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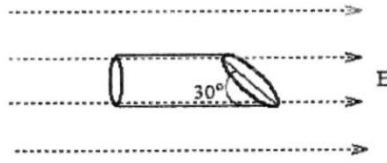
**Sample Question Paper for Master of Science (Physics)
SPSAT'18**

INSTRUCTIONS

The test is 60 minutes long & consists of 40 multiple choice questions (MCQ) adding up to 40 marks.

1. Which of the following can represent a conservative force? ($\hat{i}, \hat{j}, \hat{k}$ are unit vectors)
 - (a) $C(\hat{i}y + \hat{j}z + \hat{k}z)$
 - (b) $C(\hat{i}x + \hat{j}y + \hat{k}y)$
 - (c) $C. xyz(\hat{i} + \hat{j} + \hat{k})$
 - (d) $C(\hat{i}x + \hat{j}y + \hat{k}z)$
2. A wave travelling on a string is given by $y(x, t) = 10 \sin(0.1x - 22t)$, the wavelength & frequency of the wave are given by
 - (a) $\lambda = 62.9 \text{ cm}, \nu = 3.5 \text{ Hz}$
 - (b) $\lambda = 31.4 \text{ cm}, \nu = 7 \text{ Hz}$
 - (c) $\lambda = 0.002 \text{ cm}, \nu = 0.3 \text{ Hz}$
 - (d) $\lambda = 6.28 \text{ cm}, \nu = 35 \text{ Hz}$
3. Lissajous figure produced by two sine waves of equal frequency ω & equal amplitude A but 90° out of phase will be
 - (a) A diagonal line of length A
 - (b) A circle with radius A
 - (c) An ellipse with major axis A
 - (d) A sine wave
4. As temperature increases, the viscosity of liquid in general
 - (a) Decreases
 - (b) Increases
 - (c) Initially decreases, passes through a minimum & then increases
 - (d) Remains constant
5. Let ΔW be the work done during a reversible process. Then ΔW is
 - (a) A perfect differential for any process
 - (b) A perfect differential only for an isothermal process
 - (c) A perfect differential only for an adiabatic process
 - (d) Not a perfect differential for any process
6. Which of the following optical components is critical to differentiate between an unpolarized light & circularly polarized light?
 - (a) Half wave plate
 - (b) Quarter wave plate
 - (c) Polarizer
 - (d) Half wave plate & polarizer
7. A two hinged semicircular arch of radius R carries a concentrated load W at the crown. The horizontal thrust is
 - (a) $W/2\pi$
 - (b) W/π
 - (c) $2W/3\pi$
 - (d) $4W/3\pi$

8. A cylinder of radius R with the right side cut at an angle 30° as shown in the figure below is kept in a uniform electric field \vec{E} , with its axis along the direction of electric field.



The total electric flux linked with the entire cylinder is

- (a) 0 (b) $-(\pi R^2 E \sqrt{3})/2$ (c) $-(\pi R^2 E)/2$ (d) $\pi R^2 E$
9. The ground state energy of a one-dimensional harmonic oscillator is 6.2 eV. If the oscillator undergoes a transition from its $n = 3$ level to $n = 2$ level by emitting a photon, what is the wavelength associated with the photon?
- (a) 50 nm (b) 62 nm (c) 100 nm (d) 200 nm
10. The de-Broglie wavelength of a neutron (kinetic energy $3/2$ kT) at 00 K is
- (a) 1.5 \AA (b) 2 \AA (c) 0 \AA (d) 273 \AA
11. The commutator of two hermitian matrices is
- (a) Hermitian (b) Unitary (c) Anti-hermitian (d) Orthogonal
12. A particle of mass m has a speed $v = A/x$, where x is the displacement at time t . Then the force on the particle at time t is proportional to
- (a) $t^{1/3}$ (b) $t^{-1/2}$ (c) $t^{-2/3}$ (d) $t^{-3/2}$
13. One thousand water droplets with radius $r = 10^{-6} \text{ m}$, coalesce to form a single droplet. If the surface tension of water is $T = 7.5 \times 10^{-2} \text{ N m}^{-1}$, how much energy is liberated when the droplet coalesces?
- (a) $8.5 \times 10^{-10} \text{ J}$ (b) $8.5 \times 10^{-2} \text{ J}$ (c) $8.5 \times 10^{-5} \text{ J}$ (d) $4.5 \times 10^{-7} \text{ J}$
14. A $5 \mu\text{F}$ capacitor is charged by a 12 V battery through a resistance of 104Ω . The total amount of heat dissipated by the resistance during the charging process is equal to
- (a) 36 mJ (b) 3.6 mJ (c) 360 mJ (d) 0.36 mJ
15. For large principle quantum number (n), the spacing between two neighboring energy levels of a hydrogen atom is proportional to
- (a) $1/n$ (b) $1/n^2$ (c) $1/n^3$ (d) $(1 + n)/n^2$
16. The half-life of thorium is 1.4×10^{10} years. What is the time required for 10% of a sample of thorium to disintegrate?
- (a) 2.13×10^9 years (b) 2.13×10^7 years (c) 2.13×10^6 years (d) 2.13×10^5 years
17. A circular ring of radius a has a line charge density $\rho = \rho_0 \sec^2 \theta$, where θ is measured with respect to a fixed radius. The potential at the center is equal to
- (a) ρ_0/a (b) $\pi \rho_0/a$ (c) $\pi \rho_0$ (d) 0

