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Universiti Tun Hussein Onn Malaysia

UNIVERSITI TUN HUSSEIN ONN MALAYSIA

FINAL EXAMINATION
SEMESTER II
SESSION 2021/2022

COURSE NAME	:	ELECTROMAGNETIC FIELDS AND WAVES
COURSE CODE	:	BEV 20303/BEJ 20303/BEB 20303
PROGRAMME CODE	:	BEV/BEJ
EXAMINATION DATE	:	JULY 2022
DURATION	:	3 HOURS
INSTRUCTION	1.	ANSWER ALL QUESTIONS
	2.	THIS FINAL EXAMINATION IS AN **ONLINE** ASSESSMENT AND CONDUCTED VIA **OPEN BOOK.**

THIS QUESTION PAPER CONSISTS OF **THIRTEEN (13)** PAGES

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Q1 A perfect conductor could not contain an electrostatic field inside it. How will this behaviour affect the properties of a conductor?

(3 marks)

(i) Electric field net inside the conductor is zero

(ii) Volume charge density is zero

(iii) A potential difference between any points is zero

(iv) Current is zero

(a) (i), (ii) and (iii)

(b) (i), (ii) and (iv)

(c) (i), (iii) and (iv)

(d) (ii), (iii) and (iv)

Q2 Based on your understanding, which of the electric field intensity's components must always be continuous at the boundary?

(1 mark)

(a) Tangential

(b) Normal

(c) Vertical

(d) Horizontal

Q3 A homogenous dielectric with a relative permittivity, ε_r of 2.5 fill Region 1 ($x < 0$) while Region 2 ($x > 0$) is a free space. If $\vec{D}_1 = 12\hat{x} - 10\hat{y} + 4\hat{z}\ \mathrm{nC/m^2}$, calculate $\vec{D}_2$:

(4 marks)

(a) $\vec{D}_2 = 12\hat{x} - 4\hat{y} - 1.6\hat{z}\frac{\mathrm{nC}}{\mathrm{m^2}}$

(b) $\vec{D}_2 = 12\hat{x} + 4\hat{y} - 1.6\hat{z}\frac{\mathrm{nC}}{\mathrm{m^2}}$

(c) $\vec{D}_2 = 12\hat{x} - 4\hat{y} + 1.6\hat{z}\frac{\mathrm{nC}}{\mathrm{m^2}}$

(d) $\vec{D}_2 = 12\hat{x} + 4\hat{y} + 1.6\hat{z}\frac{\mathrm{nC}}{\mathrm{m^2}}$

Q4 A positively charged spherical shell and an electron are placed in a vacuum, as shown below. Determine the electric field, $\vec{E}$ at distance, R.

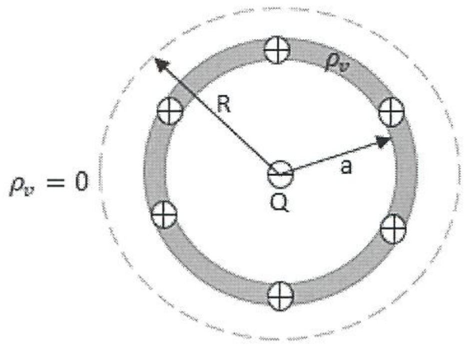
(1 mark)

(a) $\vec{E} = \frac{a^3\rho_v}{3\varepsilon R^2}\hat{R}$

(b) $\vec{E} = 0$

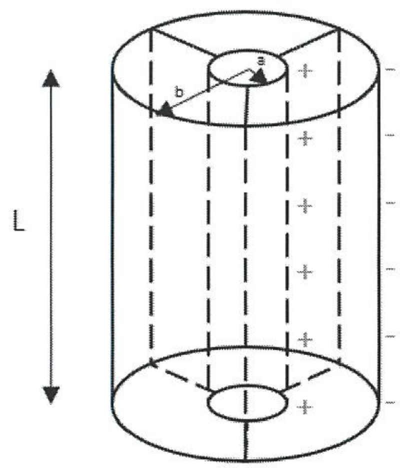
(c) $\vec{E} = \frac{Q}{4\pi\varepsilon R^2}\hat{R}$

