PHYSICAL SCIENCES
PAPER I (PART 'B')

41. The resolution of a Michelson interferometer operating with a light source of 640 *nm* wavelength is

    1. 1280 *nm.*
    2. 640 *nm.*
    3. 80 *nm.*
    4. 1 *nm.*

42. When a terminal is at virtual ground, then

    1. both current and voltage are zero.
    2. only voltage will be zero.
    3. only current will be zero.
    4. both voltage and current are not zero.

43. Platinum resistor (PTR) and a thermistor(THR) are used to measure room temperature. Which of the following is true?

    1. PTR offers more accuracy, THR more resolution.
    2. PTR offers more resolution, THR more accuracy.
    3. Both offer same accuracy, THR offers more resolution.
    4. Both offer same resolution, PTR offers more accuracy.

44. A four bit A/D converter is used to convert an analog voltage of 8*V*. The maximum error is

    1. 0.5 *V.*
    2. 1.0 *V.*
    3. 2.0 *V.*
    4. 0.25 *V.*

45. A voltage of 2300 volts is applied to a cylindrical counter with an anode wire of radius 0.01 *cm* and a cathode inner radius of 1.0 *cm*. The electric field at the anode surface is

    1. 5×10^4 *V/cm.*
    2. 5×10^3 *V/cm.*
    3. 5×10^5 *V/cm.*
    4. 5×10^2 *V/cm.*

46. A γ-ray of energy 1 *keV* is passed through a solid absorber of thickness 3 *cm* and mass attenuation coefficient 3 cm^2/g at temperature T_1. If the same absorber is melted at temperature T_2, the mass attenuation coefficient will be

    1. $3\ (T_1/T_2)^2\ cm^2/g.$
    2. $1/3\ cm^2/g.$
    3. $3\ cm^2/g.$
    4. $3\ (T_2/T_1)^2\ cm^2/g.$

47. Five panelists are required to elect a sixth member to the panel. If any of the panelists votes against a member, the member is disqualified. What would be the appropriate electronic circuit to be used in the electronic voting machine to implement the above rule?

1. XOR
2. XNOR
3. OR
4. AND

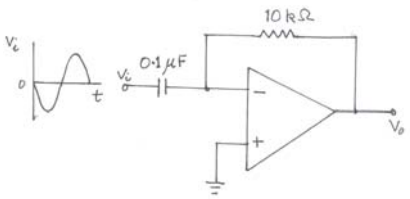
48. In an op-amp, when the input signal drives the output at a rate of voltage change greater than the slew rate, then the resulting signal

1. is enhanced.
2. is clipped .
3. is unaffected.
4. remains the same, but with 90^0 phase difference.

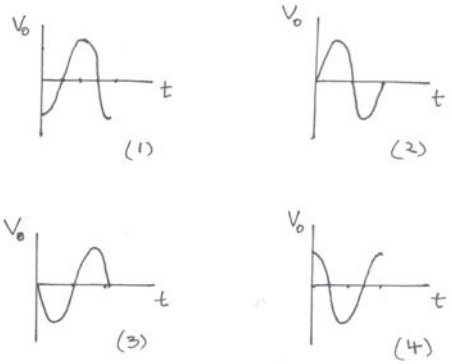
49. Sensitive experiments are often performed inside a metal enclosure known as a Faraday cage. Which of the following of Maxwell's equations governs the principle of operation of the cage?

1. $\vec{\nabla}.\vec{E} = \rho / E_0$
2. $\vec{\nabla}.\vec{B} = 0$
3. $\vec{\nabla} \times \vec{E} = -\partial \vec{B} / \partial t$
4. $\vec{\nabla} \times \vec{H} = \mu_0 \left[\vec{J} + \varepsilon_0 \frac{\partial \vec{E}}{\partial t} \right]$

50. Consider the following operational amplifier circuit with an input signal of frequency 10 *kHz*.



Which of the following represents the output waveform V_0?