18. Identify the correct statement

- (a) The entropy of a system always increases when it undergoes an irreversible process
- (b) The entropy of a system always decreases when it undergoes an irreversible process
- (c) The second law of thermodynamics follows directly from principle of conservation of energy
- (d) The internal energy of an ideal gas depends on its temperature

19. The kinetic energy of a free relativistic particle is defined as $E - m_0c^2$, where E & m_0 are respectively its total energy & rest mass. Let v be the speed of the particle when its kinetic energy is half of its rest mass energy. Then the ratio v / c is

- (a) $\sqrt{5}/3$
- (b) $1/\sqrt{2}$
- (c) 1
- (d) $\sqrt{3}/2$

20. The Boolean expression $B.(A + B) + A.(A + \bar{B})$ can be realized using a minimum number of

- (a) 1 OR gate
- (b) 1 AND gate
- (c) 2 OR gate
- (d) 2 AND gate

21. An ideal diatomic gas (of $\gamma = 5/3$) is expanded adiabatically so that its volume is doubled. By what ratio is its temperature reduced in this process?

- (a) $1/2$
- (b) $1/2^{1/3}$
- (c) $1/2^{2/3}$
- (d) $1/2^{5/3}$

22. An amplifier has a voltage gain $A_v = 1000$, input impedance $1 \text{ k}\Omega$ & output impedance 500Ω . A fraction $\beta v = 0.1$ of the output voltage is fed back in series in opposition to the input voltage. The input & output impedance after the feedback are given respectively by the approximate values

- (a) $100 \text{ k}\Omega$ & 5Ω
- (b) $1 \text{ k}\Omega$ & 5Ω
- (c) 10Ω & $50 \text{ k}\Omega$
- (d) $100 \text{ k}\Omega$ & 100Ω

23. The energy loss due to diffraction for a plane wave reflected back & forth between two plane mirrors

- (a) Decreases with an increase in the size of the mirrors
- (b) Increases with an increases in the size of the mirrors
- (c) Decreases with an increase in the separation between the mirrors
- (d) Increases with a decrease in the wavelength of the light

24. An X-ray machine operates at a potential of 50 kV . What is the minimum possible value of wavelength present in the radiation?

- (a) 0.0124 nm
- (b) 0.0248 nm
- (c) 0.124 nm
- (d) 0.248 nm

25. The moment of inertia of a spherical shell of Mass " M " & radius " R " about its diameter is

- (a) $\frac{1}{3}MR^2$
- (b) $\frac{2}{3}MR^2$
- (c) $\frac{5}{3}MR^2$
- (d) $\frac{4}{3}\pi R^3$

26. In the most general case, which one of the following quantities is NOT a second order tensor?

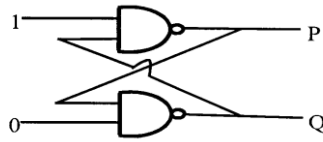
- (a) Stress
- (b) Strain
- (c) Moment of inertia
- (d) Pressure

