INDIAN ASSOCIATION OF PHYSICS TEACHERS

National Graduate Physics Examination 2012-13

Day and Date of Examination : Sunday, 20th January 2013

Time : 10 AM to 1 PM

Instructions to Candidates

1. In addition to this question paper, you are given **answer sheet for part A** and **answer paper for part B**.
2. On the answer sheet for part A, fill up all the entries carefully in the space provided, **Only in block capital. Do write the name and PIN of your city.**

   Incomplete / incorrect / carelessly filled information may disqualify your candidature
3. On part A answer sheet, use only BLUE or BLACK BALL PEN for making entries and marking answers.
4. In Part A each question has **FOUR** alternatives. Any number of these (4, 3, 2 or 1) may be correct. You have to mark **ALL** correct alternatives and mark a cross (⨯) for each, like

Q.No.	a	b	c	d
24		⨯		⨯

   Full marks are 6 for each question, you get them only when ALL correct answers are marked.
5. Part A answer sheet will be collected at the end of one hour.
6. Any rough work should be done only on the sheets provided with part B answer paper.
7. Use of non-programmable calculator is allowed.
8. No candidate should leave the examination hall before the completion of the examination. You will take away the question paper with you.

PLEASE DO NOT MAKE ANY MARK OTHER THAN (⨯) IN THE SPACE PROVIDED ON THE ANSWER SHEET OF PART A

Answer sheets for part A are likely to be evaluated with the help of a machine. Due to this, **CHANGE OF ENTRY IS NOT ALLOWED**

Scratching or overwriting may result in wrong score

DO NOT WRITE ANYTHING ON BACK SIDE OF ANSWER SHEET FOR PART A

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Part A - Maximum Marks : 150	Time for part A : 60 minutes
Part B - Maximum Marks : 150	Time for part B : 120 minutes

Part A

Mark the correct option / options (Any number of options may be correct).
Marks will be awarded only if all the correct options are marked. No negative marking.

Q1. The three vectors $\mathbf{L} = 3\mathbf{i} + 2\mathbf{j} + 5\mathbf{k}$, $\mathbf{B} = 7\mathbf{i} + 5\mathbf{j} + \alpha\mathbf{k}$ and $\mathbf{V} = 4\mathbf{i} + 2\mathbf{j} + 9\mathbf{k}$ are coplanar for the value of α =

(a) 8.5
(b) 10.5
(c) 12.5
(d) None

Q2. A planet is revolving in an elliptical orbit around the Sun which lies at one of the foci. If the eccentricity of the orbit be 'e', the ratio of the speed of the planet at the perihelion to that at the aphelion is

(a) $\frac{1+e}{1-e}$
(b) $\frac{1+e^2}{1-e^2}$
(c) $\frac{1-e}{1+e}$
(d) $\frac{1-e^2}{1+e^2}$

Q3. If the average distance between the Sun and the Earth is 1.5×10^{11} m and the power radiated by the Sun is 3.8×10^{26} watt then the average energy reaching Earth's surface is

(a) 2 cal/cm^2/minute
(b) 1400 cal/m^2/second
(c) 1400 watt/m^2
(d) 6.2×10^7 watt/m^2

Q4. According to Fresnel's theory of diffraction, when a plane wave front is divided into half period zones, then

(a) The area of each half period zone is almost equal
(b) The radii of successive circles are proportional to square root of natural numbers
(c) The width of annular space defining successive zones goes on decreasing
(d) The resultant intensity at any point is only ¼ of the intensity due to first half period zone.

Q5. Maxwell's equation $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$ is the statement of

(a) Gauss's law in electrostatics
(b) Equation of continuity
(c) Modified form of Ampere's law
(d) Faraday's law of electro-magnetic induction

Q6. Niel Bohr, in 1913, explained successfully the structure of hydrogen atom and hydrogen-like atoms on the basis of quantum theory and forwarded the concept of quantisation of

(a) Energy
(b) Momentum
(c) Angular momentum
(d) Radial & azimuthal components of angular momentum separately

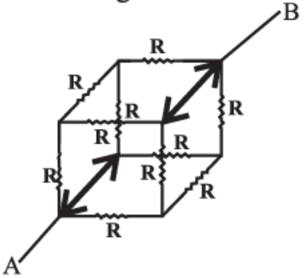
Q7. Ten identical resistances (each equal to R) are arranged along the edges of a cube whose two pairs of corners (shown by double arrow) are shorted. The electrical resistance across the diagonal AB is

(a) $\frac{5R}{6}$

(b) $\frac{3R}{4}$

(c) $\frac{7R}{12}$

(d) $\frac{R}{2}$



Q8. Some of the peculiar properties of liquid helium II are

(a) The density is maximum at λ point (T=2.19 K)

(b) Specific heat increases to very large value at λ point (T=2.19 K)

(c) It flows as an ideal liquid (viscosity tending to zero) at λ point (T=2.19 K)

(d) Under suitable conditions, it oozes out of a vertical capillary as a fountain.

