

Notations :

- 1.Options shown in green color and with ✓ icon are correct.
- 2.Options shown in red color and with ✗ icon are incorrect.

Question Paper Name: PH: PHYSICS 1st Feb Shift2
Number of Questions: 65
Total Marks: 100.0

Wrong answer for MCQ will result in negative marks, (-1/3) for 1 mark Questions and (-2/3) for 2 marks Questions.

General Aptitude

Number of Questions: 10
Section Marks: 15.0

Q.1 to Q.5 carry 1 mark each & Q.6 to Q.10 carry 2 marks each.

Question Number : 1 Question Type : MCQ

Choose the appropriate word/phrase, out of the four options given below, to complete the following sentence:

Apparent lifelessness _____ dormant life.
(A) harbours (B) leads to (C) supports (D) affects

Options :

- 1. ✓ A
- 2. ✗ B
- 3. ✗ C
- 4. ✗ D

Question Number : 2 Question Type : MCQ

Fill in the blank with the correct idiom/phrase.

That boy from the town was a _____ in the sleepy village.
(A) dog out of herd (B) sheep from the heap
(C) fish out of water (D) bird from the flock

Options :

- 1. ✗ A
- 2. ✗ B
- 3. ✓ C
- 4. ✗ D

Question Number : 3 Question Type : MCQ

Choose the sentence in which the underlined word is used correctly.

- (A) When the teacher eludes to different authors, he is being elusive.
- (B) When the thief keeps eluding the police, he is being elusive.
- (C) Matters that are difficult to understand, identify or remember are allusive.
- (D) Mirages can be allusive, but a better way to express them is illusory.

Options :

- 1. ✖ A
- 2. ✔ B
- 3. ✖ C
- 4. ✖ D

Question Number : 4 Question Type : MCQ

Tanya is older than Eric.

Cliff is older than Tanya.

Eric is older than Cliff.

If the first two statements are true, then the third statement is:

- (A) True
- (B) False
- (C) Uncertain
- (D) Data insufficient

Options :

- 1. ✖ A
- 2. ✔ B
- 3. ✖ C
- 4. ✖ D

Question Number : 5 Question Type : MCQ

Five teams have to compete in a league, with every team playing every other team exactly once, before going to the next round. How many matches will have to be held to complete the league round of matches?

- (A) 20 (B) 10 (C) 8 (D) 5

Options :

- 1. ✖ A
- 2. ✔ B
- 3. ✖ C
- 4. ✖ D

Question Number : 6 Question Type : MCQ

Select the appropriate option in place of underlined part of the sentence.

Increased productivity necessary reflects greater efforts made by the employees.

- (A) Increase in productivity necessary
- (B) Increase productivity is necessary
- (C) Increase in productivity necessarily
- (D) No improvement required

Options :

- 1. ✖ A
- 2. ✖ B
- 3. ✔ C
- 4. ✖ D

Question Number : 7 Question Type : MCQ

Given below are two statements followed by two conclusions. Assuming these statements to be true, decide which one logically follows.

Statements:

- I. No manager is a leader.
- II. All leaders are executives.

Conclusions:

- I. No manager is an executive.
- II. No executive is a manager.

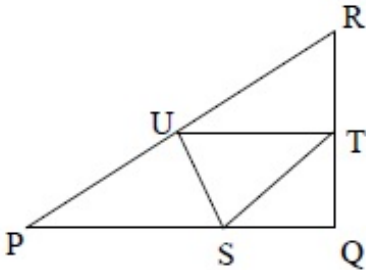
- (A) Only conclusion I follows.
- (B) Only conclusion II follows.
- (C) Neither conclusion I nor II follows.
- (D) Both conclusions I and II follow.

Options :

- 1. ✖ A
- 2. ✖ B
- 3. ✔ C
- 4. ✖ D

Question Number : 8 Question Type : NAT

In the given figure angle Q is a right angle, $PS:QS = 3:1$, $RT:QT = 5:2$ and $PU:UR = 1:1$. If area of triangle QTS is 20 cm^2 , then the area of triangle PQR in cm^2 is _____.



Correct Answer :

280

Right triangle PQR is to be constructed in the xy - plane so that the right angle is at P and line PR is parallel to the x -axis. The x and y coordinates of P, Q, and R are to be integers that satisfy the inequalities: $-4 \leq x \leq 5$ and $6 \leq y \leq 16$. How many different triangles could be constructed with these properties?

- (A) 110 (B) 1,100 (C) 9,900 (D) 10,000

Options :

1. ✖ A
2. ✖ B
3. ✔ C
4. ✖ D

Question Number : 10 Question Type : MCQ

A coin is tossed thrice. Let X be the event that head occurs in each of the first two tosses. Let Y be the event that a tail occurs on the third toss. Let Z be the event that two tails occur in three tosses. Based on the above information, which one of the following statements is TRUE?

- (A) X and Y are not independent (B) Y and Z are dependent
(C) Y and Z are independent (D) X and Z are independent

Options :

1. ✖ A
2. ✔ B
3. ✖ C
4. ✖ D

Physics

Number of Questions:

55

Section Marks:

85.0

Q.11 to Q.35 carry 1 mark each & Q.36 to Q.65 carry 2 marks each.

Question Number : 11 Question Type : MCQ

A satellite is moving in a circular orbit around the Earth. If T , V and E are its average kinetic, average potential and total energies, respectively, then which one of the following options is correct?

