

## Entrance Examination, 2018

### HCU (M.Sc.) PHYSICS

**Marks: 100**

**Time: 2:00 Hours**

1. This Question Paper has two sections: **SECTION A** and **SECTION B**
  2. **SECTION A** consists of 25 objective type questions of two marks each. There is negative marking of 0.66 mark for every wrong answer. The marks obtained by the candidate in this section will be used for resolving the tie cases.
  3. **SECTION B** consists of 50 objective type questions of one mark each. There is no negative marking in this section.
  4. All questions carry 2 marks each.  
There is no negative marking
  5. Only Scientific Calculators are permitted. Mobile phone based calculators are not permitted. Logarithmic tables are not allowed.
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## SECTION - A

Q1. If  $z = x + iy$  the function of  $f(z) = \frac{1}{(1+z^*)}$  can be expressed in the form  $u(x, y) + iv(x, y)$  as

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

Q2. The matrix

$$M = \begin{pmatrix} 0 & 0 & 1 \\ 0 & -1 & 0 \\ 1 & 0 & 0 \end{pmatrix} \text{ is}$$

- (a) Hermitian but not unitary      (b) Unitary but not hermitian  
 (c) Unitary as well as hermitian      (d) Neither hermitian nor unitary

Q3. If curl of a vector field  $\vec{F}$  vanishes then  $\vec{F}$  can always be written as

- (a) gradient of a scalar potential      (b) curl of a vector potential  
 (c) divergence of a vector potential      (d) constant times a scalar potential

Q4. The tensile strength of a wire is given by

- (a) the ratio of the maximum load to which the wire is subjected to the original cross-sectional area of the wire.  
 (b) the ratio of the minimum load to which the wire is subjected to the original cross-sectional area of the wire.  
 (c) the strength of the wire up to which it obeys Hooke's law.  
 (d) the ratio of the residual strain in the wire to the original cross-sectional area of the wire.

Q5. For a liquid with density  $\rho$ , flowing horizontally, the pressure and velocity at one point  $P_1$  and  $v_1$  and at another point  $P_2$  and  $v_2$  respectively, are related by the following equation

- (a)  $\frac{P_1}{\rho} + \frac{v_1^2}{2} = \frac{P_2}{\rho} + \frac{v_2^2}{2}$       (b)  $\frac{P_1}{\rho} + \frac{v_1^2}{2} > \frac{P_2}{\rho} + \frac{v_2^2}{2}$   
 (c)  $\frac{P_1}{\rho} + \frac{v_1^2}{2} < \frac{P_2}{\rho} + \frac{v_2^2}{2}$       (d)  $\frac{P_1}{\rho} + \frac{v_1^2}{2} = -1 \left( \frac{P_2}{\rho} + \frac{v_2^2}{2} \right)$

