UG/I/PHS/H/I/16 (New)

2016

PHYSICS

[Honours]

PAPER – I

Full Marks : 90

Time : 4 hours

The figures in the right hand margin indicate marks

Candidates are required to give their answers in their own words as far as practicable

Illustrate the answers wherever necessary

[NEW SYLLABUS]

GROUP – A

Answer any **two** questions : 15×2

1. (*a*) Expand the following function in Taylor series $F(z) = \log_e(1+z)$ around $z = 0$. 3

(*b*) What is the geometrical interpretation of 'divergence' ? State Gauss's divergence theorem. Find the divergence of the function

$$\vec{V} = r(2+\sin^2\phi)\,\hat{r} + r\sin\phi\cos\phi\,\hat{\phi} + 3z^2\hat{z}$$

where $\hat{r}, \hat{\phi}, \hat{z}$ represent the unit vectors in cylindrical co-ordinate. 1 + 1 + 3

(*c*) Find the integral

$$\int_{-1}^{+1} x^2 P_n(x) P_m(x)\,dx$$

where $P_n(x)$ represent Legendre polynomial of degree n. 3

(*d*) Expand in a Fourier series the periodic function $f(x)$ with period $2l$ where

$$f(x) = |x| \quad \text{for } -l < x < l$$

Hence show that

$$\frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots = \frac{\pi^2}{8}$$ 3 + 1

2. (*a*) Find the expression for the steady state displacement of a particle serving as a linear

(*Continued*)

harmonic oscillator under the action of an external periodic force $F\cos wt$. Find the instantaneous velocity of the particle and show that the velocity and the displacement differ in phase by $\pi/2$. 2 + 2 + 1

(*b*) What do you mean by velocity resonance ? Plot the variation of velocity amplitude of the forcing system against angular frequency of the driving force for different values of decay constant ? How does sharpness of resonance changes with decay constant ? 1+1+1

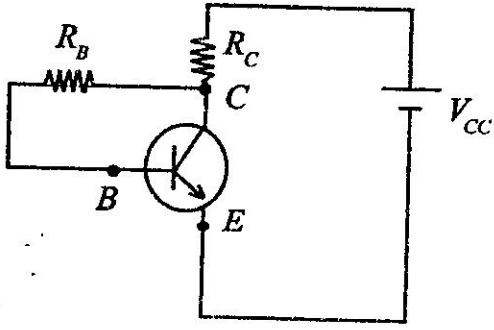
(*c*) What do you mean by acoustic pressure and acoustic intensity ? Show that the acoustic intensity for a plane progressive harmonic wave is the product of the rms acoustic pressure and rms particle velocity. 1 + 1 + 2

(*d*) The intensity level in a conversation is 70 dB above the threshold of 10^{-12} W/m^2. Calculate the amplitude of vibration of the air particles in the sound wave. Given velocity of sound = 350 m/s, density of air = 1·25g/litre mean frequency = 500 Hz. 3

3. (*a*) What do you mean by reverse saturation current ? On which factors does it depend ? 1+1

(*b*) What do you mean by the stability of bias point of a transistor ? Find the stability factor of a voltage divider type transistor biasing circuit using emitter resistance. Find the condition for its optimum operation. 1+3+1

(*c*) Consider the following circuit :



Here $V_{CC} = 12$ V, $R_c = 1$ kΩ, $\beta = 100$, and $V_{BE} = 0{\cdot}7$ V. Find R_B which makes $V_{CE} = 6{\cdot}32$ V, Find also I_B, Assume $I_{CEO} << I_B$. 3

(*d*) Show that

$$(A \oplus B) \oplus C = A \oplus (B \oplus C)$$

symbols have their usual meaning. 2

(*e*) Show that a shear θ is equivalent to two equal linear tensile strains of half the magnitude in mutually perpendicular direction. 3

4. (*a*) Explain the terms "spatial coherence" and "temporal coherence" with reference to Young's double slit experiment for interference pattern. $1\frac{1}{2}+1\frac{1}{2}$

(*b*) Show that the shape of the fringes produced in Young's experiment is hyperbolic in two dimensional plane. 4

(*c*) When a film of transparent material of refractive index 1·2 is put behind one of the slits of a two-slit Young's experiment, the zeroth order fringe moves to the position previously (before insertion of the film)

occupied by the 4th-order bright fringe. Given that the wavelength λ of the light used is 5000 Å, find the thickness of the film. 4

(*d*) What do you mean by fringes of equal width and fringes of equal inclination ? 2 + 2

GROUP – B

Answer any **five** questions : 8×5

5. (*a*) Define resolving power of a grating. Find an expression for the chromatic resolving power of a grating. 1 + 3

(*b*) For sodium light (D lines – 589·0 nm and 589·6 nm) incident normally on a grating having 100 lines/mm of width 2 cm, calculate the first order

(*i*) angle of diffraction

(*ii*) chromatic dispersion

(*iii*) resolving power.