- (A) $V = -2T$; $E = -T$ (B) $V = -T$; $E = 0$
(C) $V = -T/2$; $E = T/2$ (D) $V = -3T/2$; $E = -T/2$

Options :

1. ✔ A
2. ✖ B
3. ✖ C

Question Number : 12 Question Type : NAT

The Pauli matrices for three spin- $\frac{1}{2}$ particles are $\vec{\sigma}_1$, $\vec{\sigma}_2$, and $\vec{\sigma}_3$, respectively. The dimension of the Hilbert space required to define an operator $\hat{O} = \vec{\sigma}_1 \cdot \vec{\sigma}_2 \times \vec{\sigma}_3$ is _____

Correct Answer :

8

Question Number : 13 Question Type : NAT

The mean kinetic energy of a nucleon in a nucleus of atomic weight A varies as A^n , where n is _____ (upto two decimal places)

Correct Answer :

-0.67 to -0.66

Question Number : 14 Question Type : MCQ

Let $\vec{L}$ and $\vec{p}$ be the angular and linear momentum operators, respectively, for a particle. The commutator $[L_x, p_y]$ gives

(A) $-i\hbar p_z$

(B) 0

(C) $i\hbar p_x$

(D) $i\hbar p_z$

Options :

1. ✖ A

2. ✖ B

3. ✖ C

4. ✔ D

Question Number : 15 Question Type : MCQ

The decay $\mu^+ \rightarrow e^+ + \gamma$ is forbidden, because it violates

- (A) momentum and lepton number conservations
- (B) baryon and lepton number conservations
- (C) angular momentum conservation
- (D) lepton number conservation

Options :

- 1. ✗ A
- 2. ✗ B
- 3. ✗ C
- 4. ✓ D

Question Number : 16 Question Type : MCQ

An operator for a spin- $\frac{1}{2}$ particle is given by $\hat{A} = \lambda \vec{\sigma} \cdot \vec{B}$, where $\vec{B} = \frac{B}{\sqrt{2}}(\hat{x} + \hat{y})$, $\vec{\sigma}$ denotes Pauli matrices and λ is a constant. The eigenvalues of $\hat{A}$ are

- (A) $\pm \lambda B / \sqrt{2}$
- (B) $\pm \lambda B$
- (C) $0, \lambda B$
- (D) $0, -\lambda B$

Options :

- 1. ✗ A
- 2. ✓ B
- 3. ✗ C
- 4. ✗ D

Question Number : 17 Question Type : MCQ

In an inertial frame S , two events A and B take place at $(ct_A = 0, \vec{r}_A = 0)$ and $(ct_B = 0, \vec{r}_B = 2\hat{y})$, respectively. The times at which these events take place in a frame S' moving with a velocity $0.6c\hat{y}$ with respect to S are given by

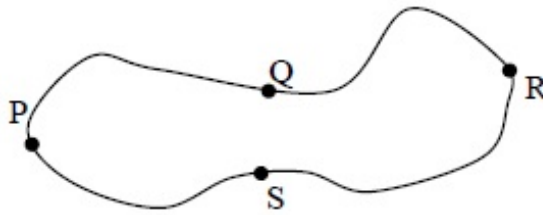
- (A) $ct'_A = 0; ct'_B = -3/2$
- (B) $ct'_A = 0; ct'_B = 0$
- (C) $ct'_A = 0; ct'_B = 3/2$
- (D) $ct'_A = 0; ct'_B = 1/2$

Options :

- 1. ✓ A
- 2. ✗ B
- 3. ✗ C
- 4. ✗ D

Given that the magnetic flux through the closed loop PQRSP is ϕ . If $\int_P^R \vec{A} \cdot d\vec{l} = \phi_1$ along PQR, the

value of $\int_P^R \vec{A} \cdot d\vec{l}$ along PSR is



(A) $\phi - \phi_1$

(B) $\phi_1 - \phi$

(C) $-\phi_1$

(D) ϕ_1

Options :

1. ✗ A

2. ✓ B

3. ✗ C

4. ✗ D

Question Number : 19 Question Type : MCQ

If $f(x) = e^{-x^2}$ and $g(x) = |x|e^{-x^2}$, then

(A) f and g are differentiable everywhere

(B) f is differentiable everywhere but g is not

(C) g is differentiable everywhere but f is not

(D) g is discontinuous at $x = 0$

Options :

1. ✗ A

2. ✓ B

3. ✗ C

4. ✗ D

Question Number : 20 Question Type : MCQ

In Bose-Einstein condensates, the particles

- (A) have strong interparticle attraction
- (B) condense in real space
- (C) have overlapping wavefunctions
- (D) have large and positive chemical potential

Options :

- 1. ✗ A
- 2. ✗ B
- 3. ✓ C
- 4. ✗ D

Question Number : 21 Question Type : MCQ

Consider a system of N non-interacting spin- $\frac{1}{2}$ particles, each having a magnetic moment μ , is in a magnetic field $\vec{B} = B \hat{z}$. If E is the total energy of the system, the number of accessible microstates Ω is given by

$$(A) \quad \Omega = \frac{N!}{\frac{1}{2} \left(N - \frac{E}{\mu B} \right)! \frac{1}{2} \left(N + \frac{E}{\mu B} \right)!}$$

$$(B) \quad \Omega = \frac{\left(N - \frac{E}{\mu B} \right)!}{\left(N + \frac{E}{\mu B} \right)!}$$

$$(C) \quad \Omega = \frac{1}{2} \left(N - \frac{E}{\mu B} \right)! \frac{1}{2} \left(N + \frac{E}{\mu B} \right)!$$

$$(D) \quad \Omega = \frac{N!}{\left(N + \frac{E}{\mu B} \right)!}$$

Options :

- 1. ✓ A
- 2. ✗ B
- 3. ✗ C
- 4. ✗ D

Question Number : 22 Question Type : MCQ

For a black body radiation in a cavity, photons are created and annihilated freely as a result of emission and absorption by the walls of the cavity. This is because

- (A) the chemical potential of the photons is zero
- (B) photons obey Pauli exclusion principle
- (C) photons are spin-1 particles
- (D) the entropy of the photons is very large

Options :

- 1. ☒ A
- 2. ☐ B
- 3. ☐ C
- 4. ☐ D

Question Number : 23 Question Type : MCQ

Consider $w = f(z) = u(x, y) + iv(x, y)$ to be an analytic function in a domain D . Which one of the following options is **NOT** correct?

