Instruction: Attempt all questions from this section
Time Allowed for this section: 20 minutes
SECTION A: MCQ

1. A projectile is launched at an angle θ with initial velocity u. The maximum height reached is given by: A) $(u^2 \sin^2\theta)/(2g)$ B) $(u^2 \cos^2\theta)/(2g)$ C) $(u^2 \sin\theta \cos\theta)/g$ D) $(u^2 \tan\theta)/g$

2. In a simple harmonic motion, the phase difference between displacement and acceleration is: A) 0° B) 90° C) 180° D) 270°

3. A body of mass m is moving in a circle of radius r with constant speed v. The centripetal acceleration is: A) v^2/r B) mv/r C) mv^2/r D) r/v^2

4. According to Newton's third law, if a rocket expels gas backwards with force F, the forward force on the rocket is: A) F (equal and opposite) B) 2F C) F/2 D) Zero (due to relativity)

5. The work done by friction on a block sliding down an inclined plane is: A) Always positive B) Always negative C) Zero if no slipping D) Equal to kinetic energy gained

6. In an elastic collision between two bodies of equal mass moving towards each other with speeds u1 and u2, the velocities after collision are: A) u1 and u2 (unchanged) B) -u2 and -u1 C) (u1 + u2)/2 for both D) Zero for both

7. The moment of inertia of a thin rod of length L about an axis perpendicular to its length and passing through its center is: A) $(1/12)$ m L^2 B) $(1/3)$ m L^2 C) m L^2 D) $(1/2)$ m L^2

8. Bernoulli's principle explains why: A) Airplanes fly B) Magnets attract iron C) Light bends in water D) Sound travels faster in solids

9. A satellite in geostationary orbit has a period of: A) 12 hours B) 24 hours C) 1 hour D) 365 days

10. The escape velocity from Earth's surface is approximately: A) 7.9 km/s B) 11.2 km/s C) 25 km/s D) 1.4 km/s

11. For an ideal gas, the internal energy U depends only on: A) Volume B) Pressure C) Temperature D) Number of moles

12. In a Carnot engine, the efficiency η is given by: A) $1 - (T_c / T_h)$ B) $(T_h - T_c)/T_h$ C) T_c / T_h D) $(T_h / T_c) - 1$

13. The first law of thermodynamics is a statement of conservation of: A) Momentum B) Energy C) Charge D) Angular momentum

14. During an adiabatic process for an ideal gas, the temperature: A) Increases if volume decreases B) Remains constant C) Always decreases D) Depends on pressure only

15. The root mean square speed of gas molecules is proportional to: A) $\sqrt{T} / M$ (T = temperature, M = molar mass) B) $T / \sqrt{M}$ C) $\sqrt{M} / T$ D) $M / \sqrt{T}$

16. The speed of sound in air increases with: A) Decrease in temperature B) Increase in humidity C) Increase in density D) Decrease in frequency

17. In a standing wave on a string fixed at both ends, the number of nodes for the fundamental mode is: A) 0 B) 1 C) 2 D) 3

18. Doppler effect: If source and observer are moving towards each other, the observed frequency is: A) Higher than source frequency B) Lower than source frequency C) Unchanged D) Zero

19. The phenomenon of beats occurs due to: A) Interference of two waves of slightly different frequencies B) Diffraction of sound waves C) Refraction in air D) Polarization of waves

20. Wave equation: The general form for a transverse wave is $y = A \sin(\omega t - kx + \varphi)$, where φ is: A) Phase constant B) Amplitude C) Wavelength D) Frequency

21. The refractive index of a medium is 1.5. The critical angle for total internal reflection is: A) $\sin^{-1}(2/3)$ B) $\sin^{-1}(1/1.5)$ C) $\cos^{-1}(1.5)$ D) $\tan^{-1}(1.5)$

22. In Young's double-slit experiment, the fringe width β is proportional to: A) $\lambda D / d$ (λ = wavelength, D = distance to screen, d = slit separation) B) $d / (\lambda D)$ C) $\lambda / (D d)$ D) $D / (\lambda d)$
23. A convex lens forms a real image when the object is placed: A) Beyond focal point B) At focal point C) Between focal point and lens D) At infinity only
24. Polarization of light proves its: A) Transverse nature B) Longitudinal nature C) Particle nature D) Wave-particle duality
25. The magnifying power of a simple microscope is maximum when the image is at: A) Infinity B) Least distance of distinct vision C) Focal point D) Center of curvature
26. Kirchhoff's voltage law is based on conservation of: A) Charge B) Energy C) Momentum D) Mass
27. The magnetic field inside a long solenoid is: A) $\mu_0 n I$ (n = turns per unit length, I = current) B) Zero C) $\mu_0 I / (2\pi r)$ D) $B = \mu_0 I / r$
28. In a series RLC circuit at resonance, the impedance is: A) R B) $X_L - X_C$ C) Zero D) Infinite
29. Coulomb's law is analogous to: A) Newton's gravitational law B) Ohm's law C) Faraday's law D) Hooke's law
30. The force on a current-carrying conductor in a magnetic field is maximum when the angle between current and field is: A) $90°$ B) $0°$ C) $180°$ D) $45°$
31. Faraday's law relates induced EMF to: A) Rate of change of magnetic flux B) Electric field strength C) Current density D) Capacitance
32. The unit of electric permittivity ε_0 is: A) F/m B) H/m C) Ω m D) V/m
33. In a transformer, the voltage ratio is equal to: A) Turns ratio B) Current ratio C) Power ratio D) Impedance ratio
34. The drift velocity of electrons in a conductor is: A) Very small ($\sim 10^{-4}$ m/s) B) Equal to speed of light C) Equal to thermal velocity D) Zero in insulators
35. Gauss's law for magnetism states that magnetic monopoles: A) Do not exist B) Exist in pairs C) Are equal to electric charges D) Depend on current
36. The photoelectric effect demonstrates: A) Particle nature of light B) Wave nature of light C) Diffraction of electrons D) Interference of photons
37. In Bohr's model, the radius of the nth orbit is proportional to: A) n^2 B) $1/n$ C) n D) $1/n^2$
38. The de Broglie wavelength λ of a particle is given by: A) h / p (h = Planck's constant, p = momentum) B) $h p$ C) p / h D) $\sqrt{h p}$
39. Nuclear fission releases energy due to: A) Conversion of mass to energy ($E = mc^2$) B) Binding energy per nucleon increase C) Electron capture D) Proton emission
40. The half-life of a radioactive substance is the time for: A) Half the atoms to decay B) All atoms to decay C) Activity to double D) Mass to halve