Q9. Choose the correct option(s)

(a) Gravitational self energy of a uniform solid sphere of mass M and radius R is $U = -\frac{3}{5}\frac{GM^2}{R}$

(b) For a twisted solid rod the angle of shear is zero on the axis of the rod

(c) For a twisted solid rod the angle of shear is independent of its radius

(d) Total energy (KE+PE) of a satellite in its orbit is always negative

Q10. Which of the following reaction (s) is / are the example of a weak nuclear interaction.

(a) $\Lambda^{o} \rightarrow p^{+} + \pi^{-}$

(b) ${}_{0}n^{1} \rightarrow {}_{1}H^{1} + {}_{-1}\beta^{0} + \overline{\upsilon}$

(c) ${}_{2}He^{4} + {}_{4}Be^{9} \rightarrow {}_{6}C^{12} + {}_{0}n^{1}$

(d) ${}_{90}Th^{234} \rightarrow {}_{91}Pa^{234} + {}_{-1}\beta^{0} + \overline{\upsilon}$

Q11. A circuit containing a cell of 10 volt, a capacitor C = 0.1μF, an inductor L = 10 mH and a resistance R would be oscillatory when

(a) R = 200 kΩ

(b) R = 20 kΩ

(c) R = 20 Ω

(d) R = 200 Ω

Q12. The kinetic energy of a particle executing S H M is plotted against its displacement in the space. The two dimensional plot is

(a) A circle

(b) A parabola

(c) An ellipse

(d) A hyperbola

Q13. In a thermodynamical process, which of the following is / are integratable i,e a path independent function or a state function

(a) Amount of heat (dQ)

(b) Internal energy (dU)

(c) Enthalpy (dH)

(d) Entropy (dS)

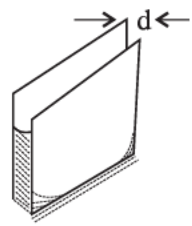
Q14 Two very wide parallel glass plates are held vertically in a water trough at a small separation d = 2R. Water rises up in the gap between the plates forming a curved meniscus. If P_0 is the atmospheric pressure and T is the surface tension of water, the pressure just below the curved liquid surface between the plates is

(a) $P = P_0 + \frac{2T}{R}$

(b) $P = P_0 + \frac{2T}{d}$

(c) $P = P_0 - \frac{2T}{R}$

(d) $P = P_0 - \frac{2T}{d}$



Q15. Pick up the correct Boolean identity/ identities for binary numbers / functions

(a) $\overline{A}.\overline{B}.\overline{C}=\overline{A+B+C}$

(b) $\overline{A}+\overline{B}+\overline{C}=\overline{A.B.C}$

(c) $\overline{A}+A=0$

(d) $\overline{A}.A=1$

Q16. Quantum mechanical operator for total energy is /are

(a) $-i\hbar\frac{\partial}{\partial t}$

(b) $-\frac{\hbar}{i}\frac{\partial}{\partial t}$

(c) $-\frac{\hbar^2}{2m}\frac{\partial^2}{\partial x^2}+V(x)$

(d) $-\frac{\hbar^2}{2m}\nabla^2+V(r)$

Q17. Which of the given expressions is / are correct relation(s) between the elastic coefficients of a material (symbols have their usual meaning):

(a) $YI_g\frac{d^2y}{dt^2}=mg\,(1-x)$

(b) $Y=3K(1-2\sigma)$

(c) $Y=\eta(2-2\sigma)$

(d) $\frac{1}{3K}+\frac{1}{\eta}=\frac{3}{Y}$

Q18. W C Sabine expressed the Time of Reverberation of a theatre in terms of its volume (V) and the total absorption ($A=\Sigma\mu dS$) of sound energy as

(a) 0.049VA

(b) $\frac{0.049V}{A}$

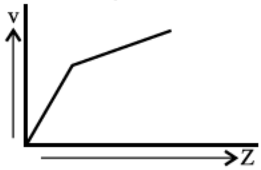
(c) $\frac{0.0161V}{A}$

(d) $\frac{24V}{cA}$ In 10

c is the speed of sound in air.