- (A) $u(x, y)$ satisfies Laplace equation in D
- (B) $v(x, y)$ satisfies Laplace equation in D
- (C) $\int_{z_1}^{z_2} f(z) dz$ is dependent on the choice of the contour between z_1 and z_2 in D
- (D) $f(z)$ can be Taylor expanded in D

Options :

- 1. ☐ A
- 2. ☐ B
- 3. ☒ C
- 4. ☐ D

Question Number : 24 Question Type : NAT

The value of $\int_0^3 t^2 \delta(3t-6) dt$ is _____ (upto one decimal place)

Correct Answer:

1.3

Which one of the following **DOES NOT** represent an exclusive OR operation for inputs A and B ?

(A) $(A + B)\overline{AB}$

(B) $A\overline{B} + B\overline{A}$

(C) $(A + B)(\overline{A} + \overline{B})$

(D) $(A + B)AB$

Options :

1. ✖ A

2. ✖ B

3. ✖ C

4. ✔ D

Question Number : 26 Question Type : MCQ

Consider a complex function $f(z) = \frac{1}{z(z+\frac{1}{2})\cos(z\pi)}$. Which one of the following statements is correct?

(A) $f(z)$ has simple poles at $z = 0$ and $z = -\frac{1}{2}$

(B) $f(z)$ has a second order pole at $z = -\frac{1}{2}$

(C) $f(z)$ has infinite number of second order poles

(D) $f(z)$ has all simple poles

Options :

1. ✖ A

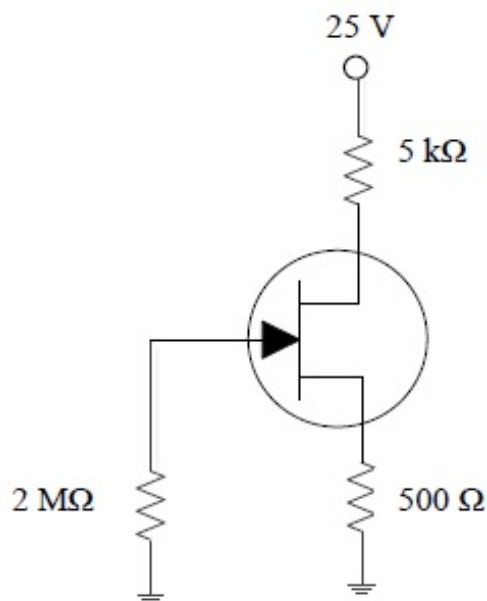
2. ✔ B

3. ✖ C

4. ✖ D

Question Number : 27 Question Type : NAT

In the given circuit, the voltage across the source resistor is 1 V. The drain voltage (in V) is _____



Correct Answer :

15

Question Number : 28 Question Type : NAT

A point charge is placed between two semi-infinite conducting plates which are inclined at an angle of 30° with respect to each other. The number of image charges is _____

Correct Answer :

11

Question Number : 29 Question Type : NAT

A beam of X-ray of intensity I_0 is incident normally on a metal sheet of thickness 2 mm. The intensity of the transmitted beam is $0.025I_0$. The linear absorption coefficient of the metal sheet (in m^{-1}) is _____ (upto one decimal place)

Correct Answer:

1844.3 to 1844.5

Question Number : 30 Question Type : NAT

The lattice parameters a, b, c of an orthorhombic crystal are related by $a = 2b = 3c$. In units of a , the interplanar separation between the (110) planes is _____ (upto three decimal places)

Correct Answer :

0.445 to 0.450

Question Number : 31 Question Type : MCQ

In a Hall effect experiment, the Hall voltage for an intrinsic semiconductor is negative. This is because (symbols carry usual meaning)

(A) $n \approx p$

(B) $n > p$

(C) $\mu_e > \mu_h$

(D) $m_e^* > m_h^*$

Options :

1. ✗ A

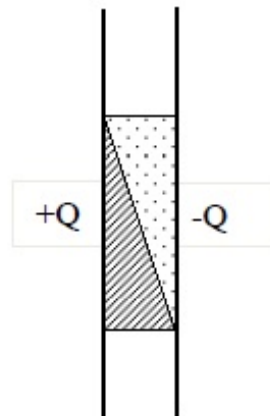
2. ✗ B

3. ✓ C

4. ✗ D

Question Number : 32 Question Type : MCQ

The space between two plates of a capacitor carrying charges $+Q$ and $-Q$ is filled with two different dielectric materials, as shown in the figure. Across the interface of the two dielectric materials, which one of the following statements is correct?



(A) $\vec{E}$ and $\vec{D}$ are continuous

(B) $\vec{E}$ is continuous and $\vec{D}$ is discontinuous

(C) $\vec{D}$ is continuous and $\vec{E}$ is discontinuous

(D) $\vec{E}$ and $\vec{D}$ are discontinuous

Options :

1. ✗ A

2. ✗ B

3. ✓ C

Question Number : 33 Question Type : NAT

The energy dependence of the density of states for a two dimensional non-relativistic electron gas is given by, $g(E) = CE^n$, where C is constant. The value of n is _____

Correct Answer :

0

Question Number : 34 Question Type : NAT

The dispersion relation for phonons in a one dimensional monatomic Bravais lattice with lattice spacing a and consisting of ions of masses M is given by, $\omega(k) = \sqrt{\frac{2C}{M} [1 - \cos(ka)]}$, where ω is the frequency of oscillation, k is the wavevector and C is the spring constant. For the long wavelength modes ($\lambda \gg a$), the ratio of the phase velocity to the group velocity is _____

Correct Answer :

1

Question Number : 35 Question Type : MCQ

Four forces are given below in Cartesian and spherical polar coordinates.