(d) $\vec{E} = \frac{Q}{4\pi\varepsilon R^2}\hat{R} + \frac{a^3\rho_v}{3\varepsilon R^2}\hat{R}$

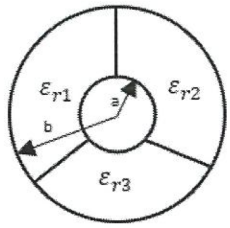


Q5 A coaxial capacitor comprises two concentric, conducting cylindrical surfaces, one with radius, a, and one with radius, b. As shown in the figure below, they are three types of insulating layers separate the two conducting surfaces equally. Calculate the total capacitance of the capacitor.

(3 marks)



Coaxial Capacitor



Top View of Coaxial Capacitor

(a) $C = \frac{2\pi L}{ln\frac{b}{a}}(\varepsilon_1 + \varepsilon_2 + \varepsilon_2)$

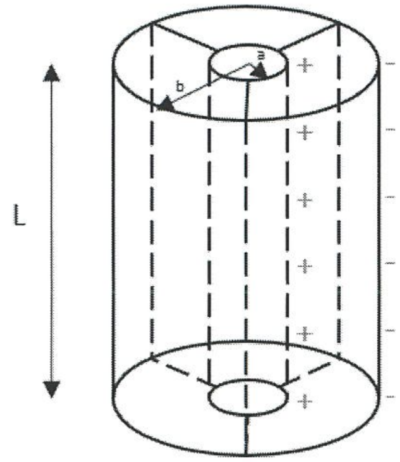
(b) $C = \frac{2\pi L}{3\ln\frac{a}{b}}(\varepsilon_1 + \varepsilon_2 + \varepsilon_2)$

(c) $C = \frac{\pi L}{\ln\frac{b}{a}}(\varepsilon_1 + \varepsilon_2 + \varepsilon_2)$

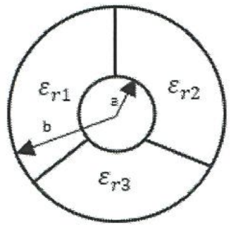
(d) $C = \frac{3\pi L}{2\ln\frac{a}{b}}(\varepsilon_1 + \varepsilon_2 + \varepsilon_2)$

Q6 A coaxial capacitor consists of two concentric, conducting cylindrical surfaces, one of radius, a, and another of radius, b. As shown in the figure below, they are three insulating layers separate the two conducting surfaces equally. Calculate the total capacitance of the capacitor if a = 4 mm, b = 8 mm, L = 20 mm, $\varepsilon_{r1} = 2$, $\varepsilon_{r2} = 3$ and $\varepsilon_{r3} = 4$.

(1 mark)



Coaxial Capacitor

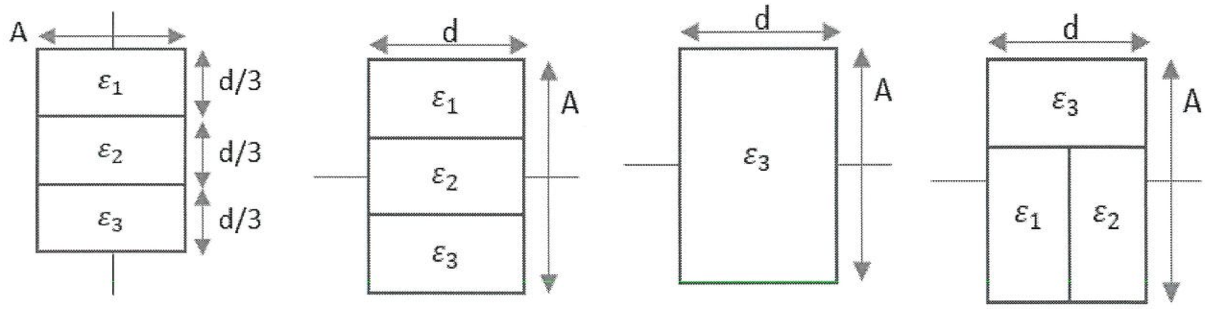


Top View of Coaxial Capacitor

(a) 7.22 pF
(b) 5.42 pF
(c) 2.41 pF
(d) 3.61 pF

Q7 Which configurations below can achieve the highest capacitance? If $\varepsilon_{r1} = 2$, $\varepsilon_{r2} = 3$ and $\varepsilon_{r3} = 4$.