- Q6. Consider a spherical soap bubble and spherical water drop which are identical in volume and have same surface tension. If  $P_b$  and  $P_d$  represent the excess pressure inside the soap bubble and water drop respectively, then the ratio  $\left(\frac{P_b}{P_d}\right)$  is equal to
- (a) 4                      (b) 2                      (c) 1                      (d) 0.5
- Q7. A simple harmonic oscillator has velocities  $v_1$  and  $v_2$  at positions  $x_1$  and  $x_2$  (from the equilibrium point) respectively. The frequency of the oscillator is given by
- (a)  $\frac{(v_1^2 + v_2^2)}{(x_1^2 + x_2^2)}$       (b)  $\frac{(v_1^2 + v_2^2)}{(x_1^2 - x_2^2)}$       (c)  $\frac{\sqrt{(v_1^2 - v_2^2)}}{\sqrt{(x_2^2 - x_1^2)}}$       (d)  $\frac{\sqrt{(v_1^2 - v_2^2)}}{\sqrt{(x_1^2 - x_2^2)}}$
- Q8. If a point object moves in a plane according to  $x = a \sin \omega t$  and  $y = a \sin 2\omega t$ , the trajectory equation of the object is given by
- (a)  $y(x) = \frac{2x(x^2 - a^2)}{a^2}$                       (b)  $y(x) = x\sqrt{1 - \frac{x^2}{a^2}}$   
(c)  $y(x) = \sqrt{1 - \frac{x^2}{a^2}}$                       (d)  $y(x) = 2x\sqrt{1 - \frac{x^2}{a^2}}$
- Q9. A cylinder with insulating wall contains  $N$  atoms of a perfect gas. The cylinder is permanently closed at one end and the other end is closed with a piston. The initial volume is  $V_1$  and the initial temperature is  $T_1$ . If the volume is suddenly increased to  $V_2$  by shifting the piston outward, then the change in internal energy is given by
- (a)  $dU = P(V_2 - V_1)$                       (b)  $dU = 0$   
(c)  $dU = R(T_2 - T_1)$                       (d)  $dU = P(V_2 - V_1)/T$
- Q10. When a gram-atomic weight of silver is heated at constant volume from  $0^\circ\text{C}$  to  $30^\circ\text{C}$ ,  $C_V = 5.85$  Cal/deg.mole, then change in entropy is
- (a) 0.92 Cal/K              (b) 0.54 Cal/K              (c) 0.61 Cal/K              (d) 0.32 Cal/K
- Q11. A microscope is focused on an object. A parallel sides glass plate of refractive index  $n$  and thickness  $d$  is inserted between the object and the microscope objective, and the microscope is now refocused. If  $x$  is the distance the microscope is moved in refocusing, then  $x$  is equal to
- (a)  $(1-n)d$               (b)  $(n-1)d$               (c)  $\left[1 - \frac{1}{nd}\right]$               (d)  $\left(1 - \frac{1}{n}\right)d$

Q12. A metal can be modelled by a system of free electrons of mass  $m$  and charge  $e$ . Assume that the resistivity of such a system arises only from the collision between electrons. If the electron density is  $n$  and mean free time between two collision is  $\tau$ , then according to Drude's theory the conductivity of the metal can be written as

- (a)  $\frac{ne^2T}{m^2}$       (b)  $\frac{n^2eT}{m}$       (c)  $\frac{neT^2}{m}$       (d)  $\frac{ne^2T}{m}$

Q13. The potential at a distance  $r$  from an electric dipole is proportional to

- (a)  $\frac{1}{r}$       (b)  $\frac{1}{r^2}$       (c)  $r^0$       (d)  $\frac{1}{r} - \frac{1}{r^2}$

Q14. The electric field at a point  $P(x, y, z)$  in space is given by

$$\vec{E}(x, y, z) = \frac{A}{\epsilon_0 L^3} (\hat{i}6x - \hat{j}2y + \hat{k}3z)$$

Where  $L$  is a length and  $K$  is constant. The charge density at the point  $P(x, y, z)$  is given by

- (a)  $\frac{7A}{L^3}$       (b)  $\frac{11A}{L^3}$       (c)  $\frac{2A}{L^3}$       (d)  $\frac{A}{L^3}$

Q15. Which of the following does not obey the super-position principle?

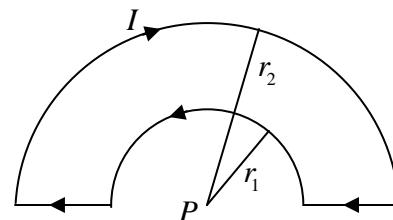
- (a) Electrostatic force      (b) Electric field  
(c) Electrostatic potential      (d) Electrostatic energy

Q16. A charged particle moves in a plane perpendicular to a magnetic field  $B$ . If it starts with some additional speed  $v$  parallel to  $B$ , the trajectory of the charged particle will be

- (a) circular      (b) elliptical      (c) parabolic      (d) helical

Q17. Consider the following steady current configuration where  $I$  is the current and  $r_1, r_2$  are the radii of the two concentric semicircles. The magnetic field at the point  $P$  is given by