(i) $\vec{F}_1 = K \exp(-r^2 / R^2) \hat{r}$

(ii) $\vec{F}_2 = K(x^3 \hat{y} - y^3 \hat{z})$

(iii) $\vec{F}_3 = K(x^3 \hat{x} + y^3 \hat{y})$

(iv) $\vec{F}_4 = K(\hat{\phi} / r)$

where K is a constant. Identify the correct option.

- (A) (iii) and (iv) are conservative but (i) and (ii) are not
- (B) (i) and (ii) are conservative but (iii) and (iv) are not
- (C) (ii) and (iii) are conservative but (i) and (iv) are not
- (D) (i) and (iii) are conservative but (ii) and (iv) are not

Options :

1. ✖ A

2. ✖ B

3. ✖ C

Question Number : 36 Question Type : NAT

Consider a system of eight non-interacting, identical quantum particles of spin-3/2 in a one dimensional box of length L . The minimum excitation energy of the system, in units of $\frac{\pi^2 \hbar^2}{2mL^2}$ is _____

Correct Answer :

5

Question Number : 37 Question Type : NAT

The excitation wavelength of laser in a Raman effect experiment is 546 nm . If the Stokes' line is observed at 552 nm , then the wavenumber of the anti-Stokes' line (in cm^{-1}) is _____

Correct Answer :

18513 to 18519

Question Number : 38 Question Type : NAT

The binding energy per molecule of NaCl (lattice parameter is 0.563 nm) is 7.95 eV . The repulsive term of the potential is of the form $\frac{K}{r^9}$, where K is a constant. The value of the Madelung constant is _____ (upto three decimal places)

(Electron charge $e = -1.6 \times 10^{-19} \text{ C}$; $\epsilon_0 = 8.854 \times 10^{-12} \text{ C}^2 \text{N}^{-1} \text{m}^{-2}$)

Correct Answer :

1.745 to 1.751

Question Number : 39 Question Type : NAT

Given that the Fermi energy of gold is 5.54 eV , the number density of electrons is _____ $\times 10^{28} \text{ m}^{-3}$ (upto one decimal place)

(Mass of electron = $9.11 \times 10^{-31} \text{ kg}$; $h = 6.626 \times 10^{-34} \text{ J.s}$; $1 \text{ eV} = 1.6 \times 10^{-19} \text{ J}$)

Correct Answer:

5.9 to 6.0

Question Number : 40 Question Type : NAT

The band gap of an intrinsic semiconductor is $E_g = 0.72 \text{ eV}$ and $m_h^* = 6m_e^*$. At 300 K , the Fermi level with respect to the edge of the valence band (in eV) is at _____ (upto three decimal places)

$$k_B = 1.38 \times 10^{-23} \text{ J K}^{-1}$$

Correct Answer :

0.394 to 0.395

Question Number : 41 Question Type : NAT

The number of permitted transitions from $^2\text{P}_{3/2} \rightarrow ^2\text{S}_{1/2}$ in the presence of a weak magnetic field is _____

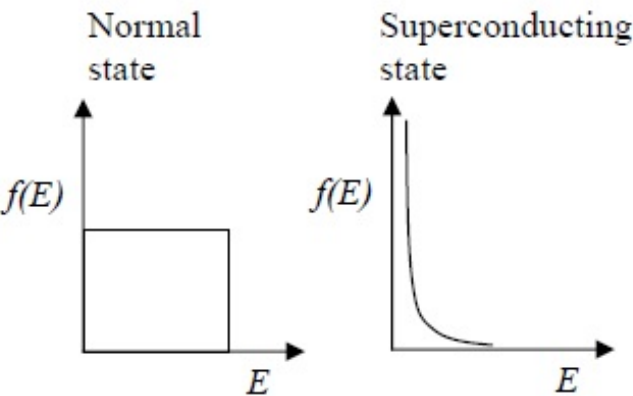
Correct Answer :

6

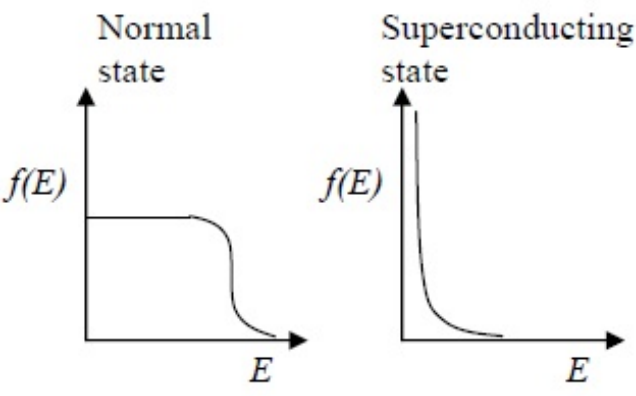
Question Number : 42 Question Type : MCQ

Which one of the following represents the electron occupancy for a superconductor in its normal and superconducting states?

