Ex:INT/P/I/V/21/2018

BACHELOR OF SCIENCE EXAMINATION, 2018

(2nd Year, 1st Semester)

PHYSICS (HONOURS)

Paper : HO - 5

Sub :

Time : Two hours

Full Marks : 50
(25 marks for each group)

Use a separate Answer Scripts for each group.

GROUP - A (25 marks)

Answer any **two** from **1 to 3.**

1. A rectangular pipe running parallel to the Z-axis (from $-\alpha$ to $+\alpha$) has three grounded metal sides, at $y = 0$, $y = a$ and $x = 0$. The fourth side at $x = b$, is maintained at a specified potential V_0 (y) 7
   (a). Develop a general formula for the potential inside the pipe
   (b). Find the potential explicitly for the case $V_0(y) = V_0$. (a constant)

2. The potential at the surface of a sphere of radius R is given by 7
   $V_0 = K \cos 3\theta$, Where K is a constant.
   Find the potential inside and outside the sphere, as well as the surface charge density on the sphere. (Assuming there is no charge inside and outside the sphere)

3. Develop the multipole expansion for the potential of an arbitrary localized charged distribution. From these prove $V_{dip}(r) = p.r / 4\pi\varepsilon_0 r^2$. (Where p is dipole moment and r is the distance from dipole). 7

Answer any two from 4 to 6

4. Describe Ampere's law in terms of vector potential.
   Describe the effect of Magnetic field on atomic orbit. 5.5

5. Obtain an expression for the magnetic field due to a uniformly magnetized sphere at
   (i) an external and
   (ii) an internal point. 5.5

6. Find the vector potential of an infinite solenoid with n turns per unit length, radius R, and current flows through it is I. 5.5

GROUP - B (25 marks)
(Mathematical Methods)
Answer any *five* questions. Each carries *five* marks.

7. (a) Show that, for the differential equation

$$x(1-x)y'' + [c - (a+b+1)x]y' - aby = 0$$

where a, b and c are positive constants, $x = \infty$ is a regular singular point. [Hint: Put $x = 1/z$ and proceed.]

(b) What type of singular point is $x = \infty$ for the differential equation

$$xy'' + (c-x)y' - ay = 0 \quad ?$$

3+2=5

8. (a) Show that the eigenvalues of a Hermitian matrix are real.
(b) If two matrices commute and one of them has a non-degenerate spectrum of eigenvalues, show that the other matrix also shares the same set of eigenvectors. 2+3=5

9. Use the generating function for Legendre polynomials to express $P_n(0)$ in terms of n. Derive the series expansion of the function that will appear on your way. 5

10. (a) Use the generating function for Hermite polynomials to show that

$$\frac{1}{2}H_{n+1}(x) = xH_n(x) - nH_{n-1}(x)$$

(b) Considering the integral $I_n = \int_0^\infty x.H_n(x).H_{n+1}(x).\exp(-x^2)dx$, show that $I_2 = 6I_1$. 2+3=5

11. Show that a similarity transformation on a matrix preserves its
(a) trace,
(b) eigenvalues along with their respective multiplicities. 2+3=5

12. Show that a matrix whose columns are the eigenvectors of another matrix, can diagonalize the latter matrix through a similarity transformation. 5

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