51. For the ground state of a particle moving freely in a one-dimentional box $0 \le x \le L$ with rigid reflecting end-points, the uncertainty product $(\Delta x)\,(\Delta p)$ is

1. $\mathrm{h}/2$
2. $\sqrt{2}\,\mathrm{h}$
3. $> \mathrm{h}/2$
4. $\mathrm{h}/\sqrt{3}$

52. Consider a system of two spin-half particles, in a state with total spin quantum number $S = 0$. The eigenvalue of the spin Hamiltonian $H = A\,\vec{S}_1.\vec{S}_2$ (A is a positive constant) in this state is

1. $A\,\mathrm{h}^2/4$
2. $-A\,\mathrm{h}^2/4$
3. $3A\,\mathrm{h}^2/4$
4. $-3A\,\mathrm{h}^2/4$

53. The energy of a 200 nm photon is
1. 0.01 eV
2. 100 eV
3. 10 eV
4. 1 eV

54. The wave function $\psi(\vec{r})$ of a particle moving in three-dimensional space has the physical dimensions of

1. $(\text{Length})^{-3/2}$
2. $(\text{Length})^{3/2}$
3. $(\text{Length})^{-1}$
4. (Length)

55. The eigenvalues of the Pauli spin matrix $\sigma_y = \begin{pmatrix} \theta & -i \\ i & 0 \end{pmatrix}$ are

1. $+1, +1$
2. $+1, -1$
3. $-i, +i$
4. $+i, +i$

56. The ground state energy of a particle in an infinite square-well potential of width L is E. If the width of the wall is reduced to $L/2$, then the ground state energy becomes

1. $2E$
2. $E/2$
3. $4E$
4. $E/4$

57. The classical definition of the orbital angular momentum of a particle is $\vec{L} = \vec{r} \times \vec{p}$. The corresponding quantum mechanical definition for the orbital angular momentum operator (taking into account the fact that $\hat{r}$ and $\hat{p}$ do not commute with each other) is

1. $\hat{L} = \vec{r} \times \vec{p}$
2. $\vec{L} = \frac{1}{2}[(\vec{r} \times \vec{p}) + (\vec{p} \times \vec{r})]$
3. $\vec{L} = \frac{1}{2i}[(\vec{r} \times \vec{p}) - (\vec{p} \times \vec{r})]$
4. $\vec{L} = \frac{\hat{r}}{r}(\vec{p} \times \vec{r})$

58. Given the Hamiltonian $\hat{H} = \hat{H}_0 + i\hat{T}$, where $\hat{H}_0$ and $\hat{T}$ are hermitian operators, which of the following statements are correct?

1. $\hat{H}$ is a hermitian operator and the total probability is conserved
2. $\hat{H}$ is a hermitian operator and the total probability is <u>*not*</u> conserved
3. $\hat{H}$ is <u>*not*</u> a hermitian operator and the total probability is conserved
4. $\hat{H}$ is <u>*not*</u> a hermitian operator and the total probability is <u>*not*</u> conserved

59. The Hamiltonian of a three-level system is

$$H = a\begin{pmatrix} 2 & 0 & 0 \\ 0 & 0 & 1 \\ 0 & 1 & 0 \end{pmatrix}$$

The energy eigenvalues are

1. $2a,\ a,\ -a$
2. $2a,\ a,\ 0$
3. $2a,\ 0,\ 0$
4. $2a,\ a,\ a$

60. The ground state energy of a particle in the one-dimensional potential

$$V(x) = \begin{cases} \frac{1}{2} m w^2 x^2 & \text{for } x > 0 \\ \infty & \text{for } x < 0 \end{cases}$$

is equal to

1. $\hbar\omega$
2. $\frac{3}{2}\hbar\omega$
3. $2\hbar\omega$
4. $\frac{5}{2}\hbar\omega$

61. Let k be the wave number of the incident plane wave in a scattering experiment. If the scattering is purely a p-wave with the phase shift $\delta_1 = \pi/4$, then the total scattering cross-section is