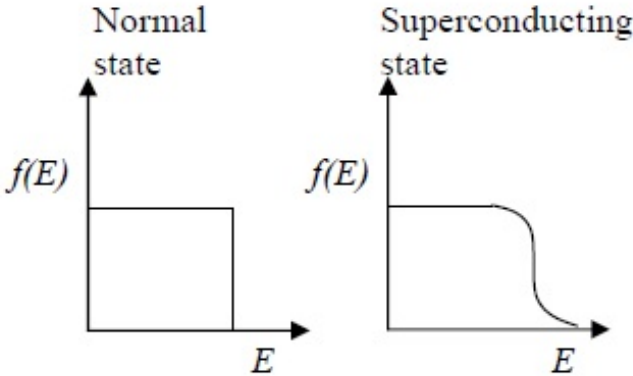
(A)



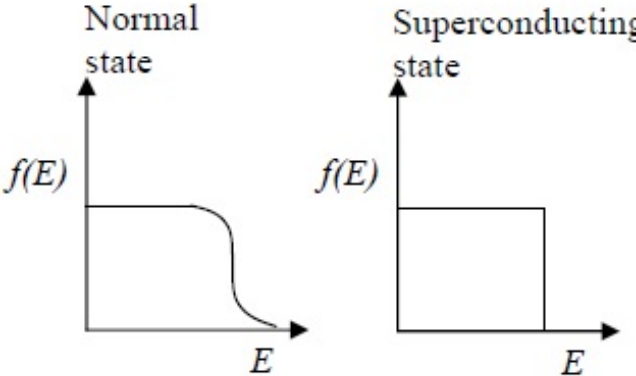
(B)



(C)



(D)

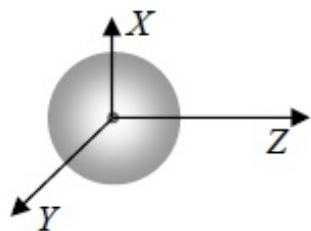


Options :

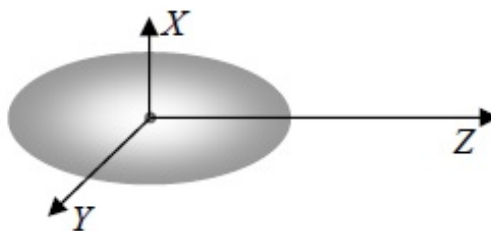
- 1. ✗ A
- 2. ✓ B
- 3. ✗ C
- 4. ✗ D

Question Number : 43 Question Type : MCQ

A charge $+q$ is distributed uniformly over a sphere, with a positive charge q at its center in (i). Also in (ii), a charge $-q$ is distributed uniformly over an ellipsoid with a positive charge q at its center. With respect to the origin of the coordinate system, which one of the following statements is correct?



(i)



(ii)

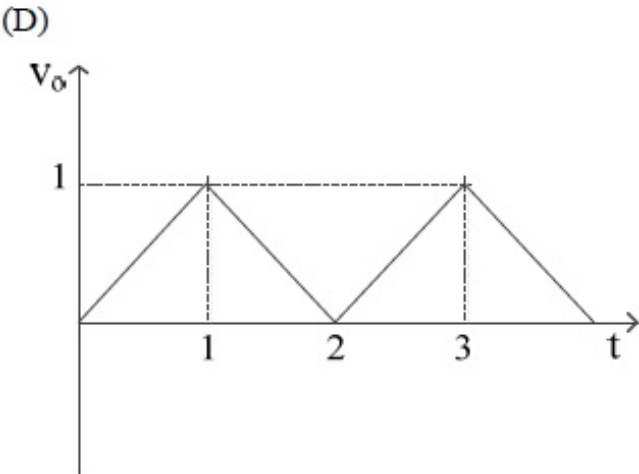
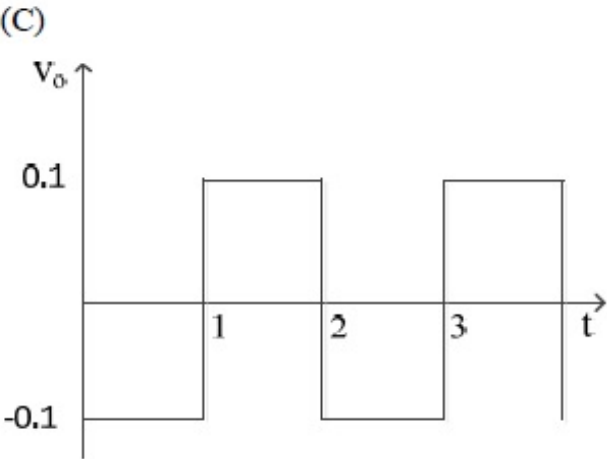
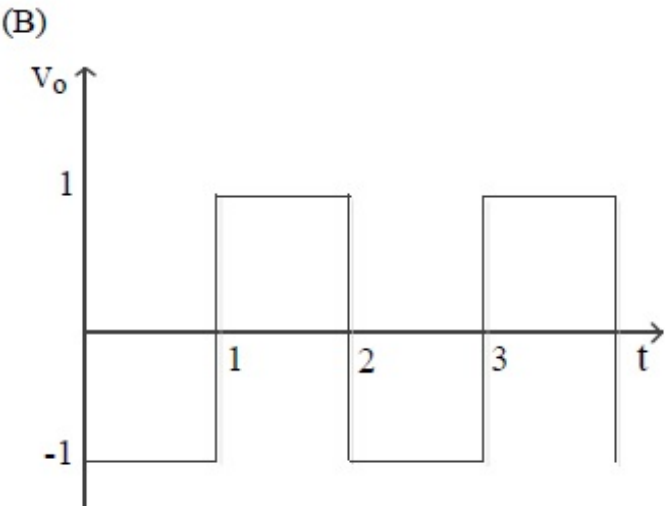
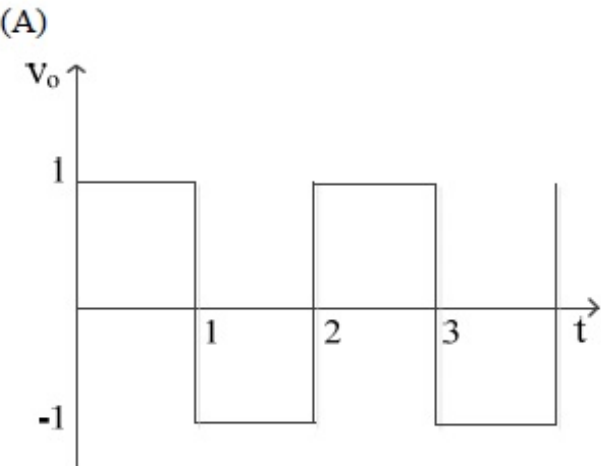
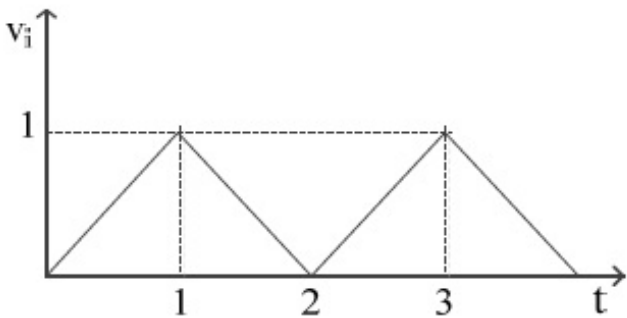
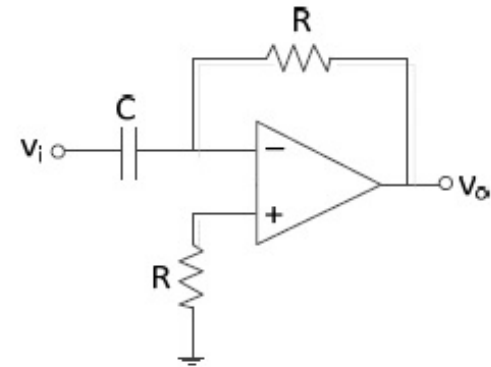
- (A) The dipole moment is zero in both (i) and (ii)
- (B) The dipole moment is non-zero in (i) but zero in (ii)
- (C) The dipole moment is zero in (i) but non-zero in (ii)
- (D) The dipole moment is non-zero in both (i) and (ii)

