \frac{\sigma}{\omega\varepsilon} = 1$$

○ Lossy dielectric

Q4 (f): The electric field component of a wave in a certain medium is given by *

$$\vec{E} = 10\sin\left(10^8 t - \frac{1}{3}z\right)\hat{y} \quad \text{V/m}$$

	Lossless dielectric	Lossy dielectric	Free space	Perfect conductor	It is travelling in the +z direction	It is travelling in the -z direction	It is travelling in the +y direction	It is travelli in the directic
What type of medium is it?	○	○	◉	○	○	○	○	○
Find the direction of wave propagation.	○	○	○	○	◉	○	○	○

Q4 (g): The electric field intensity of a linearly polarized uniform plane wave propagating in the positive z-direction in seawater at z = 0 is given below. Given that the relative permittivity of seawater is 72, its relative permeability equals to 1, and its conductivity is 4 S/m. Find the (i) type of propagation medium, (ii) attenuation constant, (iii) phase constant, (iv) intrinsic impedance, (v) phase velocity, (vi) wavelength, and (vii) skin depth. Please upload your answer in the form of either pdf or image file (Maximum file size is 1 GB). *

$$\vec{E} = 100\cos(10^7 \pi t)\hat{x} \quad \text{V/m}$$

ABC

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