Odd Semester, 2020

(Held in March, 2021)

PHYSICS

(Honours)

[PHY–06 (T)]

(Electrodynamics, Electronics—II)

Marks : 56

Time : 3 hours

The figures in the margin indicate full marks for the questions

Answer Question No. **1**, which is compulsory and *any* **four** from the rest

1. *(a)* The dielectric constant of helium gas is 1·0000684 at NTP. Calculate the electron polarizability of helium atoms if the gas contains $2 \cdot 7 \times 10^{26}$ atoms/m^3. Given permittivity of free space (ε_0) = $8 \cdot 86 \times 10^{-12}$ F/m. 2

(b) A differential amplifier has a voltage gain of 150 and a CMRR of 90 dB. The input signals are 50 mV and 100 mV with 1 mV of noise on each input. Find *(i)* the output signal *(ii)* the noise on the output. 2+2=4

(c) Evaluate the following mixed mode FORTRAN expression for A = 3·0, B = 5·0, I = 8 and J = 3 : 2

$$\left(A**2*2+I/3+13\right)*J$$

(d) A plane electromagnetic wave is travelling in the positive z-direction in an unbounded lossless dielectric medium with relative permeability $\mu_r = 1$ and relative permittivity $\varepsilon_r = 3$. The peak electric field and magnetic field intensities are 6 V/m and $2 \cdot 76 \times 10^{-2}$ A/m respectively. Find the—

(i) speed of the wave in the medium;

(ii) peak Poynting vector $S(z, t)$. 2+2=4

2. *(a)* State and prove uniqueness theorem in Electrostatics regarding electric potential. Use this theorem to prove that the electric field inside a conductor is zero. 2+3+3=8

(b) Show that the potential function

$$\phi = \frac{q}{\sqrt{x^2+y^2+z^2}}$$

satisfies Laplace's equation. 3

3. *(a)* Consider a uniformly polarized sphere and assuming that the total surface charge on this polarized sphere is zero, obtain *(i)* expression for the potential *(ii)* electric field both inside and outside this sphere. 3+2+2=7

(b) Obtain the boundary conditions satisfied by the field vectors $\vec{E}$ and $\vec{D}$ at the interface between two homogeneous dielectrics. 4

4. *(a)* Obtain an expression for the vector potential of a infinitely long solenoid, both inside and outside the solenoid. 3+2=5

(b) Develop the wave equations governing $\vec{E}$ and $\vec{H}$ in free space starting from Maxwell's equation in free space. Assuming plane wave solutions for the wave equation, show that the electromagnetic field vectors $\vec{E}$ and $\vec{H}$ are both perpendicular to the direction of propagation. 3+3=6

5. *(a)* What is Poynting vector? Give its significance. Show that the energy density of an electromagnetic field is given by

$$U = \frac{1}{2}\left(\varepsilon_0 E^2 + \mu_0 H^2\right)$$ 2+1+3=6

(b) Discuss how an operational amplifier (OP Amp) can be used as an adder with a suitable circuit diagram. 5

6. *(a)* What do you understand by multistage transistor amplifier? Explain RC coupled transistor amplifier with special reference to frequency response, advantages, disadvantages and application, with the help of a neat diagram. 1+7=8

(b) With the help of a neat diagram explain the operation of a Hertley oscillator. 3

7. *(a)* How does light propagate through an optical fibre? Discuss the structure of step index and graded index optical fibre. 2+3=5

(b) Simplify the following Boolean expression : 2

$$Y = \overline{(A + \overline{B} + C) + (B + \overline{C})}$$

(c) Perform the following binary subtraction using 2's complement method : 1

$$(110011)_2 - (100111)_2$$

(d) What negative number does $(10011011)_2$ represent in decimal system? 1

(e) Convert $(59 \cdot 4375)_{10}$ into binary. 2

8. *(a)* What are multiplexers and demultiplexers? Discuss a 1 : 4 demultiplexer with the help of a circuit diagram. 1+1+3=5

(b) What are flowcharts? Give a brief explanation of the various symbols used in drawing them. 1+3=4

(c) What is a FORTRAN variable? Explain any two FORTRAN variable types. 1+1=2

9. *(a)* Explain any *four* FORTRAN statements from the following : 2×4=8

(i) Computed GOTO statement

(ii) Assignment statement

(iii) Do statement

(iv) Implicit statement

(v) Equivalence statement

(b) Explain formatted and unformatted I/O statements with illustration. 1½×2=3

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