Q19. A small spherical ball of density ρ and radius r is dropped in a viscous liquid where it experiences a dragging force proportional to its velocity. The velocity of the ball against the distance fallen is best represented by the curve

(a)



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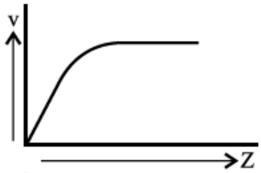

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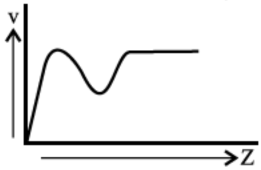
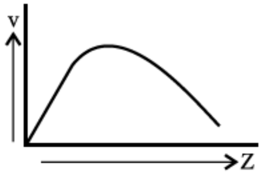


(d)



Q20. Let the distance between a ion and the nearest neighbour ion in the face centred cubic lattice of is 'p'. The distance between the Na^+ ion and the next nearest neighbour Cl^- ion is

(a) p 2

(b) p 3

(c) 2p

(d) None of these

Q21. A circle of area πR^2 is made to move parallel to one of its diameters with a speed of 0.8c. As a result of Lorentz transformations, the area is decreased by

(a) 20%

(b) 36%

(c) 40%

(d) 64%

Q22. A bowling ball is thrown down the alley in such a way that it slides without rolling. Because of friction, it later rolls without sliding. In this process, the force of friction

(a) initially acts opposite to the direction of motion and later in the direction of motion
(b) causes linear retardation
(c) causes angular acceleration
(d) stops acting when pure rolling begins

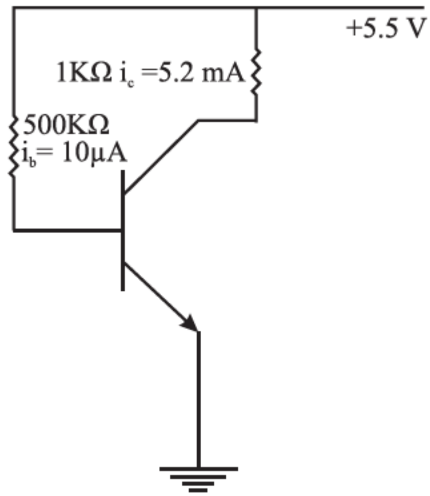
Q23. Which of the following is/are true regarding the principal quantum number n in the theory of hydrogen atom?

(a) It cannot be zero.
(b) It decides the total energy of n^{th} circular orbit
(c) It affects the total energy of n^{th} elliptical orbit
(d) The radius of n^{th} circular orbit is proportional to n^2.

Q24. Choose the correct statement (s).

(a) A linearly polarised light on passing through a $\frac{\lambda}{4}$ plate can never stay a linearly polarised light.
(b) A circularly polarised white light on passing through a $\frac{\lambda}{4}$ plate becomes plane polarised light.
(c) Circularly polarised monochromatic light after passing through $\frac{\lambda}{2}$ plate remains circularly polarised light.
(d) Given an elliptically polarised light, It can not be converted into a plane polarised light using a $\frac{\lambda}{4}$ plate alone

Q25. In the given circuit, the npn transistor is being used as



(a) An oscillator
(b) An amplifier
(c) In working mode
(d) In saturation mode

PART B-1 **(10 x 5 = 50)**

Answer all the following in brief (not more than 10 lines) with appropriate reasoning

B_1 Deep water runs calm. Explain.

B_2 The curl of a conservative force is always zero. Argue.

B_3 The speed of a transverse wave on a string stretched by a tension T is expressed as $v \propto \sqrt{\frac{T}{m}}$ Justify.

B_4 Scalar and vector potentials describe the concept of an electric field. Argue.

$B_{5.}$ No engine can be more efficient than a Carnot's engine working between same limits of temperature. Prove.

B_6 The two mirrors of a Michelson interferometer are set exactly perpendicular to each other and the rear surface of the slightly silvered glass plate bisects the angle between them. The interference fringes seen in the telescope are circular with the order increasing as their diameter decreases. Explain

B_7 The de Broglie wavelength of an electron moving with speed $\frac{c}{\sqrt{2}}$ is equal to its compton wavelength. Show.

B_8 In a two terminal network, the maximum power is transferred to the load when the load impedance is the complex conjugate of the internal impedance of the generator. Justify.

B_9 It is well known that the electric field **E** is a conservative field. Also the curl of a conservative field is zero but one of the Maxwell's equation of EM theory is $\nabla \times \mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}$. Resolve.

B_{10} Whether a load line is DC or AC. Explain. How can DC and AC load lines be constructed on to the output characteristics of an electronic device? Whether or not, an AC load line is steeper than a DC load line. Argue.

PART B-II (10 x 10 = 100)

Answer all the following in brief (not more than 10 lines) with appropriate reasoning

P1 A particle of mass m moves in a circle of radius R under the influence of a central attractive force $\mathbf{F} = -\frac{K}{r^2} e^{-\frac{r}{\alpha}}$

(a) Determine the condition on the constant α such that the circular motion be stable.