1. $2\pi/k^2$
2. $6\pi/k^2$
3. 0
4. k^2

62. Plane polarized light will be rotated when it is passed through a solution of

1. Na Cl O_3
2. CH Cl F_2
3. HC Br Cl F
4. Br CH_3

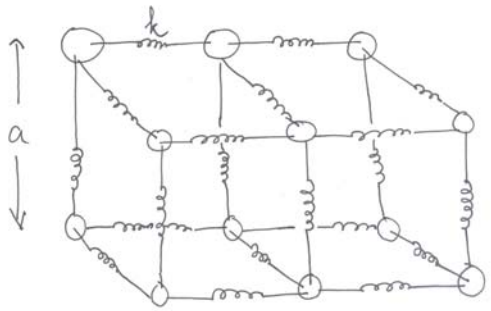
63. The specific heat of silicon monoxide at high temperatures, as compared to silicon dioxide, is

1. larger .
2. smaller.
3. equal.
4. dependent on other parameters not specified here.

64. You are shown a spectrum consisting of a series of equally spaced lines. This could be

1. the rotational spectrum of CO.
2. the vibrational spectrum of N_2.
3. the NMR spectrum of CH_4.
4. the Mossbauer spectrum of $Fe_3 O_4$.

65. The figure below shows a "bead-spring" model of a simple cubic crystalline lattice. The springs have spring constants k and the lattice spacing is a. For this model, the shear modulus governing displacements along the x - direction with a gradient along the z - direction is:



1. 0.
2. k / a.
3. $k / 6a$.
4. k / a^2.

66. The ratio $\kappa / \sigma T$ (where κ is the thermal conductivity, σ is the electrical conductivity and T is the temperature) for metals

1. is strongly dependent on the number density of the charge carriers.
2. is independent of the temperature T.
3. varies widely from one metal to another .
4. is approximately independent of the particular metal.

67. Let $U(x) = \frac{1}{2} ax^2 - bx^3 + cx^4$ be the energy cost of stretching the unit cell of a certain crystal by an amount x, (a, b and c are constants with a and c being positive). Then at temperature T the coefficient of linear thermal expansion (to first order in b and zeroth order in c) is proportional to

1. $a^2 b$.
2. b / a^2.
3. a^2 / b.
4. $1 / ba^2$.

68. The dispersion relation for spinwaves in a three dimensional Heisenberg ferromagnet is $\omega = Ak^2$, where ω is the frequency, k is the wave number, and A is a constant. The contribution of spin waves to the specific heat, at low temperatures T, is proportional to

1. $T^{2/3}$
2. $T^{3/2}$
3. T^{2}
4. $T^{1/2}$

69. For a one- dimensional monatomic lattice with lattice constant a the normal modes satisfy the relation

1. $\omega(q) = \omega\left(q + \frac{2\pi}{a}\right)$
2. $\omega(q) = \omega\left(q + \frac{\pi}{2a}\right)$
3. $\omega(q) = \omega\left(q + \frac{\pi}{a}\right)$
4. $\omega(q) = \omega\left(q + 2\pi a\right)$

70. Consider a gas of non-interacting electrons at T=0. If the electrons (of mass m) are replaced by neutrons (of mass M) keeping the density $n = N/V$ the same, the Fermi energy ε_F is changed by a factor

1. $\frac{M}{m}$.
2. $\left(\frac{M}{m}\right)^{2/3}$.
3. $\left(\frac{M}{m}\right)^{3/2}$.
4. $\frac{m}{M}$.

71. For a one- dimensional Debye solid, the lattice specific heat at low temperatures T will be proportional to

1. $T^{1/2}$.
2. T.
3. $T^{3/2}$.
4. T^{2}.

72. The dispersion relation for a certain type of excitation is given by $\omega = A\,k^a$, where A *and* $a > 0$ are constants. For these excitations, the group velocity is less than the phase velocity when

1. $a = 1$.
2. $a = \sqrt{2}$.
3. $a < 1$.
4. $a \geq 2$.

73. ^{10}Be in its first excited state has spin–parity 2^+. It gets de-excited to the ground state, which has spin parity 0, by γ–emission. The multipoles carried by γ are

1. $E2$.
2. $M2$.
3. $E2$, $M2$.
4. $E4$.

