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M.Sc. (CBCS) DEGREE EXAMINATION,
NOVEMBER 2015.

First Semester

Physics

MATHEMATICAL PHYSICS – I

(For those who joined in July 2012 onwards)

Time : Three hours

Maximum : 75 marks

PART A — ($10 \times 1 = 10$ marks)

Answer ALL questions.

Choose the correct answer.

1. The curl of a vector field is always

- (a) a scalar
- (b) a vector
- (c) a numeric
- (d) sometimes a scalar and sometimes a vector

2. The line integral of a vector field around the boundary of the unit are around a given point is called

- (a) Gradient of a vector field
- (b) Divergence of a vector field
- (c) Tubes of vector field
- (d) Curl of a vector field

3. In terms of Legendre polynomials $x^2 + x$ is equal to

- (a) $P_0 + P_1 + 2P_2$
- (b) $(1/3)P_0 + P_1 + (1/3)P_2$
- (c) $(1/3)P_0 + P_1 + (2/3)P_2$
- (d) $(1/3)P_0 + (2/3)P_2$

4. If n is a positive integer, then the value of $\Gamma(n)$ is

- (a) $n!$
- (b) $(n-1)!$
- (c) $(n-2)!$
- (d) $(n-1)!/2^n$

5. The number of independent components of an antisymmetric tensor or rank 2 in n dimensional space is

- (a) $2n$
- (b) $n(n+1)/2$
- (c) n^2
- (d) $n(n-1)/2$

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6. The velocity of a particle is
 (a) a scalar
 (b) a contravariant vector
 (c) a covariant vector
 (d) a tensor of rank 2
7. Set of all even numbers form a group under the law of
 (a) ordinary multiplication
 (b) ordinary addition
 (c) ordinary addition and ordinary multiplication
 (d) neither ordinary addition nor ordinary multiplication.
8. Each irreducible representation of an Abelian group is
 (a) one dimensional
 (b) two dimensional
 (c) three dimensional
 (d) n – dimensional with $n > 3$

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9. In heat flow equation $\nabla^2 u = \frac{1}{h^2} \frac{\partial u}{\partial t}$, the quantity h is called
 (a) planck constant (b) conductivity
 (c) diffusivity (d) heat flow constant
10. The Laplace's differential equation is
 (a) $\nabla^2 \phi = 0$ (b) $\nabla^2 \phi = \rho$
 (c) $\nabla^2 \phi = 1$ (d) $\nabla^2 \phi = -1$

PART B — (5 × 5 = 25 marks)

Answer ALL questions, choosing either (a) or (b).

11. (a) Define the term : Gradient of scalar field. Show that $\nabla r^n = nr^{n-2}r$.
 Or
 (b) Define the terms : solenoidal and irrotational of a vector field. Show that $u \times v$ is solenoidal if u and v are irrotational.
12. (a) Find the values of $P_1(x)$ and $P_2(x)$ from the Rodrigue's formula for Legendre polynomial.

Or

- (b) Show that $\beta(m,n) = \frac{\Gamma(m)\Gamma(n)}{\Gamma(m+n)}$ where $m > 0$ and $n > 0$.

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13. (a) Define symmetric and an antisymmetric tensor. Express the tensor A as a sum of a symmetric and an antisymmetric tensor.

Or

- (b) Show that the inner product of tensors A^p_{st} and B^{qs} is tensor of rank 3.
14. (a) Define the terms isomorphism and homomorphism in group theory. Give atleast two properties of each.

Or

- (b) What is meant by reducible and irreducible representation of a group? Give the irreducible representation for SU (2) group.
15. (a) Solve the one dimensional Laplace equations under Cartesian coordinate system.

Or

- (b) Obtain the D'Alembert's solution of a vibrating string.

PART C — (5 × 8 = 40 marks)

Answer ALL questions, choosing either (a) or (b).

16. (a) Give the physical significance of divergence and curl of a vector field. State Gauss divergence, Stoke's and Green theorem in vector analysis.

Or

- (b) What is meant by orthonormal sets in vector space? Explain the Gramm-Schmidt orthonormalisation method.
17. (a) Apply power series method to the Legendre's differential equation and obtain its solution.

Or

- (b) (i) Write the Rodrigue's formula and orthogonal properties of Hermite polynomial.

(ii) Show that for

$$n \geq 0, H_n(-x) = (-1)^n H_n(x).$$

18. (a) Distinguish between contravariant and covariant tensors on the basis of transformation laws obey by them and prove that an entity which on inner multiplication with an arbitrary tensor always gives a tensor, is itself a tensor.

Or



- (b) Express the kinetic energy of a particle in tensor form. Discuss the applications of tensor analysis to the dynamics of a particle in a non-relativistic case.
19. (a) Define the terms a group, a subgroup and a class. Show that for a finite group every representation is equivalent to a unitary representation.

Or

- (b) What is meant by a character table in a group? Construct the same for the irreducible representations for C_{3v} point group.
20. (a) State and solve the Laplace equation for the case of one-dimensional steady flow of heat through a infinite rod.

Or

- (b) Write a note on the vibration of circular and rectangular membranes and their solutions.
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