Options :

- 1. ✓ A
- 2. ✗ B
- 3. ✗ C
- 4. ✗ D

Question Number : 44 Question Type : MCQ

Consider the circuit shown in the figure, where $RC = 1$. For an input signal V_i shown below, choose the correct V_o from the options:



Options :

- 1. ✗ A
- 2. ✓ B
- 3. ✗ C
- 4. ✗ D

Question Number : 45 Question Type : MCQ

A long solenoid is embedded in a conducting medium and is insulated from the medium. If the current through the solenoid is increased at a constant rate, the induced current in the medium as a function of the radial distance r from the axis of the solenoid is proportional to

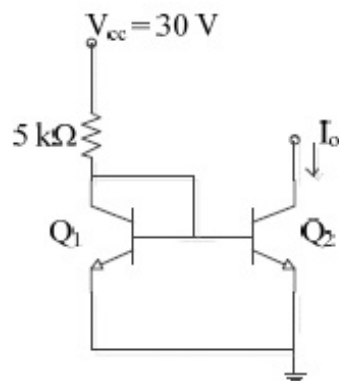
- (A) r^2 inside the solenoid and $\frac{1}{r}$ outside (B) r inside the solenoid and $\frac{1}{r^2}$ outside
 (C) r^2 inside the solenoid and $\frac{1}{r^2}$ outside (D) r inside the solenoid and $\frac{1}{r}$ outside

Options :

1. ✖ A
2. ✖ B
3. ✖ C
4. ✔ D

Question Number : 46 Question Type : NAT

In the simple current source shown in the figure, Q_1 and Q_2 are identical transistors with current gain $\beta = 100$ and $V_{BE} = 0.7 \text{ V}$



The current I_o (in mA) is _____ (upto two decimal places)

Correct Answer :

5.74 to 5.75

Question Number : 47 Question Type : MCQ

Match the phrases in Group I and Group II and identify the correct option.

Group I

- (P) Electron spin resonance (ESR)
 (Q) Nuclear magnetic resonance (NMR)
 (R) Transition between vibrational states of a molecule
 (S) Electronic transition

Group II

- (i) radio frequency
 (ii) visible range frequency
 (iii) microwave frequency
 (iv) far-infrared range

(A) (P-i), (Q-ii), (R-iii), (S-iv)

(B) (P-ii), (Q-i), (R-iv), (S-iii)

(C) (P-iii), (Q-iv), (R-i), (S-ii)

(D) (P-iii), (Q-i), (R-iv), (S-ii)

Options :

1. ✗ A
2. ✗ B
3. ✗ C
4. ✓ D

Question Number : 48 Question Type : MCQ

Consider the motion of the Sun with respect to the rotation of the Earth about its axis. If $\vec{F}_c$ and $\vec{F}_{Co}$ denote the centrifugal and the Coriolis forces, respectively, acting on the Sun, then

(A) $\vec{F}_c$ is radially outward and $\vec{F}_{Co} = \vec{F}_c$

(B) $\vec{F}_c$ is radially inward and $\vec{F}_{Co} = -2\vec{F}_c$

(C) $\vec{F}_c$ is radially outward and $\vec{F}_{Co} = -2\vec{F}_c$

(D) $\vec{F}_c$ is radially outward and $\vec{F}_{Co} = 2\vec{F}_c$

Options :

1. ✗ A
2. ✗ B
3. ✓ C
4. ✗ D

Question Number : 49 Question Type : NAT

In a rigid-rotator of mass M , if the energy of the first excited state is 1 meV , then the fourth excited state energy (in meV) is _____

Question Number : 50 Question Type : MCQ

A plane wave $(\hat{x} + i\hat{y})E_0 \exp[i(kz - \omega t)]$ after passing through an optical element emerges as $(\hat{x} - i\hat{y})E_0 \exp[i(kz - \omega t)]$, where k and ω are the wavevector and the angular frequency, respectively. The optical element is a