74. Two protons are placed at a distance of about 10^{-13} cm from each other. The ratio of the strength of strong and electromagnetic forces between them is roughly

1. 10.
2. 1.
3. 10^3.
4. 10^{-5}.

75. Which of the following is not an acceptable potential for the deuteron ($V_0 > 0$; k, $\mu > 0$)?

1. $V(r) = -V_0\, e^{-\mu r}$;
2. $V(r) = -V_0$ for $r < R_0$
   $= 0$ for $r > R_0$
3. $V(r) = -\frac{1}{2} k r^2$
4. $V(r) = \frac{-V_0}{1 + e^{\mu r}}$

76. The total cross-section for $\mu^+ \mu^- \rightarrow e^+ e^-$ at very high values of the centre of mass energies, $\sqrt{s} >> m_e$, is expected to behave as

1. $\frac{e^2}{s^2}$.
2. $\frac{e^4}{s^2}$.
3. constant.
4. $\frac{e^4}{s}$.

77. Which of the following is true for β-decay of the neutron? The process

1. violates both parity and charge conjugation symmetry.
2. violates parity but conserves charge conjugation symmetry.
3. conserves parity but violates charge conjugation symmetry.
4. conserves both parity and charge conjugation symmetry.

78. The Coulomb repulsion term which contributes to the binding energy of a nucleus ${}^{A}X_{Z}$ is proportional to

1. Z.
2. Z^2.
3. Z(ZZ

80. The neutral pion π^0 at rest decays into two photons. One of the photons is right circularly polarized. The other photon is

1. also right circularly polarized.
2. left circularly polarized.
3. unpolarized.
4. plane polarized.

81. A 100 MeV proton and a 100 MeV alpha particle are detected in the same detector. What is the ratio of energy loss per unit path length i.e. $\left(\frac{dE}{dx}\right)_p : \left(\frac{dE}{dx}\right)_\alpha$?

1. 1:1.
2. 1:2.
3. 1:4.
4. 1:16.

82. The number of ways in which 5 identical bosons can be distributed in 4 states is

84. The standard deviation of the energy of a system in the canonical ensemble is equal to

1. $\sqrt{C_v}$

2. $k_B T^2 C_v$

3. $\sqrt{k_B T^2 C_v}$

4. $\sqrt{k_B T C_v}$

85. Blackbody radiation is enclosed inside a spherical cavity of radius r at a temperature T. What would be the temperature of the enclosure if the radius expands to $2r$ adiabatically ?

1. $T/2$

2. T

3. $T/\sqrt{2}$

4. $2T$

86. Which of the following is <u>not</u> a periodic function of θ ?

1. $\sin\theta + \pi\cos\theta$

2. $\sin(\pi\theta) + \cos(\pi\theta)$

3. sin cos( )

88. The Legendre polynomial $P_n(x)$, where $-1 \leq x \leq +1$

1. is singular at $x = \pm 1$

2. satisfies $\int_{-1}^{1} {}_{n}^{2}(\ )\ \ 1$

111. An electric point charge $+q$ is placed at the point (1, 1) of the xy-plane in which two grounded semi-infinite conducting plates along the positive x and y-axes meet (see figure). The electric potential in the positive quadrant at a large distance r goes as

1. $V(r) \sim r^{-1}$
2. $V(r) \sim r^{-2}$
3. $V(r) \sim r^{-3}$
4. $V(r) \sim r^{-4}$

112. In a given frame of reference, it is found that the electric field $\vec{E}(\vec{r},t)$ and the magnetic field $\vec{B}(\vec{r},t)$ are perpendicular to each other at all points, *i.e.* $\vec{E}(\vec{r},t)\cdot\vec{B}(\vec{r},t)=0$. If the fields observed in any other inertial frame are $\vec{E}'$ and $\vec{B}'$, then

1. $\vec{E}' // \vec{B}'$ at all points.
2. $\vec{E}'\cdot\vec{B}' < 0$ at all points.
3. $\vec{E}'\cdot\vec{B}' > 0$ at all points.
4. $\vec{E}'\cdot\vec{B}' = 0$ at all points.