(2 marks)



(a) (b) (c) (d)

Q8 Choose the **CORRECT** statements to represent the " Magnetic Field Lines is always continuous".

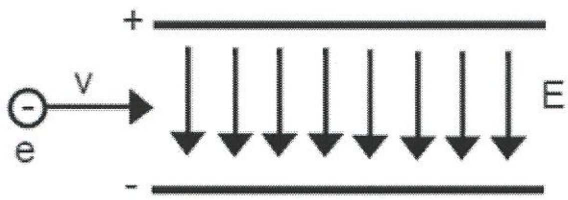
(2 marks)

(i) An iron atom with north and south poles will be formed if the magnet splits continuously.
(ii) Magnetic field lines orient from the north to the south pole of the magnet
(iii) Two field lines can intersect each other.
(iv) The north and south poles cannot be separated

(a) (i), (ii) and (iii)
(b) (i), (ii) and (iv)
(c) (i) and (iii)
(d) (ii) and (iv)

Q9 An electron with charges, -e, travels with a velocity,v, into a region between two charged plates. Choose the **CORRECT** statement to justify the direction of the magnetic field, $\vec{B}$ if the magnetic force, $\vec{F}_m$, opposes the electric force, $\vec{F}_e$, due to the electric field of magnitude E on the electron.

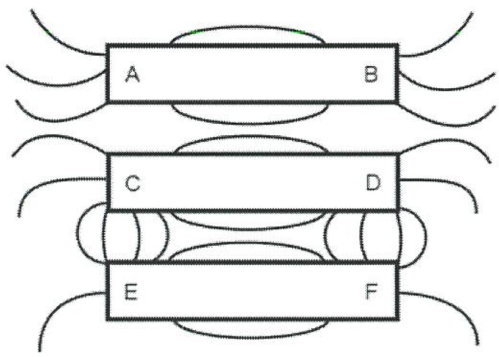
(2 marks)



(a) The magnetic field is directed into the page because the magnetic force, F_m, is towards the bottom of the page.
(b) The magnetic field is directed into the page because the magnetic force, F_m is towards the top of the page.
(c) The magnetic field is directed out of the page because the magnetic force, F_m is towards the bottom of the page.
(d) The magnetic field is directed out of the page because the magnetic force, F_m is towards the top of the page.

Q10 A physics student decided to fix three magnets and surround them with iron filings to observe the magnetic field lines formed. The graphic below depicts what the student saw. Based on the figure below, what poles must be the same as pole E to obtain the result below?

(2 marks)

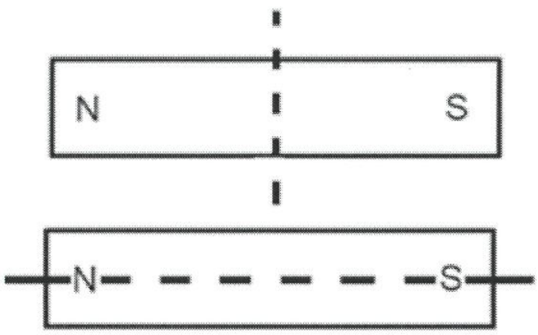


(i) A
(ii) B
(iii) C
(iv) D

(a) (i) and (iii)
(b) (ii) and (iv)
(c) (i) and (iv)
(d) (ii) and (iii)

Q11 Assume that the two magnets shown below are sufficiently separated that their forces do not interact. Which of the following statements is **CORRECT** if each of the magnets displayed is cut along the dotted line?

