KATHMANDU UNIVERSITY
End Semester Examination
March/April 2017

Marks Scored:

Level : B.Sc.
Year : III

Course : PHYS 302
Semester: I

Exam. Roll No. :

Time : 30 mins.

F.M. : 20

Registration No.:

Date APR 0 9 2017

SECTION "A"
[20 Q.×1=20 marks]

I. *Choose and tick the most appropriate answer. The symbols, unless mentioned otherwise, have their usual meanings.*

1. In cylindrical coordinate, which one of the following relations between $\hat{\rho}$ and $\hat{\phi}$ is not correct?

[a] $\frac{\partial \hat{\phi}}{\partial \phi} = -\hat{\rho}$ [b] $\frac{\partial^2 \hat{\phi}}{\partial \phi^2} = 0$ [c] $\frac{\partial \hat{\rho}}{\partial \phi} = \hat{\phi}$ [d] $\frac{\partial^2 \hat{\phi}}{\partial \phi^2} = -\hat{\phi}$

2. The covariant derivative of a contravariant tensor A^p is defined as

[a] $A^q_{,p} = \frac{\partial A^p}{\partial x^q} + \left\{ \begin{matrix} p \\ qs \end{matrix} \right\} A^s$ [b] $A^p_{,q} = \frac{\partial A^p}{\partial x^q} + \left\{ \begin{matrix} p \\ qs \end{matrix} \right\} A^s$

[c] $A^q_{,p} = \frac{\partial A^p}{\partial x^q} - \left\{ \begin{matrix} p \\ qs \end{matrix} \right\} A^s$ [d] $A^q_{,p} = \frac{\partial A^p}{\partial x^q} + \left\{ \begin{matrix} p \\ sp \end{matrix} \right\} A^s$

3. The value of Christoffel's symbols [22,1] in cylindrical coordinate is

[a] $\rho cos\theta$ [b] ρ [c] $-\rho$ [d] $-\rho cos\theta$

4. Which one of the following statements does not include the Dirichlet's condition so that one can expand a function $f(x)$ as a Fourier series?

[a] The function must be periodic.
[b] The function must be single-valued.
[c] The function must be discontinuous within a period
[d] The integral over one period of $|f(x)|$ converges.

5. The three kets $|1\rangle$, $|2\rangle$ and $|3\rangle$ satisfy the linear combination $a_1|1\rangle + a_2|2\rangle + a_3|3\rangle = 0$. These vectors are said to be linearly dependent if

[a] $a_1 = 1,\ a_2 = 2,\ a_3 = 3$ [b] $a_1 = -1,\ a_2 = 2,\ a_3 = 3$
[c] $a_1 = 1,\ a_2 = -2,\ a_3 = 3$ [d] $a_1 = 0,\ a_2 = 2,\ a_3 = 0$

6. The Green's function, $G(\vec{r},\vec{r}')$, is

[a] anti-symmetric.
[b] symmetric.
[c] is discontinuous everywhere.
[d] such that $\nabla G(\vec{r},\vec{r}')$ is continuous at $\vec{r} = \vec{r}'$

7. The residue of $f(z) = \frac{1}{(z-2)(z-1)^3}$ at $z = 1$ is

[a] -1 [b] 1 [c] 2π [d] 4π

8. The value of $\oint \frac{cosz}{z^3} dz$ is equal to

[a] 4π [b]π [c] πi [d] $-\pi$i

9. The generating function of Laguerre polynomials $\sum_{n=0}^{\infty} \frac{L_n(x)}{n!} t^n$ is

[a] $\frac{e^{\frac{xt}{1-t}}}{1-t}$ [b] $\frac{e^{-\frac{xt}{1-t}}}{1-t}$

[c] $\frac{e^{\frac{xt}{1-t}}}{1+t}$ [d] $\frac{e^{\frac{xt}{1+t}}}{1-t}$

10. The recursion formula for the Hermite polynomial is

[a]$a_{\lambda+2} = \frac{2(n+\lambda)}{(\lambda+1)(\lambda+2)} a_\lambda$ [b] $a_{\lambda+2} = -\frac{2n}{(\lambda+1)(\lambda+2)} a_\lambda$

[c] $a_{\lambda+2} = \frac{2(n-\lambda)}{(\lambda+1)(\lambda+2)} a_\lambda$ [d] $a_{\lambda+2} = -\frac{2(n-\lambda)}{(\lambda+1)(\lambda+2)} a_\lambda$

II. *Fill in the following blanks with appropriate answer. The symbols, unless mentioned otherwise, have their usual meanings*

11. A vector $\vec{A}$ in spherical polar coordinate is given as $\vec{A} = A_r\hat{r} + A_\theta\hat{\theta} + A_\phi\hat{\phi}$. Then $\nabla \cdot (A_r\hat{r})$ is equal to ....

