Gx559

Ollscoil na hÉireann, Gaillimh
National University of Ireland, Galway

SEMESTER I, EXAMINATIONS, 1999 (SPECIAL SUMMER PAPER)

THIRD YEAR ELECTRONIC ENGINEERING

E.M. THEORY & APPLICATIONS I

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Duration of Examination: *Two* Hours

Instructions: Answer *all* questions in Section A
and *three* questions in Section B

Section A - Attempt All Questions (25 Marks)

Clearly circle one of the options (a), (b), (c), (d) or (e). If you circle more than one you will score no marks for that question.

A1. The expression $\Delta \times \vec{e} = -\dfrac{\partial B}{\partial t}$ is a form of:

(a) Stokes' Theorem

(b) One of Maxwell's Integral Laws

(c) Faraday's Law

(d) None of the above

A2. Magnetic Vector Potential, $\vec{a}$, has a natural zero of potential which is:

(a) The same as the zero of Electric Potential

(b) Undefined mathematically

(c) Has an arbitrary value

(d) None of the above

A3. Displacement Current is a correction factor introduced by Maxwell to compensate for an effective current caused by:

(a) The rate of change of magnetic flux with respect to time

(b) The rate of change of electric field strength with respect to time

(c) The rate of change of electric flux with respect to time

(d) None of the above

A4. The fundamental unit of Electric Charge is the:

(a) Farad

(b) Ampere

(c) Coulomb

(d) Hertz

(e) None of the above

A5. Liouville was:

(a) A town in France where Maxwell performed his famous experiments

(b) One of Maxwell's laboratory assistants

(c) A 18th Century French Mathematician

(d) None of the above

A6. The velocity of propagation of an Electromagnetic wave is:

(a) $2\pi\mu_0\varepsilon_0$

(b) $\dfrac{1}{2\pi\mu_0\varepsilon_0}$

(c) $2\pi\sqrt{\mu_0\varepsilon_0}$

(d) $\dfrac{1}{2\pi\sqrt{\mu_0\varepsilon_0}}$

(e) None of the above

A7. A suitable solution of the 1-dimensional equation has the form (c is velocity of propagation):

(a) $f(z)-ct^2$

(b) $f(z-c^2t)$

(c) $f(t)-\frac{z}{c}$

(d) $f(z-ct^2)$

(e) None of the above

A8. The Poynting Vector describes the:

(a) Spatial Distortion of the Electric and Magnetic Fields

(b) Energy stored per unit volume by the Electric and Magnetic Fields

(c) Power Flow per unit Area of the Electric and Magnetic Fields across a surface

(d) All of the above

(e) None of the above

A9. The time averaged energy stored at a point in the electric field is given as:

(a) $\frac{1}{2}\varepsilon_0 EE^*$

(b) $\frac{1}{\sqrt{2}}\varepsilon_0 EE^*$

(c) $\frac{1}{4}\varepsilon_0 EE^*$

(d) $\frac{1}{2\sqrt{2}}\varepsilon_0 EE^*$

(e) None of the above

A10. The expression $\sigma^2\vec{e}+\omega^2\mu_0\varepsilon_0\vec{e}=0$ is known as:

(a) Helmholtz's Equation

(b) Liouville's Equation

(c) Stokes' Equation

(d) Faraday's Equation

(e) None of the above

A11. The Intrinsic Admittance of Free Space is:

(a) $\sqrt{\varepsilon_0\mu_0}$

(b) $\frac{\sqrt{\varepsilon_0}}{\sqrt{\mu_0}}$

(c) $\frac{\sqrt{\mu_0}}{\sqrt{\varepsilon_0}}$

(d) $\frac{1}{\sqrt{\varepsilon_0\mu_0}}$

(e) None of the above

A12. The Wavelength of an Electro-Magnetic wave in Free Space is:

(a) $\frac{2\pi c}{\omega}$

(b) $2\pi\omega c$

(c) $\frac{\omega c}{2\pi}$

(d) $\frac{c}{2\pi\omega}$

(e) None of the above

Section B - Attempt 3 out of 5 (75% of Marks, 25 Marks each)

1. (a) Define electric potential

(b) A total charge of (40/3)nC is uniformly distributed around a circular ring of radius 2m. Find the potential at a point on the axis 5 m from the plane of the ring. Compare with the result where all the charge is at the origin in the form of a point charge.

(c) Repeat with the total charge distributed uniformly over a circular disk of radius 2 m.

[25 Marks]

2. (a) By considering the flow of electro-magnetic energy across a closed surface, show that the power flow at a point is given by the Poynting vector $\vec{p} = \vec{e} \times \vec{h}$.

(b) A voltage source is connected to a resistor by a length of coaxial cable (Figs.1 and 2). If, in the insulation of the cable $\vec{d} = (\rho_s a / r)\hat{r}$, $a < r < b$, where $\rho_s Cm^{-2}$ is the surface charge density of the inner conductor, show that the total power flow across the surface, *S*, in Fig.1 is equal to the power dissipated in the resistor.

(c) Why does power flow through the insulation of the cable but not in the conductors? Would this be the case in a real cable?

[25 Marks]

3. (a) Define mutual and self-inductance in terms of magnetic flux linkages.

(b) Calculate, from first principles, the inductance per unit length of a standard co-axial cable (Fig. 2) stating any assumptions made in the analysis.

[25 Marks]

4. (a) State Gauss' electric flux theorem and the divergence theorem.

(b) Given a uniform line charge of $\rho_c Cm^{-1}$ surrounded by a concentric cylinder, radius r, carrying a uniform surface charge density of $\rho_c Cm^{-2}$ determine $\vec{d}$ in all regions. Neglect fringing.

(c) Given that $\vec{d} = (10r^3/r^3)\hat{r}Cm^{-2}$ in cylindrical co-ords, show that the divergence theorem holds over the volume defined by $1<r\leq 2$ $-5<z<+5$

[25 Marks]

5. (a) What is meant by a motional electrical field?

(b) Give the full expression for induced potential in a conductor moving in a time-varying magnetic field. The circular disc in Fig. 3 rotates at ω rad s^{-1} in a uniform magnetic field of flux density $\vec{b} = |b|\hat{k}$. Sliding contacts connect the voltmeter to the disc. What voltage is indicated on the meter?

(c) If the magnitude of $\vec{b}$ increases linearly with respect to time, i.e. $\vec{b} = b_0|t|\hat{k}$, how would the voltage reading be affected?

[25 Marks]