(2 marks)

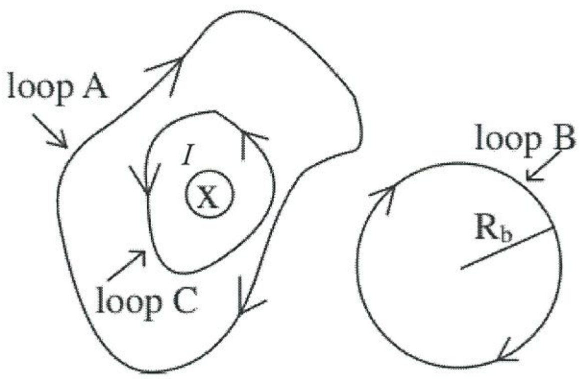


(i) The top pair of magnets would experience attraction
(ii) The bottom pair of magnets would experience attraction
(iii) The top pair of magnets would experience repulsion
(iv) The bottom pair of magnets would experience repulsion

(a) (i) and (ii)
(b) (iii) and (iv)
(c) (i) and (iv)
(d) (ii) and (iii)

Q12 Consider a very long wire carrying a steady current, I as shown in the figure below. Three oriented loops are also shown in the figure below. Which statement(s) is (are) **CORRECT**:

(2 marks)



(i) $\oint_A \vec{B}.\vec{dl} = \mu_0 I$

(ii) $\oint_A \vec{B}.\vec{dl} = -\mu_0 I$

(iii)The magnetic field at every point around loop B is $\frac{\mu_0 I}{2\pi R_b}$

(iv)$\oint_A \vec{B}.\vec{dl} > \oint_B \vec{B}.\vec{dl} > \oint_C \vec{B}.\vec{dl}$

(v) An external agent would do negative work when moving a positive charge around loop **B** in the direction of loop *B*.

(a) (i) and (iv)
(b) (ii) and (iv)
(c) (iii) and (v)
(d) (i), (iv) and (v)

Q13 Two parallel and coaxial current loops of radius, *a*, are separated by a distance, D. When you look at the loops along the axis, you notice that the current direction for both loops is not the same. What is the magnitude of the magnetic field at a location halfway between the loops on the axis?

(1 mark)

(a) $\frac{\mu_0 I a^2}{4(a^2+D^2)^{3/2}}$
(b) $\frac{\mu_0 I a^2}{2(a^2+D^2)^{3/2}}$
(c) 0
(d) $\frac{2\mu_0 I}{D}$

Q14 Two equal charges are released in a uniform magnetic field, one static and the other moving at a constant velocity of 10^4 m/s. Which charge experiences the greatest force from the magnetic field?

(1 mark)

(a) The static charge
(b) The moving charge if its velocity is parallel to the magnetic field direction when it released
(c) The moving charge, if its velocity is perpendicular to the magnetic field direction when it is released.
(d) All the charges above experience equal forces when released in the same magnetic field

Q15 Determine is the magnitude of force per 1.1m length of a pair of conductors of a direct current line carrying 10 A and spaced 100 mm apart?

(1 mark)

(a) 22 x 10^{-8} N
(b) 22 x 10^{-5} N
(c) 22 x 10^{-6} N
(d) 22 x 10^{-5} N

Q16 Choose the best statement that explains why a constant magnetic field cannot do work on a moving charged particle?

(1 mark)

(a) The magnetic field is conservative
(b) The magnetic force is a velocity-dependent force

(c) The magnetic field is a vector, and work is a scalar quantity
(d) The magnetic force is always perpendicular to the velocity of the particle.

Q17 What is the purpose of an *Amperian Path* in Ampere's circuital law?

(1 mark)

(a) Computation of magnetic field intensity
(b) Determination of differential element of path length
(c) Estimation of electric flux density
(d) Detection of a loop in a constant plane

Q18 Following is the definition of Faraday's Law:

(1 mark)

(a) It is a basic law of electromagnetism which demonstrates the interaction of magnetic flux and the induced voltage in a closed circuit.

(b) It is defined as a relationship between current distribution and electric field intensity.

(c) It is a combination of two different field components in normal and tangential directions respectively.

(d) All of the above.

Q19 Mr. Faraday and Mr. Joseph Henry had conducted numerous experiments both in London and New York respectively and discovered the following:

(1 mark)

(a) Electric current density is directly proportional to a conductive material's conductivity and electric field intensity.