12. The geodesics in a Riemannian space are given by ....

13. The expression of Christoffel's symbols of second kind is ....

14. The Fourier sine transform of $f(x) = |1|$ in the interval [-π, π] is ....

15. The Laplace transform of $f(x) = \cos(\omega t + \theta)$ is ....

16. If the eigenvalue of an operator for an eigenfunction is α then eigenvalue of 3rd power of the operator is ....

17. The Green's function $G(\vec{r}, \vec{r}')$ in spherical polar coordinate is ....

18. The singularities of a multiple valued function are called ....

19. A complex function $f(z) = u(x,y) + iv(x,y)$. If $u(x,y) = e^x cosy$, the function is analytic if $v(x,y)$ is equal to ....

20. If $J_{\frac{3}{2}}(x)$ and $J_{-\frac{3}{2}}(x)$ are two Bessel's functions, then the ratio of $J_{\frac{3}{2}}(x)$ and $J_{-\frac{3}{2}}(x)$ is equal to ....

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Time : 2 hrs. 30 mins.

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F.M. : 55

SECTION "B"
[5 Q.×4=20 marks]

1. Prove that $\frac{\partial^2 x^m}{\partial \bar{x}^j \partial \bar{x}^k} = \overline{\left\{ {n \atop jk} \right\}} \frac{\partial x^m}{\partial \bar{x}^n} - \frac{\partial x^p}{\partial \bar{x}^j} \frac{\partial x^q}{\partial \bar{x}^k} \left\{ {m \atop pq} \right\}$

2. What is a Hilbert space? State and explain the Gram-Schmidt process of orthogonalization.

OR

Show that the eigen values of a Hermitian matrix are real and the eigen vectors are orthogonal.

3. Find the Fourier transform of the Gaussian distribution function $f(x) = e^{\frac{-x^2}{a^2}}$

4. What is a delta function? State its properties and prove $\delta(x - x') = \frac{1}{2\pi} \int_{-\infty}^{\infty} e^{ik(x-x')}\, dk$.

OR

Using Generating function of the Bessel Polynomial, show that
$cosx = J_0(x) - 2J_2(x) + 2J_4(x) - \cdots$
$sinx = 2J_1(x) - 2J_3(x) + 2J_5(x) - \cdots$

5. What is an analytic function? Obtain the Cauchy-Riemann condition for an analytic function in polar form.

SECTION "C"
[5 Q.×7=35 marks]

6. Define residue theorem. Use this theorem to find $\int_0^{\infty} \frac{dx}{1+x^n}$

7. What do you mean by orthogonal curvilinear coordinate system? Find the expression for divergence and curl in orthogonal curvilinear coordinate system.

OR

If a given vector is defined with respect to two general curvilinear coordinate system (u_1, u_2, u_3) and $(\bar{u}_1, \bar{u}_2, \bar{u}_3)$ find the relation between the contravariant components and covariant components of the vectors in two-coordinate system.

8. Write down the Legendre's differential equation and obtain its power series solution.

9. Find the Fourier series of $f(x) = x^2$ for $-\pi \leq x \leq \pi$ .Also sketch it and using the result, find the series $\sum_{n=1}^{\infty} \frac{1}{(2n-1)^2} = \frac{\pi^2}{8}$.

OR

Define Laplace transform. A battery of emf E_0 is connected in series with an inductor of inductance L and a capacitor of capacitance C. Initially the charge in the capacitor is zero. Find the charge in the capacitor and current in the circuit at time t.

10. Using the Green's function, solve

$\frac{d^2 G(x,x_0)}{dx^2} + k^2 G(x, x_0) = \delta(x, x_0)$ under the boundary condition

$\frac{dG(x,x_0)}{dx}|_{x=0} = \frac{dG(x,x_0)}{dx}|_{x=2} = 0$