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PHY-501

Mathematical Physics and Classical Mechanics

M.Sc. Physics (MSCPHY-12/13/16/17)

First Year Examination, 2019 (June)

Time : 3 Hours] **Max. Marks : 80**

Note : This paper is of Eighty (80) marks divided into three (03) sections A, B and C. Attempt the questions contained in these sections according to the detailed instructions given therein.

SECTION–A

(Long Answer Type Questions)

Note : Section 'A' contains four (04) long answer type questions of Nineteen (19) marks each. Learners are required to answer any two (02) questions only.

(2×19=38)

1. Describe recurrence relations for legendre polynomials. By using the relation $(n + 1)p_{n+1}(x) = (2n + 1)xp_n(x) - np_{n-1}(x)$. Evaluate $p_2(1.5)$ and $p_3(2.1)$.

2. (a) Find the fourier transform of

$$F(t) = \begin{matrix} 1 - t^2 & |t| < 1 \\ 0 & |t| > 1 \end{matrix}$$

and hence evaluate $\int_0^t \frac{\cos t - \sin t}{t^3} \cos\left(\frac{t}{2}\right) dt$.

(b) Describe the basic theory of Laplace transform. Find the Laplace transform of $f(t) = \sin h\ wt$ where $t \geq 0$.

3. (a) Explain the Hamilton-Jacobi equation for Hamilton's principal function.

(b) The fundamental Poisson brackets provide the most convenient way to decide whether a given transform is canonical. Discuss.

4. (a) Show that $\frac{\partial A_\lambda}{\partial x_\mu}$ is not a tensor although A_λ is a covariant tensor of rank one.

(b) Derive an expression for the Gregory-Newton forward and backward difference interpolation formula.

SECTION–B

(Short Answer Type Questions)

Note : Section 'B' contains eight (08) short answer type questions of eight (08) marks each. Learners are required to answer any four (04) questions only. (4×8=32)

1. Show that $J_3(x) = \left(\frac{8}{x^2} - 1\right) J_1(x) - \frac{4}{x} J_n(x)$.

2. Show that $H_n(x)$ satisfies the recurrence relation

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

3. Find the Fourier transform of e^{-at^2}, $a > 0$.

4. Find the Laplace transform of $\cos^2(at)$.

5. What do you understand by the equation

$a_{ij}a^{ik} = \delta_j^k$?

What do you call these two tensors ?

6. What is D'Alembert's principle ? Derive Lagrange's equations of motion from it for conservative system.

7. Explain numerical solution of ordinary differential equation with a suitable example.

8. Explain the term interpolation and discuss inverse interpolation.

SECTION–C

(Objective Type Questions)

Note : Section 'C' contains ten (10) objective type questions of one (01) mark each. All the questions of this section are compulsory. (10×1=10)

1. Legendre polynomial $p_5(x) = \lambda(63x^5 - 70x^3 + 15x)$ where λ is equal to

(a) 1/2

(b) 1/5

(c) 1/8

(d) 1/10.

2. If $J_{n+1}(x) = \frac{2}{x} J_n(x) - J_0(x)$ then n is

(a) 0

(b) 2

(c) –1

(d) None of these.

3. What is Fourier cosine transform of $e^{-x^2/2}$?

(a) e^{-s^2}

(b) $e^{-s^2/2}$

(c) $\frac{1}{2} e^{-s^2}$

(d) None of these.

4. Find the inverse Laplace transform of $f(s) = \frac{8}{(s^2+4)^2}$.

(a) 4 sin 2t

(b) 2t cos 2t

(c) sin2t – 2t cos 2t

(d) None of these.

5. What is the rank of inner product of tensors A_r^{pq} and B_l^s ?

(a) a tensor of rank 3

(b) a tensor of rank 5

(c) a vector

(d) none of these.

6. What is an antisymmetric tensor of rank two in two-dimensional space ?

(a) a vector

(b) a scalar

(c) a pseudo scale

(d) none of these.

7. If the Lagrangian does not depend on time explicitly

(a) the Hamiltonian is constant

(b) the Hamiltonian can not be constant

(c) the kinetic energy is constant

(d) the potential energy in constant.

8. Hamilton's principal function S and Hamilton's characteristic function W for conservative system are related as

(a) $S = W$

(b) $S = W - Et$

(c) $S = W + Et$

(d) S is not related to W

where E is the total energy and *t* is the time.

9. What is order of error in Simpson's $\frac{3}{8}$ rule of numerical integration ?

(a) $o(h^2)$

(b) $o(h^3)$

(c) $o(h^4)$

(d) $o(h^5)$.

10. Which of the following is not the value of $\frac{1}{2}(E - E^{-1})$?

(a) $\mu\delta$

(b) sinh hD

(c) $\Delta + \nabla$

(d) $\Delta - \nabla$.