(b) Magnetic fields can induce an electric current in a closed loop, but only if the magnetic flux linking the surface of the loop changes with time.

(c) A uniform magnetic field distribution can be generated on a filamentary wire

(d) Electromotive force (e.m.f.) can be induced in a closed loop by a galvanometer deflection.

Q20 If the number of turns in the coil is increased, the induced electromotive force in the coil will ______________________.

(1 mark)

(a) Increase

(b) Decrease

(c) Remains same

(d) None of the above

Q21 A __________________ of the galvanometer shows that the flow of induced__________________ is detected through the square loop. Choose the **CORRECT** answers to fill in the black.

(2 marks)

(a) momentary deflection, current

(b) change in deflection, voltage

(c) change in electric field, electromotive force

(d) uniform change, motional electromotive force

Q22 Following is the explanation of Maxwell's Equations:

(1 mark)

(a) Maxwell's equations represent one of the most elegant and concise ways to state the fundamentals of electricity and magnetism.

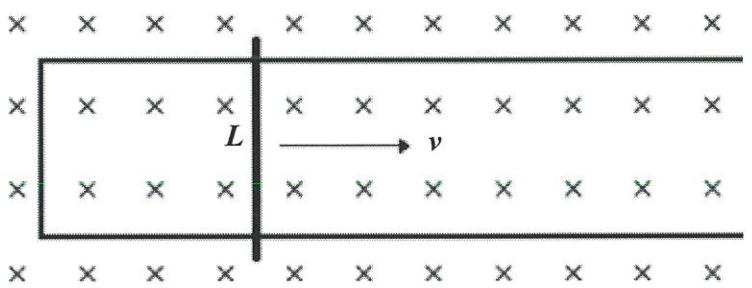
(b) Maxwell's Equations are a set of 4 complicated equations that describe the world of electromagnetics.

(c) Maxwell's equations help in understanding the creation of electric and magnetic fields from electric charges and current.

(d) All of the above.

Q23 Determine the direction of the induced current in the circuit using the figure below if a conducting rod with length, L, moves horizontally on a set of conducting rails at a constant velocity, v through a magnetic field, $\vec{B}$.

(1 mark)



(a) Clockwise

(b) Counterclockwise

(c) Right

(d) Left

Q24 A coil of copper wire is moved parallel to a uniform magnetic field. As a result, the induced electromotive force (e.m.f.) will ________________ in the coil.

(1 mark)

(a) depend on the intensity of the magnetic field

(b) depend on the velocity

(c) be zero

(d) be infinite

Q25 An induced __________________ in a loop can also be discovered when the loop which is connected to a galvanometer is _______________ from the coil connected with a battery.

(2 marks)

(a) current density, moved closer to

(b) electric field intensity, away from

(c) electromotive force (e.m.f.), away from

(d) magnetic flux, away from

Q26 A magnetic field is formed when a current flows through a wire. On the other hand, computer cables produce little to no magnetic field outside of their shielding. What makes this possible? (Hint: computer cables have multiple wires inside them.)

(1 mark)

(a) The cables are insulated with plastics
(b) The supply and return cables run parallel, and their magnetic fields essentially cancel out
(c) The supply and return cables run antiparallel, and their magnetic fields essentially cancel out
(d) The currents are too small to create a significant magnetic field

Q27 Determine the flux passing through the plane Π/4 section defined by $0.01\text{m} \leq \rho \leq 0.05\text{m}$ and $0 \leq z \leq 2$ m in free space. A 2.5 A currents element is positioned in the + $\hat{a}_z$ along the z-axis.

(2 marks)

(a) 1.61 x 10-6 Wb

(b) 1.25 x 10-4 Wb

(c) 2.65 x 10-4 Wb

(d) 1.75 x 10-6 Wb

Q28 In a magnetic field, a coil with a resistance of 500 Ω is placed. Determine the current at the coil at t = 3 sec if the magnetic flux, ϕ associated with a coil, fluctuates with time t (sec) as $\phi = 100t^2 + 4$.