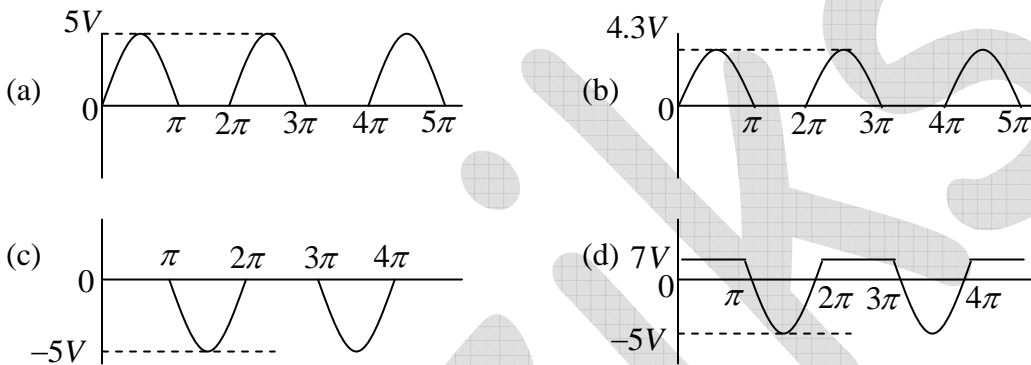
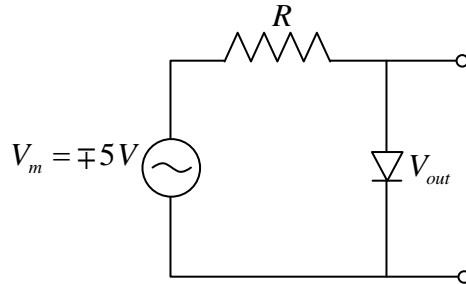
- (a)  $B = \frac{\mu_0 I}{4} \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$       (b)  $B = \frac{\mu_0 I}{8} \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$   
(c)  $B = \frac{\mu_0 I}{2} \left( \frac{1}{r_1} - \frac{1}{r_2} \right)$       (d)  $B = 0$



Q18. It is given that the average power dissipated by an  $A.C$  circuit is zero. The circuit contains

- (a) only pure resistive elements      (b) only pure reactive elements  
(c) both resistive and reactive elements      (d) nonlinear elements.

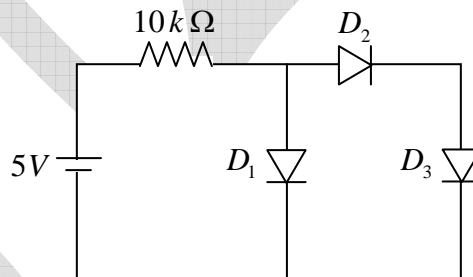
Q19. Which of the following wave does represent the Out-put voltage that is drawn across the practical silicon diode in the circuit?



Q20. Which of the following is a valid Boolean expression?

- (a)  $A + AB = A + B$     (b)  $A + \bar{A}B = A$     (c)  $A + AB = A$     (d)  $A + A\bar{B} = \bar{B}$

Q21. Which of the following statements is true for the partial silicon connected in the circuit shown in the figure below?



- (a)  $D_1$  is forward biased,  $D_2$  and  $D_3$  are reverse biased  
 (b)  $D_2$  and  $D_3$  are forward biased,  $D_1$  is reverse biased  
 (c)  $D_1$  is forward biased and either  $D_2$  or  $D_3$  is forward biased  
 (d) All three diodes ( $D_1$ ,  $D_2$  and  $D_3$ ) are forward biased

- Q22. The length of a spaceship is measured to be half its actual length by an observer. What is the speed of spaceship relative to the observer?
- (a)  $2.598 \times 10^8 \text{ m/s}$  (b)  $3.543 \times 10^8 \text{ m/s}$   
(c)  $5.234 \times 10^8 \text{ m/s}$  (d)  $7.823 \times 10^8 \text{ m/s}$
- Q23.  $\hat{A}$ ,  $\hat{B}$  and  $\hat{C}$  are Hermitian operators, where  $\hat{A}$  and  $\hat{B}$  do not have simultaneous eigen functions. Which of the following relation can be true?
- (a)  $\{\hat{A}, \hat{B}\} = \hat{C}$  (b)  $\{\hat{A}, \hat{B}\} = \hat{C}$  (c)  $\{\hat{A}, \hat{B}\} = 0$  (d)  $\{\hat{A}, \hat{B}\} = i\hat{C}$
- Q24. Consider a particle confined in a one-dimensional box of length  $L$ . The energy spacing between any two consecutive energy levels is proportional to
- (a)  $L^2$  (b)  $L$  (c)  $L^{-1}$  (d)  $L^{-2}$
- Q25. The specific heat of an ideal classical gas of  $N$  molecules at temperature  $T$  is equal to
- (a)  $Nk_B T$  (b)  $\frac{1}{2} Nk_B T$  (c)  $\frac{3}{2} Nk_B T$  (d)  $3Nk_B T$