113. Consider the $(n \times n)$ matrix A with every element equal to unity. Which of the following statement is correct ?

1. The eigenvalues of A are all equal to unity.
2. All the eigenvalues of A are zero.
3. The largest eigenvalue of A is n.
4. A cannot be diagonalised by a similarity transformation.

114. The total energy E of a particle of mass m executing small oscillations about the origin along on the x-direction is given by

$$E=\frac{1}{2}mv^2+V_0\cosh\left(\frac{x}{L}\right),$$

where V_0 and L are positive constants. The time period T of oscillation is

1. $T=\frac{1}{2\pi}\sqrt{\frac{m}{V_0}}$.
2. $T=2\pi\sqrt{\frac{L}{m}}$.
3. $T=\pi L\sqrt{\frac{m}{E}}$.
4. $T=2\pi\sqrt{\frac{mL^2}{V_0}}$.

115. A canonical transformation in classical Hamiltonian dynamics

1. cannot be made if there is more than one degree of freedom.
2. leaves the canonical Poisson bracket relations unchanged.
3. can only be made for the cartesian components of the coordinates and momenta.
4. cannot be time-dependent.

116. The motion of a particle of mass m is described in a non-inertial frame of reference that is rotating with a uniform angular velocity $\vec{\omega}$. If $\vec{r}$ denotes the position of the particle in the non-inertial frame

1. the centrifugal force on the particle is $-m\omega^2\vec{r}$
2. the centrifugal force on the particle is $-m\vec{\omega}\times(\vec{\omega}\times\vec{r})$.
3. the Coriolis force on the particle is $-m\left(\vec{\omega}\times\dfrac{d\vec{r}}{dt}\right)$
4. the Coriolis force on the particle $-2m\omega^2\vec{r}$

117. The Lagrangian of a particle of mass m moving in a central potential $V(r)$ is

$$L=\frac{1}{2}m\left(\dot{r}^2+r^2\dot{\theta}^2+r^2\sin^2\theta\,\dot{\varphi}^2\right)-V(r)$$

1. θ is a cyclic coordinate.
2. θ and φ are cyclic coordinates.
3. φ is a cyclic coordinate.
4. r is a cyclic coordinate

118. A relativistic particle of rest mass m_0 is moving with a speed v. The value of v at which its kinetic energy is equal to its rest energy is

1. $v = c/2$
2. $v = c/4$
3. $v = c/\sqrt{2}$
4. $v = 2\left(\sqrt{2}-1\right)c$

119. An asymmetric rigid body has three distinct principal moments of inertia, with $I_x < I_y < I_z$. If we consider rotation with uniform angular velocity about the x, y and z axes, respectively, then the motion is

1. stable about the y-axis, but not about the x and z axes.
2. stable about the x and y axes, but not about the z-axis.
3. stable about the y and z axes, but not about the x axis.
4. stable about the x and z axes, but not about the y-axis.

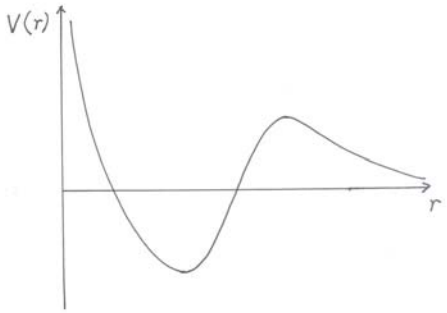
120. The constant acceleration due to gravity on the surface of a planet whose mass is twice the mass of Earth is found to be the same as the constant acceleration due to gravity on the surface of Earth. If R_e is the radius of Earth, then the radius of the planet must be

1. $2R_e$
2. $R_e/2$
3. $4R_e$
4. $\sqrt{2}\,R_e$

121. A particle of electric charge $+q$ and mass m is fired at a nucleus of charge $+Q$ and mass M in a Rutherford scattering experiment. In the center of mass frame,

1. the total energy, the total angular momentum and the total linear momentum are all conserved.
2. the total energy and the total angular momentum are conserved, but not the total linear momentum
3. the total energy is conserved, but not the total angular momentum and the total linear momentum
4. only the total electric charge is conserved, and no other quantity is conserved

122. A particle moves in the central potential $V(r)$ shown in the figure below



Which of the following statements is true?

