Oscillations & Waves

1. **Define SHM. Derive the expression for energy in SHM. Show KE and PE vary with time but total energy remains constant. [VIMP]**

2. **Define damped oscillation. Derive the differential equation and classify the types (overdamped, underdamped, critical). [VIMP]**

3. **Develop a differential equation of forced oscillation in LCR circuit and derive the condition for resonance. [VIMP]**

4. **Compare mechanical and electrical oscillations. Derive equation for damped mechanical oscillation. [IMP]**

5. **Write characteristics of a progressive wave. Derive energy expression for it. [IMP]**

6. **Explain sharpness of resonance and derive amplitude expression for forced EM oscillation. [IMP]**

7. **What is LC oscillation? Derive its differential equation and compare with mass-spring system. [IMP]**

8. **What is a compound pendulum? Derive its time period. Show oscillation and suspension centers are interchangeable. [VIMP]**

9. **What is a torsional pendulum? Derive the expression for time period. Why is it amplitude-independent? [IMP]**

10. **For a bar pendulum, prove the time period is minimum when the distance between CG and pivot equals radius of gyration. [IMP]**

🔊 Acoustics & Sound

11. **Explain reverberation. Derive Sabine's formula. What are the conditions for good acoustics? [VIMP]**

12. **Why are Newton's rings circular? Derive an expression for the radius in transmitted light. [IMP]**

13. **Describe bad acoustics and methods of improvement. [MOD]**

14. **A vibrating object has amplitude reduced to 1/e in 50s. Find the relaxation time and time to reduce to 1/3. [MOD]**

🌈 Optics

15. **Explain interference in wedge-shaped thin films. Derive fringe width formula. [VIMP]**

16. **Describe Newton's Rings. How to use them to find refractive index of a liquid? [VIMP]**

17. **What is diffraction? Derive intensity expression for single-slit diffraction. [VIMP]**

18. **Define dispersive power and resolving power of a grating. Derive their expressions. [IMP]**

19. **Two wavelengths coincide at different orders in a grating. Derive lines/cm from diffraction angle. [MOD]**

20. **Derive formula for radius of Newton's dark ring. Show relation with fringe order. [MOD]**

21. **What is chromatic aberration? Derive condition for achromatic combination of lenses. [MOD]**

22. **Explain Nicol prism. How does it work as a polarizer and analyzer? [IMP]**

23. **Compare circular, plane, and elliptically polarized light. How to identify them? [MOD]**

24. **Describe construction and action of a quarter-wave and half-wave plate. [MOD]**

25. **Describe construction of Ramsden's eyepiece and locate its cardinal points. [MOD]**

🔬 Fiber Optics

26. **What is optical fiber? Derive expression for acceptance angle and numerical aperture. [VIMP]**

27. **Compare single-mode and multimode fibers in terms of attenuation, cost, and efficiency. [IMP]**

28. **Given refractive indices, calculate cladding index, NA, and acceptance angle. [MOD]**

⚡ Electrostatics

29. **Define electric dipole. Derive electric field at axial and equatorial points. [VIMP]**

30. **Define quadrupole. Derive electric field or potential at axial point. [IMP]**

31. **Define and derive expression for potential due to a uniformly charged ring at axial point. [IMP]**

32. **State and prove Gauss's Law. Use it to find electric field inside a uniformly charged sphere. [VIMP]**

33. **Derive field inside a cylinder with volume charge density. [MOD]**

34. **What is the relationship among D, E, and P vectors? Derive it. [MOD]**

35. **A capacitor has dielectric inserted. Calculate new capacitance, energy, charge. [MOD]**

🧲 Magnetism & EM

36. **State Ampere's Law. Derive B inside and outside a long current-carrying wire. [VIMP]**

37. **What is self-induction? Derive inductance of solenoid and toroid. [IMP]**

38. **Derive growth and decay of current in RL and RC circuits. Plot current-time graph. [VIMP]**

39. **What is Hall Effect? Derive expression for Hall voltage and coefficient. [IMP]**

40. **Define Poynting vector. Prove $S = E \times B/\mu_0$ and explain significance. [IMP]**

41. **List Maxwell's equations. Derive EM wave equation and show wave speed in medium < c. [VIMP]**

🔋 Circuits & EM Waves

42. **An inductor and resistor are connected to a battery. Derive expression for voltage across inductor over time. [IMP]**

43. **Determine energy stored in an inductor and energy density in magnetic field. [MOD]**

44. **Write and explain modified Ampere's law with Maxwell’s correction. Define displacement current. [VIMP]**

45. **Find electric field from a circular coil on its axis. Show coil behaves like magnetic dipole at large distance. [MOD]**

🧪 Quantum & Modern Physics

46. **State and derive time-independent Schrodinger equation. Solve for particle in 1D box. [VIMP]**

47. **Define tunneling effect. Derive transmission coefficient for a barrier. [IMP]**

48. **What is the physical meaning of wave function? [IMP]**

49. **In a cyclotron, derive energy expression and show independence from electric field. [IMP]**

50. **Explain principle, design and application of laser (He-Ne or semiconductor). Include population inversion. [VIMP]**