(2 marks)

(a) 1.0 A

(b) 1.2 A
(c) 0.5 A
(d) 2 A

Q29 Skin depth phenomenon is found in which materials?

(1 mark)

(a) Conductors

(b) Insulators

(c) Dielectrics

(d) Semiconductors

Q30 The electric field component of a wave in free space is given by $\vec{E} = 10\ cos(10^8 t - kz)\hat{a}_y$ V/m. It can be concluded that:

(2 marks)

(i) The wave is propagating in *-z* direction

(ii) The wave number, k, is 0.33 rad/m

(iii) The wavelength, λ, is 18.85 m

(iv) The wave amplitude is 10mV/m

(a) (i) and (iv)

(b) (ii) and (iii)

(c) (i) and (iii)

(d) (ii) and (iii)

Q31 Given that $\hat{H} = 0.5e^{-0.1x} sin(10^6 t - 2x)\hat{a}_z$ A/m, which of these statements is **INCORRECT**?

(2 marks)

(a) $\alpha = 0.1$ Np/m

(b) $\beta = 2$ rad/m

(c) $\omega = 10^6$ rad/s

(d) The wave is polarized in the z-direction.

Q32 What is the major factor for determining whether a medium is free space, a lossless dielectric, a lossy dielectric, or a good conductor?

(1 mark)

(a) Attenuation constant

(b) Constitutive parameters (σ, ε, μ)

(c) Loss tangent

(d) Reflection coefficient

Q33 In a certain medium, $\vec{E} = 10cos(10^8 t - 3y)\hat{a}_x$ V/m. What type of medium is it?

(1 mark)

(a) Free space

(b) Lossy dielectric

(c) Lossless dielectric

(d) Perfect conductor

Q34 A blue beam of light falls on two narrow slits producing an interference pattern on a screen. If instead of blue light, a red beam of light was used in the same experiment, which changes to the interference pattern can be observed?

(1 mark)

(a) Interference fringes move closer to the central maximum

(b) No change in interference

(c) Interference fringes move further away from the central maximum

(d) Bright fringes are replaced with dark fringes.

Q35 Choose the **CORRECT** answer to represent the equation of the intrinsic impedance, η for the plane waves in lossless dieletric.

(1 mark)

(a) $\eta = 120\pi$

(b) $\eta = \sqrt{\frac{\mu}{\varepsilon}} \angle 0^0$

(c) $= \sqrt{\frac{\omega\mu}{\sigma}} \angle 45^0$

(d) $= \sqrt{\frac{\mu}{\varepsilon}} \angle 90^0$

Q36 Electromagnetic waves travelling in a medium having relative permeability, $\mu_r = 1.3$ and relative permittivity, $\varepsilon_r = 2.14$. The speed of electromagnetic waves in the medium must be:

(2 marks)

(a) 1.8×10^8 ms^{-1}

(b) 1.8×10^4 ms^{-1}

(c) 1.8×10^6 ms^{-1}

(d) 1.8×10^2 ms^{-1}

Q37 Both oscillating electric and magnetic fields generated by time varying fields as derived from Maxwell Equations work together to form the following electromagnetic waves:

(2 marks)

(a) Microwaves
(b) Infrared radiation
(c) Gamma Rays
(d) All the above

Q38 A uniform plane wave propagation in perfect dielectric (dielectric medium without losses) at $+z$ direction. Electric field is given as

$$\vec{E}(z,t) = 377\, cos\left[\omega\, t - \left(\frac{4\pi}{3}\right) z + \frac{\pi}{6}\right] \hat{a}_x \; V/m$$

If the average power density is $377\ \text{W/m}^2$, determine the dielectric constant value and the wave frequency for the medium if $\mu = \mu_o$.

(2 marks)

(a) $\varepsilon_r = 4$ and f = 100 MHz
(b) $\varepsilon_r = 6$ and f = 40 MHz
(c) $\varepsilon_r = 9$ and f = 99 MHz
(d) $\varepsilon_r = 5$ and f = 75 MHz

-END OF QUESTIONS-