1. Both a stable circular orbit and an unstable circular orbit are possible
2. Only a stable circular orbit is possible
3. Only an unstable circular orbit is possible
4. No circular orbit is possible

123. A particle of mass m is thrown upwards from the surface of the Earth with initial velocity components u_x and u_y along the horizontal and vertical directions respectively. The trajectory, therefore is given by $x(t) = u_x t$, $y(t)=u_y t - \frac{1}{2} g t^2$. The instant of time at which the acceleration and velocity vectors are perpendicular to each other is given by

1. u_x/g
2. $|u_x - u_y|/g$
3. $(u_x + u_y)/g$
4. u_y/g

124. The Lagrangian of a particle of mass m moving in two dimension is

$L = \frac{1}{2} m(\dot{x}^2 + \dot{y}^2) - \frac{1}{2} k (x^2 + y^2)$

If the particle has a finite angular momentum *l* about the origin, then we may conclude that it executes

1. oscillatory motion about the origin $r = 0$
2. periodic motion with a constant value of r
3. oscillatory motion along the x-axis
4. oscillatory motion along the y-axis

125. A particle moves in one dimension in a potential $V(x) = x^2/2 + x^3/3$, in suitable units. If E is the total energy of the particle, then the motion is

1. always bounded if $0 \le E \le \frac{1}{6}$
2. always unbounded if $0 \le E \le \frac{1}{6}$
3. always bounded if $E < 0$
4. bounded if $0 \le E \le \frac{1}{6}$ and the initial position satisfies $-1 < x(0) < \frac{1}{2}$

126. Let A and B be the Hermitian operators corresponding to two physical observables of a system, such that $[A, B] \neq 0$. We may conclude *in general* that

1. the uncertainty product is always $(\Delta A)(\Delta B) > \frac{\hbar}{2}$.
2. the system can never be in a state in which $(\Delta A)(\Delta B) = 0$.
3. neither A nor B can have any eigenstates.
4. A and B *may* have one or more common eigenstate(s), but not a complete set of these.

127. The electronic configuration of the ground state of the Na atom is $^2S_{1/2}$. This implies that

1. $S = 2,\ L = 0,\ J = 2$
2. $S = 0,\ L = 1/2, J = 1/2$
3. $S = 1/2, L = 0, J = 1/2$
4. $S = 0,\ L = 2,\ J = 2$

128. The mirrors of a laser cavity are separated by a distance L. If T is the time taken by the light to travel from one mirror to the other and back, the mode separation is

1. $\frac{1}{T}$
2. $\frac{2}{T}$
3. $\frac{1}{2T}$
4. $\frac{1}{\sqrt{2}T}$

129. A semiconductor diode is employed for rectification of an alternating voltage of 10V and a current of 1A. The forward voltage on the diode, after the system has been in operation for several hours of power dissipation,

1. does not change
2. increases by ~ 100 mV
3. increases by ~1 mV
4. degreases by ~ 100 mV

130. The maximum efficiency of an ideal class B amplifier is

1. 87.5%
2. 50%
3. 68.5%
4. 78.5%

131. A free electron gas has DC electrical conductivity $\sigma_0 = \frac{ne^2\tau}{m}$ where n is the number density of carriers, e is the charge of the carriers, τ is the relaxation time and m is the effective mass of the carriers. Assuming that there is only one relaxation time, the AC conductivity at frequency ω is modeled by

1. $(1 - i\omega\tau)\sigma_0$
2. $\frac{\sigma_0}{1+\omega^2\tau^2}$
3. $(1 + i\omega\tau)\sigma_0$
4. $\frac{\sigma_0}{1 - i\omega\tau}$