## SECTION - B

- Q26. Given the three vectors  $\vec{A} = 3\hat{i} + 2\hat{j} - \hat{k}$ ,  $\vec{B} = 6\hat{i} + 4\hat{j} - 2\hat{k}$  and  $\vec{C} = \hat{i} - 2\hat{j} - \hat{k}$ , which of the following relations is true?
- (a)  $\vec{A} \parallel \vec{B}$  and  $\vec{B} \perp \vec{C}$  (b)  $\vec{A} \parallel \vec{C}$  and  $\vec{B} \perp \vec{C}$   
(c)  $\vec{B} \parallel \vec{C}$  and  $\vec{A} \perp \vec{B}$  (d)  $\vec{A} \parallel \vec{B}$  and  $\vec{B} \parallel \vec{C}$
- Q27.  $\lambda_1$  and  $\lambda_2$  are two eigenvalues of the matrix

$$M = \begin{pmatrix} p & r \\ s & p \end{pmatrix}.$$

Then the value of  $(\lambda_1 - \lambda_2)^2$  will be

- (a)  $p^2 - rs$  (b)  $4p^2 - rs$  (c)  $4rs$  (d)  $4(p^2 - rs)$
- Q28. The sum
- $$\sum_{n=1}^{\infty} \frac{1}{(2n-1)(2n+1)}$$
- is equal to
- (a) 1 (b)  $\frac{1}{2}$  (c)  $\frac{1}{4}$  (d)  $\frac{1}{8}$

Q29. If  $n$  is greater than 1, then

$$\frac{1}{n} - \ln\left(\frac{n}{n-1}\right)$$

is

- (a) greater than 1 (b) greater than 0 but less than 1  
(c) less than 1 (d) equal to 1

Q30. The sum of the series

$$1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \frac{1}{9} - \frac{1}{11} + \dots$$

is equal to

- (a)  $\frac{\pi}{2}$  (b)  $\frac{\pi}{4}$  (c)  $\pi$  (d)  $\frac{100}{101}$

Q31. Which of the following can be the square of  $i(\sqrt{-1})$ ?

- (a)  $(1+i), -(1-i)$  (b)  $\frac{1}{\sqrt{2}}(1+i), -\frac{1}{\sqrt{2}}(1-i)$   
(c)  $\frac{1}{\sqrt{2}}(1+i), \frac{1}{\sqrt{2}}(1-i)$  (d)  $\frac{1}{\sqrt{2}}(1+i), (1-i)$

Q32. What is the angular momentum of the electron in a hydrogen atom about its nucleus? It is given that the mass of electron is  $9.11 \times 10^{-31} \text{ kg}$  and the radius of electron orbit is  $0.58 \times 10^{-10} \text{ m}$

- (a)  $2.28 \times 10^{-34} \text{ kgm}^2 \text{ s}^{-1}$  (b)  $1.06 \times 10^{-34} \text{ kgm}^2 \text{ s}^{-1}$   
(c)  $4.43 \times 10^{-32} \text{ kgm}^2 \text{ s}^{-1}$  (d)  $6.28 \times 10^{-32} \text{ kgm}^2 \text{ s}^{-1}$

Q33. Two blocks of masses  $m_1 = 1.3 \text{ kg}$  and  $m_2 = 2.8 \text{ kg}$  are connected by a cord of negligible mass over a frictionless pulley. The magnitude of the block acceleration and the tension in the cord are given by

