KATHMANDU UNIVERSITY
End Semester Examination
February/March, 2018

Marks Scored:

Level : B.Sc.
Year : III

Course : PHYS 302
Semester: I

Exam. Roll No. : Time: 30 mins. F. M. : 20

Registration No.: Date MAR 13 2018

SECTION "A"
[20Q.×1=20 marks]

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

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. Kronecker delta is a mixed tensor of rank

[a] 3 [b] 4 [c] 2 [d] 1

3. The value of Christoffel's symbols $[12,2]$ in cylindrical coordinate is

[a] 0 [b] ρ [c] $\rho\cos\theta$ [d] 1

4. Which one of the following statements is not included in 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 independent if

[a] $a_1 = 3,\ a_2 = -5,\ a_3 = 2$ [b] $a_1 = a_2 = a_3 = \frac{1}{3}$
[c] $a_1 = 1,\ a_2 = 1,\ a_3 = -2$ [d] $a_1 = a_2 = a_3 = 0$

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 $w(z) = \frac{1}{(z-2)(z-3)^2}$ at $z = 3$ is

[a] $2\pi i$ [b] 1 [c] -1 [d] 4π

8. A complex function $f(z)=u(x,y)+iv(x,y)$ is analytic. If $u(x,y)=x^3-3xy^2$ then $v(x,y)$ is equal to ....

[a] $3x^2-y^2$ [b] $3xy-y^3$ [c] $3x^2y^2-y^3$ [d] $3x^2y-y^3$

9. The generating function of Hermite differential equation is

[a] $f(x,t)=e^{2xt-t^2}$ [b] $f(x,t)=e^{2xt+t^2}$

[c] $f(x,t)=e^{2x-t^2}$ [d] $f(x,t)=e^{\frac{x}{2}[t-\frac{1}{t}]}$

10. The recursion formula for the Legendre polynomial is

[a] $a_{r+2}=\dfrac{(k+r)(k+r+1)-\lambda}{(k+r+2)(\mathrm{k+r+1})}a_r$ [b] $a_{r+2}=\dfrac{(k+r)(k+r+1)+\lambda}{(k+r+2)(\mathrm{k+r+1})}a_r$

[c] $a_{r+2}=\dfrac{(k+r)(k+r-1)+\lambda}{(k+r+2)(\mathrm{k+r-1})}a_r$ [d] $a_{r+2}=\dfrac{(k+r)(k+r-1)+\lambda}{(k+r-2)(\mathrm{k+r+1})}a_r$

II. *Fill in the following blanks with appropriate answer.*

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. For an orthogonal coordinate system, $\mathrm{g}_{ij}=$..........................

13. The Christoffel symbol of second kind is given by...................................

14. The Fourier transform of Gaussian distribution function is.............................

15. The Laplace transform of $e^{-at}\sin\omega\mathrm{t}$ is ....

16. The eigen values of a Skew-Hermitian matrices are ....

17. The Green's function of ∇^2 in cylindrical coordinate is ....

18. The Cauchy Riemann conditions are given by ....

19. The value of $\int_0^\infty \frac{dx}{1+x^6}=$ ....

20. If $J_n(x)$ is the Bessel function of first kind then the ratio of $J_{\frac{1}{2}}(x)$ and $J_{-\frac{1}{2}}(x)$ equals to

....

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SECTION "B"

[5 Q.×4=20 marks]

1. Derive transformation law for the Christoffel's symbol of first kind.

2. What do you mean by similarity transformation? Show that the trace and determinant of a matrix are invariant under similarity transformation.

OR

Find the Fourier series expansion of $f(x)=x^2$ in the interval $-\pi \le x \le \pi$.

3. What do you mean by Laplace transform? Find the first and second order derivatives of Laplace transform.

4. Define step function $\in(x)$ and Dirac delta function $\delta(x)$. Show that one way of determining delta functions as the differential coefficient of the step function.

OR

Defining the generating function, establish the orthogonality condition for Laguerre polynomial.

5. What do you mean by analytic function? If $f(z)$ is analytic inside and on the boundary of a simply connected region R, prove that $f^n(z)=\frac{n!}{2\pi i}\oint_c \frac{f(\xi)d\xi}{(\xi-z)^{(n+1)}}$

SECTION "C"

[5 Q.×7=35 marks]

6. Integrate by the method of residue $\int_0^{2\pi} \frac{d\theta}{a+b\cos\theta}$ if $a>|b|$.

7. What do you mean by curvilinear coordinate system? Find the expression for gradient, divergence and curl in cylindrical 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 vectors in the two-coordinate system.

8. Write down the Bessel's differential equation. Obtain its power series solution.

9. The one- dimensional wave equation for a transverse wave in a string is

$$\frac{\partial^2\phi(x,t)}{\partial x^2}=\frac{1}{v^2}\frac{\partial^2\phi(x,t)}{\partial t^2}$$

where,

$$\phi(x,t)\to 0 \text{ and } \frac{\partial\phi}{\partial x}\to 0 \text{ as } (x\to\pm\infty).\ \phi(x,0)=f(x) \text{ and } \frac{\partial\phi}{\partial t}|_{t=0}=0.$$

Solve by Fourier transform method.

OR

If the Schwartz inequality takes the form $|\int g_1(x)dx|^2 |\int g_2(x)dx|^2 \geq |\int g_1(x)g_2(x)dx|^2$ where $g_1(x)$ and $g_2(x)$ are any proper functions along the real x-axis, show that $\Delta x \Delta p_x \geq \frac{\hbar}{2}$, where $\Delta x = \sqrt{<x^2>}$ and $\Delta p_x = \sqrt{<\hbar^2 k^2>}$

10. What do you understand by Green's function? Solve the Poisson's equation in 3D using the Green's function method.