132. A proton and a neutron are both subject to a uniform magnetic field. Which of the following is true?

1. Both particles undergo Larmor precession because they have non-zero intrinsic magnetic moments.
2. The neutron does not precess because its intrinsic magnetic moment is zero
3. The proton does not precess because its intrinsic magnetic moment is zero.
4. Both the particles precess and the direction of the precession is the same for the two particles

133. The Van der Waals equation of state for 1 mole of a gas is

$$\left(P+\frac{a}{V^2}\right)(V-b)= RT$$

where a and b are constants. If U is the internal energy of n moles of this gas, then $\left(\frac{\partial U}{\partial V}\right)_T$ is

1. zero
2. $\frac{a}{\left(\frac{V}{n-b}\right)^2}$
3. $\left(\frac{a}{nV}\right)^2$
4. $\frac{a}{(V/\ n)^2}$

134. If in interior of a unit sphere we have $\vec{\nabla}.\vec{J}=$ a positive constant, where $\vec{J}$ is the current density then we may conclude that;

1. according to Gauss' theorem, the charge contained in the unit sphere is constant in time
2. according to Gauss' theorem, charge is flowing into the unit sphere
3. according to the continuity equation, the charge density within the unit sphere must necessarily be uniform
4. according to the continuity equation, the change density inside the unit sphere diminishes with time

135. Choose the correct statement from the following:

1. The magnetic field $\vec{B}$ is a vector and not a pseudovector.
2. $\vec{E}.\vec{B}$ is a scalar and not a pseudoscalar.
3. $\vec{E}\times\vec{B}$ is a pseudovector.
4. The magnetic vector potential $\vec{A}$ *is a* pseudovector.

136. Given any arbitrary electric and magnetic fields $\vec{E}(\vec{r},t)$ *and* $\vec{B}(\vec{r},t)$, it is always possible to choose the scalar potential $\phi\ (\vec{r},t)$ and vector potential $\vec{A}(\vec{r},t)$ such that

1. $\vec{A}(\vec{r},t)$ is identically zero.
2. $\phi\ (\vec{r},t)$ is identically zero.
3. $\left|\vec{A}\ (\vec{r},t)\right|$ is any given non-zero constant.
4. the conditions $\nabla.\vec{A}=0$ and $\frac{1}{c}\frac{\partial\phi}{\partial t}+\nabla.\vec{A}=0$ are simultaneously satisfied.

137. In a certain region *R*, Maxwell's equations for the electric and magnetic fields are given by

$$\nabla\cdot\vec{E}=0,\ \nabla\cdot\vec{B}=0,\ \nabla\times\vec{E}=-\frac{\partial\vec{B}}{\partial t},\ \nabla\times\vec{B}=\mu_0\varepsilon_0\frac{\partial\vec{E}}{\partial t}.$$

We may conclude that:

1. Both the scalar and the vector potential are necessarily constant in the region R.
2. The electric field $\vec{E}$ and the magnetic field $\vec{B}$ must necessarily be uniform in R.
3. There are no sources for electric charges and currents in R.
4. The electric field $\vec{E}$ is necessarily perpendicular to the magnetic field $\vec{B}$ at every point in R.

138. The sum of

$$1-\frac{\pi^2}{2!\ 4^2}+\frac{\pi^4}{4!\ 4^4}-\frac{\pi^6}{6!\ 4^6}+\cdots$$ is

1. not convergent
2. $\frac{\pi}{2}$
3. $\frac{\pi}{\sqrt{2}}$
4. $\frac{1}{\sqrt{2}}$

139. Consider the alpha-decay reaction

$Po_{84}^{210} \rightarrow Pb_{82}^{206} + He_2^4$
where atomic masses are

m(*Po*) = 210.0483 amu
m (*Pb*) = 206.0386 amu
m (*He*) = 4.0039 amu
1 amu = 931.141 MeV.

The kinetic energy of the alpha particle will be
1. 5.4 keV.
2. 2.7 keV.
3. 5.4 MeV.
4. 10.8 MeV

140. Consider the operators a and a^+, satisfying the commutation relation $[a, a^+] = I$, the unit operator. There are no normalisable eigenstates of the operator

1. $a^+ a$
2. a
3. a^+
4. $(a^+ a)^2$