- (A) quarter wave plate (B) half wave plate
(C) polarizer (D) Faraday rotator

Options :

1. ✖ A
2. ✔ B
3. ✖ C
4. ✖ D

Question Number : 51 Question Type : MCQ

The Lagrangian for a particle of mass m at a position $\vec{r}$ moving with a velocity $\vec{v}$ is given by $L = \frac{m}{2} \vec{v}^2 + C \vec{r} \cdot \vec{v} - V(r)$, where $V(r)$ is a potential and C is a constant. If $\vec{p}_c$ is the canonical momentum, then its Hamiltonian is given by

- (A) $\frac{1}{2m} (\vec{p}_c + C \vec{r})^2 + V(r)$ (B) $\frac{1}{2m} (\vec{p}_c - C \vec{r})^2 + V(r)$
(C) $\frac{p_c^2}{2m} + V(r)$ (D) $\frac{1}{2m} p_c^2 + C^2 r^2 + V(r)$

Options :

1. ✖ A
2. ✔ B
3. ✖ C
4. ✖ D

Question Number : 52 Question Type : MCQ

The Hamiltonian for a system of two particles of masses m_1 and m_2 at $\vec{r}_1$ and $\vec{r}_2$ having velocities

$\vec{v}_1$ and $\vec{v}_2$ is given by $H = \frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2 + \frac{C}{(\vec{r}_1 - \vec{r}_2)^2} \hat{z} \cdot (\vec{r}_1 \times \vec{r}_2)$, where C is a constant. Which

one of the following statements is correct?

- (A) The total energy and total momentum are conserved
- (B) Only the total energy is conserved
- (C) The total energy and the z - component of the total angular momentum are conserved
- (D) The total energy and total angular momentum are conserved

Options :

- 1. ✖ A
- 2. ✖ B
- 3. ✔ C
- 4. ✖ D

Question Number : 53 Question Type : NAT

A particle of mass 0.01 kg falls freely in the earth's gravitational field with an initial velocity $v(0) = 10 \text{ ms}^{-1}$. If the air exerts a frictional force of the form, $f = -kv$, then for $k = 0.05 \text{ Nm}^{-1}\text{s}$, the velocity (in ms^{-1}) at time $t = 0.2 \text{ s}$ is _____ (upto two decimal places)

(use $g = 10 \text{ ms}^{-2}$ and $e = 2.72$)

Correct Answer :

4.93 to 4.98

Question Number : 54 Question Type : MCQ

In the nuclear shell model, the potential is modeled as $V(r) = \frac{1}{2}m\omega^2r^2 - \lambda \vec{L} \cdot \vec{S}$, $\lambda > 0$. The correct spin - parity and isospin assignments for the ground state of ^{13}C is

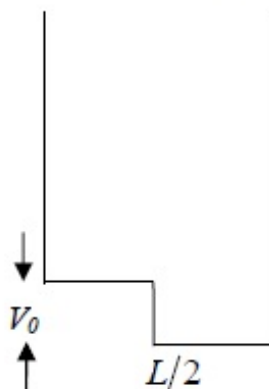
- | | |
|-----------------------------------|-----------------------------------|
| (A) $\frac{1}{2}^-; \frac{-1}{2}$ | (B) $\frac{1}{2}^+; \frac{-1}{2}$ |
| (C) $\frac{3}{2}^+; \frac{1}{2}$ | (D) $\frac{3}{2}^-; \frac{-1}{2}$ |

Options :

- 1. ✔ A

Question Number : 55 Question Type : MCQ

A particle is confined in a box of length L as shown below.



If the potential V_0 is treated as a perturbation, including the first order correction, the ground state energy is

(A) $E = \frac{\hbar^2 \pi^2}{2mL^2} + V_0$

(B) $E = \frac{\hbar^2 \pi^2}{2mL^2} - \frac{V_0}{2}$

(C) $E = \frac{\hbar^2 \pi^2}{2mL^2} + \frac{V_0}{4}$

(D) $E = \frac{\hbar^2 \pi^2}{2mL^2} + \frac{V_0}{2}$

Options :

1. ✖ A

2. ✖ B

3. ✖ C

4. ✔ D

Question Number : 56 Question Type : NAT

Suppose a linear harmonic oscillator of frequency ω and mass m is in the state

$$|\psi\rangle = \frac{1}{\sqrt{2}} \left[|\psi_0\rangle + e^{i\frac{\pi}{2}} |\psi_1\rangle \right] \text{ at } t=0 \text{ where } |\psi_0\rangle \text{ and } |\psi_1\rangle \text{ are the ground and the first excited states, respectively.}$$

The value of $\langle \psi | x | \psi \rangle$ in the units of $\sqrt{\frac{\hbar}{m\omega}}$ at $t=0$ is _____

Correct Answer :

0

Question Number : 57 Question Type : MCQ

A particle with rest mass M is at rest and decays into two particles of equal rest masses $\frac{3}{10}M$ which move along the z axis. Their velocities are given by

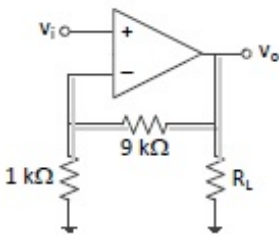
- (A) $\vec{v}_1 = \vec{v}_2 = (0.8c)\hat{z}$
- (B) $\vec{v}_1 = -\vec{v}_2 = (0.8c)\hat{z}$
- (C) $\vec{v}_1 = -\vec{v}_2 = (0.6c)\hat{z}$
- (D) $\vec{v}_1 = (0.6c)\hat{z}; \quad \vec{v}_2 = (-0.8c)\hat{z}$

Options :

1. ✖ A
2. ✔ B
3. ✖ C
4. ✖ D

Question Number : 58 Question Type : MCQ

In the given circuit, if the open loop gain $A = 10^5$, the feedback configuration and the closed loop gain A_f are



- (A) series-shunt, $A_f = 9$
- (B) series-series, $A_f = 10$
- (C) series-shunt, $A_f = 10$
- (D) shunt-shunt, $A_f = 10$

Options :

1. ✖ A
2. ✖ B
3. ✔ C
4. ✖ D

Question Number : 59 Question Type : MCQ

A function $y(z)$ satisfies the ordinary differential equation $y'' + \frac{1}{z}y' - \frac{m^2}{z^2}y = 0$, where $m = 0, 1, 2, 3, \dots$. Consider the four statements P, Q, R, S as given below.

