Ref. No.: Ex/ME(M2)/BS/B/Ph/T/112/2024

B.E. MECHANICAL ENGINEERING

1ST YEAR 1ST SEMESTER 2024

Subject: PHYSICS

Time: 3 Hours **Full Marks: 100**

Answer any ten questions. Symbols used have their usual meanings.

1. (a) What do you understand by restoring force and retarding force of a damped vibration?
   (b) Write down the differential equation of Simple Harmonic motion and find out its general solution.
   $(2+2)+(2+4)$

2. (a) Mentioning the physical meaning of each term, write down the differential form of equation of motion of a particle executing damped vibration.
   (b) Find out the solution of the above equation for low damping. $(2+2)+6$

3. (a) Distinguish between 'group velocity' and 'phase velocity'. Derive the relation between these two velocities.
   (b) Find out the frequency and wave velocity of plane progressive wave given by the expression: $y = 10\sin(200\pi t - 4\pi x)$ $(3+3)+(2+2)$

4. (a) What do you understand by an ideal fluid? Derive the mass continuity equation for an ideal fluid flow.
   (b) Establish Bernoulli's equation in case of an ideal fluid flow, and hence, state Bernoulli's theorem.
   $(1+4)+(4+1)$

5. (a) Deduce Poiseuille's formula for the rate of flow of liquid through a capillary tube for streamline flow.
   (b) A tube of radius R and length L is connected in series with another of radius R/2 and length L/8. If the pressure across the two tubes taken together is P, deduce the pressure across the tube separately.
   $6+4$

6. (a) Define terminal velocity. Determine coefficient of viscosity of a fluid by considering the falling of a spherical ball of radius 'r' through the fluid of density 'σ' with terminal velocity 'v_t'.
   (b) A drop of water of radius 0.01m is falling through medium of density 1.21 kgm^{-3} and $\eta = 1.8 \times 10^{-5} Nsm^{-2}$. Find the terminal velocity of the drop. $(2+4)+4$

7. (a) Write down the properties of lines of force. What do you understand by electric flux density? Explain whether electric flux density is a scalar or a vector quantity.
   (b) Prove Gauss's theorem considering a charge 'q' surrounded by a closed surface. $(3+2+1)+4$

8. (a) State Biot-Savart's Law. Write down its vector form.
   (b) Determine the induced magnetic field due to a long linear current carrying wire at a point 'R' distance apart, using Ampere's circuital law. $(3+1)+6$

9. (a) State and express Faraday's law of electromagnetic induction.
   (b) Deduce the growth of current in a circuit containing a resistance 'R' and an inductor of inductance 'L' which are connected in series with a cell of steady emf 'E'. What is meant by time constant of this circuit? $3+(5+2)$

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10. (a) Write down Maxwell equations for electromagnetic fields in free space. How do the equations modify if the electric field is static?

    (b) Establish the wave equation satisfied by the magnetic field $\vec{B}(\vec{r}, t)$ using Maxwell equations.

    (c) Mention how the normal and tangential components of electric field behave near the interface of two different non-magnetic media. $(3+1)+4+2$

11. (a) In case of Young's double slit interference experiment, find out the relation of fringe width as a function of the wavelength of incident radiation. Write down the ratio of fringe widths if two different lights are used in the same set up.

    (b) Fringes are produced with monochromatic light of wavelength $\lambda = 600$ nm and the location of central maxima is noted. A thin glass plate is placed in the path of one of the interfering beams and the central maxima is shifted to the position of the previously occupied fourth maxima. Find the thickness of the glass plate. Refractive index of glass $= 1.5$. $(5+1)+4$

12. (a) What are the differences between Fresnel diffraction and Fraunhofer diffraction?

    (b) For single slit diffraction, find out the condition for central maxima.

    (c) What is the highest order of spectrum that may be seen for a light of wavelength 500 nm by using a plane transmission grating of 2000 lines/cm? $2+5+3$

13. (a) Show that when the angle of incidence is equal to the angle of polarization, reflected and refracted rays are at right angle to each other.

    (b) Two mutually perpendicular oscillations of unequal amplitudes are superposed on each other. Find out the state of polarization if the phase difference between them is $\frac{\pi}{2}$.

    (c) What are coherence time and coherence length? $3+4+3$

14. (a) Write down the position-momentum uncertainty principle and briefly discuss its significance. Mention another pair of variables satisfying the same criterion.

    (b) An electron of mass 9.1×10^{-31} kg is moving with a speed of 500 ms^{-1} with an accuracy of 0.008%. Determine the accuracy limit of the location of the electron. Given, $h = 6.63 \times 10^{-34}$ J s.

    (c) A particle of mass 'm' and charge 'q' is passing through a region of potential difference 'V'. Find out the expression of de Broglie wavelength of the particle. $(3+1)+3+3$

15. (a) How is the wave function of a particle constrained to move in one dimension used to determine its probability density?

    (b) A particle is strictly confined within a region of length L. Write down the form of the potential. Solve the Schrödinger equation for the particle to show that its energy is quantized. Plot the wave function for first two eigen states. $2+(1+5+2)$