(*iv*) Are the D lines resolved in the first order ? (1 + 1 + 1 + 1)

6. (*a*) What do you mean by elliptically polarised light ? Explain how a quarter-wave plate can be used to analyse polarised light. How can you distinguish between an elliptically polarised light and a mixture of plane polarised and unpolarised light ? 1+3+2

(*b*) What is zone plate ? Explain its difference with convex lens. 1 + 1

7. (*a*) For stationary waves in a stretched transversely vibrating string, the displacement at a point x at a time t is

$$y(x,t) = \sum_{S=1}^{\infty} \frac{A}{S^2} \sin\frac{S\pi a}{L} \sin\frac{S\pi x}{L} \cos\frac{S\pi ct}{L}$$

where $x = a$ is the point of excitation and C is the velocity of propagation of the wave along the string. The other symbols are standard.

(*i*) Find the initial displacement of the fifth harmonic.

(*ii*) Calculate the frequency and the wavelength of second harmonic ($a \neq L/2$).

(*iii*) The string is excited at $x = a = L/3$. Find the first three harmonics that are present.

(*iv*) What happens if the string after excitation be touched at the same point ($x = a$) ? 1+2+2+1

(*b*) Define 'decibel' and 'phon'. 2

8. (*a*) Set up the equation of motion of a spherical body of radius r moving vertically downward through a viscous fluid. Calculate the steady terminal velocity V_t. Draw V_t against r curve. 1 + 2 + 1

(*b*) Draw the circuit diagram of a Bridge rectifier. Explain its operation. 2 + 2

9. (*a*) What is resonance ? Distinguish between amplitude and velocity resonance. 1 + 3

(*b*) A plane progressive wave in one-dimension is given by $y = a \sin (wt - kx + \alpha)$ where the

notations have their usual meaning. Calculate the instantaneous kinetic energy and potential energy per unit volume for the wave. 4

10. Derive the system matrix for a combination of two thin lenses separated by a distance. Hence find the equivalent focal length. Find the positions of principal planes and discuss how the locations of principal planes change as a function of the distance between the two lenses. 3 + 1 + 4

11. (*a*) Draw the circuit diagrams for positive logic two input OR and AND gates using diodes and explain their operations. 2 + 2

(*b*) Establish the relation $I_C = \beta I_B + (1 + \beta) I_{CBO}$, where the symbols have their usual meanings. 2

(*c*) Subtract $(1101)_2$ from $(1010)_2$ by 1's complement method. 2

12. (*a*) Using Leibnitz's theorem derive Rodrigue's formula of Legendre polynomial. 5

(*b*) Show that (*i*) in polar co-ordinates $\frac{\partial(x,y)}{\partial(r,\theta)} = r$ (*ii*) in cylindrical co-ordinates $\frac{\partial(x,y,z)}{\partial(\rho,\phi,z)} = \rho$. 3

GROUP – C

Answer any five questions : 4 × 5

13. Solve

$$x^2\frac{d^2y}{dx^2} - x\frac{dy}{dx} + 2y = x\log x$$ 4

14. Show that

$$\nabla^2(\log r) = \frac{1}{r^2}$$ 4

15. Distinguish between avalanche breakdown and Zener breakdown. 2 + 2

16. What is piezoelectricity ? Indicate briefly how is it used to generate ultrasonic waves. 2 + 2

17. Check Stoke's theorem for the vector

$$\vec{V} = (2xz + 3y^2)\hat{j} + (4yz^2)\hat{k}$$

for the surface of a unit square located at first quadrant of Y-Z plane. 4

18. The equations of motion of two coupled oscillators are

$$\ddot{q}_1 + \sqrt{2}q_2 + 4q_1 = 0$$

and $$\ddot{q}_2 + \sqrt{2}q_1 + 5q_2 = 0$$

Find the normal frequencies and the ratios of the amplitudes of the normal modes. 2 + 2

19. Newton's ring are formed with a source of light containing two wavelengths λ_1 and λ_2. If mth order dark ring due to λ_1 coincides with the $(m + 1)$th order dark ring due to λ_2, Prove that the radius of the mth dark ring of λ_1 is equal to $\sqrt{\frac{\lambda_1\lambda_2 R}{\lambda_1 - \lambda_2}}$, where R is the radius of curvature of lower curved surface. 4