27. An electron is moving with a velocity of $0.85c$ in the same direction as that of a moving photon. The relative velocity of the electron with respect to photon is
- (a) c (b) $-c$ (c) $0.15c$ (d) $-0.15c$
28. Across a first order phase transition, the free energy is
- (a) Proportional to the temperature
 (b) A discontinuous function of the temperature
 (c) A continuous function of the temperature but its first derivative is discontinuous
 (d) Such that the first derivative with respect to temperature is continuous
29. Two gases separated by an impermeable but movable partition are allowed to freely exchange energy. At equilibrium, the two sides will have the same
- (a) Pressure & temperature (b) Volume & temperature
 (c) Pressure & volume (d) Volume & energy
30. The entropy function of a system is given by $S(E) = aE(E_0 - E)$ where a & E_0 are positive constants. The temperature of the system is
- (a) Negative for some energies (b) Increases monotonically with energy
 (c) Decreases monotonically with energy (d) Zero
31. In the β decay process, the transition $2^+ \rightarrow 3^+$, is
- (a) Allowed both by Fermi & Gamow-Teller selection rule
 (b) Allowed by Fermi & but not by Gamow-Teller selection rule
 (c) Not allowed by Fermi but allowed by Gamow-Teller selection rule
 (d) Not allowed both by Fermi & Gamow-Teller selection rule
32. At a surface current, which one of the magnetostatic boundary condition is not correct?
- (a) Normal component of the magnetic field is continuous
 (b) Normal component of the magnetic vector potential is continuous
 (c) Tangential component of the magnetic vector potential is continuous
 (d) Tangential component of the magnetic vector potential is not continuous
33. A circularly polarized monochromatic plane wave is incident on a dielectric interface at Brewster angle. Which one of the following statements is CORRECT?
- (a) The reflected light is plane polarized in the plane of incidence & the transmitted light is circularly polarized
 (b) The reflected light is plane polarized perpendicular to the plane of incidence & the transmitted light is plane polarized in the plane of incidence
 (c) The reflected light is plane polarized perpendicular to the plane of incidence & the transmitted light is elliptically polarized
 (d) There will be no reflected light & the transmitted light is circularly polarized

34. Consider a linear collection of N independent spin $1/2$ particles, each at a fixed location. The entropy of this system is (k is the Boltzmann constant)

- (a) Zero (b) Nk (c) $0.5Nk$ (d) $Nk(\ln 2)$

35. Shown in the figure is a combination of logic gates. The output values at P & Q are correctly represented by which of the following.



- (a) 0 0 (b) 1 1 (c) 0 1 (d) 1 0

36. A plane in a cubic lattices makes intercepts of a , $a/2$ & $2a/3$ with the three crystallographic axis respectively. The miller indices for this plane are:

- (a) (2 4 3) (b) (3 4 2) (c) (6 3 4) (d) (1 2 3)

37. Consider Rydberg (hydrogen-like) atoms in a highly excited state with n around 300. The wavelength of radiation coming out of these atoms for transition to the adjacent lies in the range.

- (a) Gamma rays ($\lambda \sim \text{pm}$) (b) UV ($\lambda \sim \text{nm}$) (c) Infrared rays ($\lambda \sim \mu\text{m}$) (d) RF ($\lambda \sim \text{m}$)

38. For an atomic nucleus with atomic number Z & mass number A , which of the following is (are) correct?

- (a) Nuclear matter & nuclear charge are distributed identically in the nuclear volume
 (b) Nuclei with $Z > 83$ & $A > 209$ emit α -radiation
 (c) The surface contribution to the binding energy is proportional to $A^{2/3}$
 (d) β -decay occurs when the proton to neutron ratio is large, but not when it is small

39. For a point dipole of dipole moment $\vec{p} = p\hat{z}$ located at the origin, which of the following is (are) correct?

- (a) The electric field at $(0, b, 0)$ is zero
 (b) The work done in moving charge q from $(0, b, 0)$ to $(0, 0, b)$ is $\frac{qp}{4\pi\epsilon_0 b^2}$.
 (c) The electrostatic potential at $(0, 0, b)$ is zero
 (d) If a charge q is kept at $(0, 0, b)$ it will exert a force of magnitude $\frac{qp}{4\pi\epsilon_0 b^3}$ on the dipole

40. Which of the following is due to inhomogeneous refractive index of earth's atmosphere?

- (a) Red colour of the evening Sun (b) Blue colour of the sky
 (c) Oval shape of the evening Sun (d) Large apparent size of the evening Sun.