Reg No.:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

B.Tech Degree S6 (S, FE) / S4 (PT) (S) Examination January 2024 (2019 Scheme)

Course Code: ECT302

Course Name: ELECTROMAGNETICS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks.

		Marks
1	Find the vector projection of $\vec{A} = 2\vec{a_x} + \vec{a_y} - 2\vec{a_z}$ on $\vec{B} = 5\vec{a_x} - 10\vec{a_y} + 3\vec{a_z}$.	(3)
2	A point charge of 6 nC is located at origin in free space. Find the potential difference between the points P_1 (0.2,-0.4, 0.4) and P_2 (1, 0, 0).	(3)
3	Calculate the capacitance of 1 km length of an air-filled co-axial cable with inner diameter 6 mm and outer diameter 14 mm.	(3)
4	State and prove Ampere's Circuital Law for a time varying electromagnetic field.	(3)
5	Find the skin depth of a Copper material with $\varepsilon_r = 5$ and frequency of propagation is 2MHz in z-direction.	(3)
6	What is the expression for propagation constant for general unbounded medium? What will be the values of the ratio $\left(\frac{\sigma}{\omega\varepsilon}\right)$ for good-dielectric and good-conducting medium?	(3)
7	Find the reflection coefficient and VSWR of a transmission line of characteristic impedance 50Ω and load impedance $j50\Omega$.	(3)
8	Define a distortion less transmission line. What is the condition for distortion less line?	(3)
9	Explain why TEM wave cannot propagate in a single conductor hollow waveguide.	(3)
10	A rectangular waveguide with dimensions 5x3cm operates at 10GHz. Find f_c, λ_c and λ_g for the dominant mode.	(3)

PART B

Answer one full question from each module, each carries 14 marks.

Module I

11	a)	Determine the flux of $\vec{D} = \rho^2 \cos^2\phi\, \vec{a_\rho} + z\sin\phi\, \vec{a_\phi}$ c/m^2 over the closed surface of the cylinder, $0 \le z \le 1$, *and* $r = 4$. Verify divergence theorem.	(8)
	b)	Show that the electric field intensity $\vec{E}$ is the gradient of potential V.	(6)

OR

12 a) State Gauss law in electrostatics. Apply Gauss law to find E-field of an infinite sheet of charge of uniform charge ρ_s C/m^2. (8)

b) The region $y < 0$ consists of a perfect conductor while region $y > 0$ is a dielectric medium with $\varepsilon_r = 2$. If there is a surface charge of 2nC/m^2 on the conductor interface. Determine $\vec{E}$ and $\vec{D}$ at A (3,-2, 2) and B (-4, 1, 5). (6)

Module II

13 a) Derive the electromagnetic wave equation in a lossy dielectric medium. (8)

b) From fundamental laws, derive the continuity equation for current. (6)

OR

14 a) Derive the expression for energy stored in electric field. (7)

b) At the boundary of different materials, obtain the boundary conditions for the tangential and normal components of $\vec{H}$-field, with zero and nonzero surface currents. (7)

Module III

15 a) Using Maxwell's equation for free space, show that $\nabla^2 H = \frac{1}{c^2}\frac{\partial^2 H}{\partial t^2}$. (7)

b) If $\varepsilon_r = 9$, $\mu = \mu_0$, for a medium in which a wave with a frequency f= 0.3 GHz is propagating. Find the propagation constant and intrinsic impedance of the medium when conductivity $\sigma = 0$. (7)

OR

16 a) Obtain the expressions for reflection coefficient and transmission coefficient of plane wave when it is normally incident on the interface between two different dielectric boundaries. (7)

b) For a uniform plane wave propagating in z-direction, $\vec{E} = 20\sin\left(10^8 t - \beta z\right)\overrightarrow{a_y}$ in free space. Find D, H, β and phase velocity for the wave. (7)

Module IV

17 a) State Poynting theorem. Derive Poynting theorem starting from Maxwell's equations. (7)

b) A lossless transmission line is 80cm long and operates at a frequency of 600MHz. The line parameters are $L = 0.25\mu H/m$ and $C = 100pF/m$. Find the characteristic impedance, the phase constant, the phase velocity on the line and the input impedance for $Z_L = 100\Omega$. (7)

OR

18 a) For a transmission line derive the expression for input impedance and reflection coefficient. (8)

b) A distortionless transmission line operating at 500 MHz has $Z_0 = 80\Omega$, $\alpha = 0.04 Neper/m$, $\beta = 1.5 rad/m$. Find the line parameters. (6)

Module V

19 a) Obtain the input impedances for open circuited and short circuited transmission lines. Explain how they relate to characteristic impedance of the line. (6)

b) In a rectangular waveguide for which a = 1.5cm, b = 0.8 cm, $\sigma = 0$, $\mu = \mu_0$ and $\varepsilon = 4\varepsilon_0$, $H_x = 2\sin\left(\frac{\pi x}{a}\right)\cos\left(\frac{3\pi y}{b}\right)\sin\left(\pi 10^{11} t - \beta z\right) \text{A/m}$. Determine: (8)

i) Mode of propagation ii) cut off frequency iii) Phase constant, β

iv) Propagation constant, γ v) Intrinsic wave impedance, η

OR

20 a) A 60Ω lossless line is terminated with a load, $Z_L = 60 + j60\,\Omega$. If the line is 0.6λ long, then using Smith chart, Find (i) Reflection coefficient at load (ii) VSWR and (iii) Input impedance (8)

b) Examine whether the following modes propagate inside an air filled rectangular waveguide of dimension 7.21cm x 3.4 cm operating at 5 GHz. i) TE_{01} ii) TM_{11} iii) TE_{30} (6)

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