- P: z^m and z^{-m} are linearly independent solutions for all values of m
- Q: z^m and z^{-m} are linearly independent solutions for all values of $m > 0$
- R: $\ln z$ and 1 are linearly independent solutions for $m = 0$
- S: z^m and $\ln z$ are linearly independent solutions for all values of m

The correct option for the combination of valid statements is

- (A) P, R and S only (B) P and R only (C) Q and R only (D) R and S only

Options :

- 1. ✖ A
- 2. ✖ B
- 3. ✔ C
- 4. ✖ D

Question Number : 60 Question Type : MCQ

The entropy of a gas containing N particles enclosed in a volume V is given by $S = Nk_B \ln \left(\frac{aVE^{3/2}}{N^{5/2}} \right)$, where E is the total energy, a is a constant and k_B is the Boltzmann constant. The chemical potential μ of the system at a temperature T is given by

- (A) $\mu = -k_B T \left[\ln \left(\frac{aVE^{3/2}}{N^{5/2}} \right) - \frac{5}{2} \right]$

(C) $\mu = -k_B T \left[\ln \left(\frac{aVE^{3/2}}{N^{3/2}} \right) - \frac{5}{2} \right]$
- (B) $\mu = -k_B T \left[\ln \left(\frac{aVE^{3/2}}{N^{5/2}} \right) - \frac{3}{2} \right]$

(D) $\mu = -k_B T \left[\ln \left(\frac{aVE^{3/2}}{N^{3/2}} \right) - \frac{3}{2} \right]$

Options :

- 1. ✔ A
- 2. ✖ B
- 3. ✖ C
- 4. ✖ D

Question Number : 61 Question Type : NAT

Let the Hamiltonian for two spin- $\frac{1}{2}$ particles of equal masses m , momenta $\vec{p}_1$ and $\vec{p}_2$ and

positions $\vec{r}_1$ and $\vec{r}_2$ be $H = \frac{1}{2m} p_1^2 + \frac{1}{2m} p_2^2 + \frac{1}{2} m \omega^2 (r_1^2 + r_2^2) + k \vec{\sigma}_1 \cdot \vec{\sigma}_2$,

where $\vec{\sigma}_1$ and $\vec{\sigma}_2$ denote the corresponding Pauli matrices, $\hbar \omega = 0.1 \text{ eV}$ and $k = 0.2 \text{ eV}$. If the ground state has net spin zero, then the energy (in eV) is _____

Correct Answer :

-0.3

Question Number : 62 Question Type : MCQ

The average energy U of a one dimensional quantum oscillator of frequency ω and in contact with a heat bath at temperature T is given by

(A) $U = \frac{1}{2} \hbar \omega \coth\left(\frac{1}{2} \beta \hbar \omega\right)$

(B) $U = \frac{1}{2} \hbar \omega \sinh\left(\frac{1}{2} \beta \hbar \omega\right)$

(C) $U = \frac{1}{2} \hbar \omega \tanh\left(\frac{1}{2} \beta \hbar \omega\right)$

(D) $U = \frac{1}{2} \hbar \omega \cosh\left(\frac{1}{2} \beta \hbar \omega\right)$

Options :

1. ✓ A

2. ✗ B

3. ✗ C

4. ✗ D

Question Number : 63 Question Type : NAT

A monochromatic plane wave (wavelength = 600 nm) $E_0 \exp[i(kz - \omega t)]$ is incident normally on a diffraction grating giving rise to a plane wave $E_1 \exp[i(\vec{k}_1 \cdot \vec{r} - \omega t)]$ in the first order of diffraction. Here $E_1 < E_0$ and $\vec{k}_1 = |\vec{k}_1| \left[\frac{1}{2} \hat{x} + \frac{\sqrt{3}}{2} \hat{z} \right]$. The period (in μm) of the diffraction grating is _____ (upto one decimal place)

Correct Answer :

1.2

Question Number : 64 Question Type : MCQ

The Heaviside function is defined as $H(t) = \begin{cases} +1 & \text{for } t > 0 \\ -1 & \text{for } t < 0 \end{cases}$ and its Fourier transform is given by

$-2i/\omega$. The Fourier transform of $\frac{1}{2}[H(t+1/2) - H(t-1/2)]$ is

(A) $\frac{\sin\left(\frac{\omega}{2}\right)}{\omega/2}$

(B) $\frac{\cos\left(\frac{\omega}{2}\right)}{\omega/2}$

(C) $\sin\left(\frac{\omega}{2}\right)$

(D) 0

Options :

1. ☒ A
2. ☐ B
3. ☐ C
4. ☐ D

Question Number : 65 Question Type : NAT

The atomic masses of $^{152}_{63}\text{Eu}$, $^{152}_{62}\text{Sm}$, ^1_1H and neutron are 151.921749, 151.919756, 1.007825 and 1.008665 in atomic mass units (*amu*), respectively. Using the above information, the *Q*-value of the reaction $^{152}_{63}\text{Eu} + n \rightarrow ^{152}_{62}\text{Sm} + p$ is _____ $\times 10^{-3}$ *amu* (upto three decimal places)

Correct Answer :

2.830 to 2.835