(b) Compute the frequency of small radial oscillations about the circular orbit.

P2 A solid homogenous circular cone of height h and semi vertical angle θ oscillates about a horizontal axis passing through its vertex and perpendicular to its symmetry axis. Write down the general equation of Simple Harmonic Motion for this system. Show that the length of an equivalent simple pendulum is

$L = \frac{1}{5} h\,(4 + \tan^2\theta)$

Find its time period when

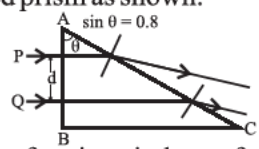
$h = 1.0$ m and $\theta = \frac{\pi}{6}$.

P3 A string 120 cm in length sustains a standing wave with points on the string, at which the displacement amplitude is equal to 3.5 mm, being separated by 15 cm. Find

(a) the maximum displacement amplitude

(b) which overtone do these oscillations of the string correspond to?

P4 Two parallel beams of light P and Q (distance d apart) both containing radiations of wavelengths 400 nm and 500 nm (each individually being mutually coherent) are incident normally on a right angled prism as shown.



The refractive index of the prism is expressed by Cauchy's formula

$\mu(\lambda) = a + \frac{b}{\lambda^2}$

Where a and b are positive constants. The value of b is such that the condition of total internal reflection is satisfied at the face AC for one wavelength and not for the other wavelength when a = 1.20. Find

(a) the value of b
(b) the deviation of the emergent beam
(c) the resultant intensity if a converging lens is used to bring the transmitted beams to focus. Given that the intensities of the beams on transmission through the prism are 4I and I respectively.

P5 A point charge +q is placed at a distance d from the centre of an earthed conducting sphere of radius R. Using the method of electrical images, obtain expressions for

(a) the strength of image charge and its location in the sphere.
(b) the electric field E at a general point on the surface of the conducting sphere.
(c) the surface charge density of induced charge on the sphere.
(d) force of electrostatic attraction between the sphere and the charge +q.

P6 (a) A Geiger Muller counter initially records 360 counts per second when placed 2.0 m away from a radioactive source of half life T = 15 minute. After 1.5 hour, in a new position, the counter records 30 counts per second. Estimate the new location of the counter relative to the source.

(b) A certain mass of Oxygen gas ($\gamma = 1.4$) suffers Joule-Kelvin expansion at 27°C. Calculate the change in temperature if the pressure difference on the two sides of the porous plug is ΔP = 150 atmosphere. Given that oxygen gas obeys equation $\left(P + \frac{a}{V^2}\right)(V - b) = RT$ with the constants

$$a = 1.32 \times 10^{-1} \frac{Nm^4}{mol^2} \ \& \ b = 3.12 \times 10^{-5} \frac{m^3}{mol}$$

P7 In the first betatron developed by D W Kerst at the University of Illinois in 1940 for electron acceleration, an electron was made to move in a circular orbit in the presence of a time varying magnetic field. What is the working principle of this machine? Obtain an expression for the electron momentum in terms of orbit radius and the magnetic field. How does the flux at the orbit change so as to keep electron accelerating? Do we receive the accelerated electron beam continuously from the machine? Estimate the energy and speed of accelerated electrons if the rate of change of flux at the orbit is 400 volt and the electrons revolve at 2×10^5 rev/sec before being ejected.

P8 H_α lines produced by hydrogen atom and deuterium atom are measured as λ_H = 6551.01 Å and λ_D = 6562.80 Å, respectively. Hundred years ago, how this information was used to estimate the ratio of deuterium mass to that of hydrogen atom? It is to be noted here that the mass of hydrogen atom is 1837 times the electron mass.

P9 Use one dimensional Schrodinger equation $-\frac{\hbar^2}{2m}\frac{\partial^2\psi}{\partial x^2} + V(x)\psi = E\psi$ to show that a particle of microscopic dimension confined in a finite potential well of depth V_0 defined by the limits $V(x) = 0$ for $-a \le x \le a$ in the well and $V(x) = V_0$ for $-a \ge x \ge a$ outside the well has two classes of solution which are complimentary to each other. Obtain energy eigen values in each case and show that the energy levels depend upon the well parameters V_0 and a.

P10 The mobility of electrons and holes in a sample of intrinsic germanium, at 300 K, is 0.39 and 0.19 $m^2 V^{-1} s^{-1}$, respectively. Compute the forbidden energy band gap of germanium if the conductivity (σ) of this sample is measured to be 2.32 $\Omega^{-1} m^{-1}$. Use $k_B = 1.38 \times 10^{-23}$ J/K & $e = 1.6 \times 10^{-19}$ C.