- (a)  $5.2 \text{ m/s}^2$  and  $16 \text{ N}$  (b)  $3.6 \text{ m/s}^2$  and  $17 \text{ N}$   
(c)  $5.2 \text{ m/s}^2$  and  $10 \text{ N}$  (d)  $5.2 \text{ m/s}^2$  and  $12 \text{ N}$

Q34. Two gravitationally bound stars with equal masses  $m$ , separated by a distance  $d$ , revolve about their centre of mass in circular orbits. The period of their motion is proportional to

- (a)  $\left(\frac{d^3}{m}\right)^{1/2}$  (b)  $\left(\frac{d^3}{m^2}\right)^{1/2}$  (c)  $\left(\frac{d^2}{m^{3/2}}\right)^{1/3}$  (d)  $\left(\frac{d}{m}\right)^{3/2}$

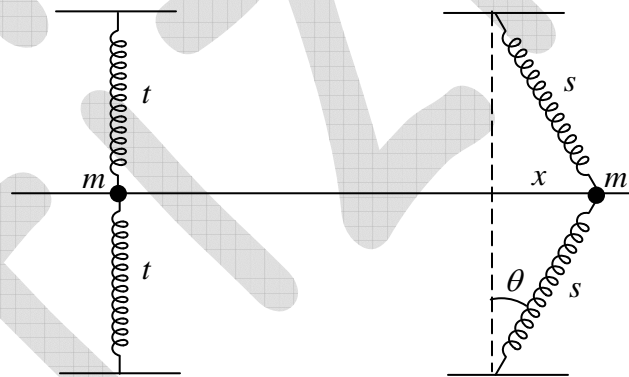
Q35. Consider a particle of mass  $m$  whose motion starts from rest in a constant gravitational field. If a resisting force equal to  $kmv^2$  where  $v$  is the velocity of the particle and  $k$  is a constant, is encountered by the particle, then what is the distance the particle falls in accelerating from velocity  $v_0$  to  $v_1$ ?

- (a)  $k \ln \left[ \frac{g - kv_0^2}{g - kv_1^2} \right]$                       (b)  $\frac{1}{k} \ln \left[ \frac{g - kv_0^2}{g - kv_1^2} \right]$   
 (c)  $\frac{1}{2k} \ln \left[ \frac{g - kv_0^2}{g - kv_1^2} \right]$                       (d)  $\frac{2}{k} \ln \left[ \frac{g - kv_0^2}{g - kv_1^2} \right]$

Q36. The speed of a particle of mass  $m$  varies with the distance  $x$  as  $v(x) = ax^{-n}$ . Assume  $v(x=0) = 0$  at  $t = 0$ . The force  $F(t)$  responsible is proportional to

- (a)  $t^{-(2n+1)/(n+1)}$                       (b)  $t^{-(n+1)/(2n+1)}$                       (c)  $t^{-(2n+1)/(n+2)}$                       (d)  $t^{-(n+2)/(2n+1)}$

Q37. Consider a particle of mass  $m$  suspended between two identical springs. The mass  $m$  is displaced towards right by distance  $x$  (much smaller than  $l$ ) as shown in figure and then left to oscillate. In leading order, the acceleration of the mass is proportional to



(a) Equilibrium position                      (b) Extended position

- (a)  $-x$                       (b)  $-x^2$                       (c)  $-x^3$                       (d)  $-e^{-x}$

Q38. The motion of the cyclonic wind is

- (a) anticlock wise in both northern and southern hemispheres  
 (b) clock-wise in both northern and southern hemispheres  
 (c) clock-wise in northern hemisphere and anticlock-wise in southern hemisphere.  
 (d) anticlock-wise in northern hemisphere and clock-wise in southern hemisphere.



- Q39. What is the dimension of viscosity ( $\eta$ ) ?  
(a)  $M^{-1}L^{-1}T^{-1}$       (b)  $M^{-1}L^{-1}T$       (c)  $ML^{-1}T^{-1}$       (d)  $MLT^{-1}$
- Q40. A rod is subjected to uniaxial load within linear elastic limit. When the change in the stress is 300 Mps, the change in the strain is 0.001. If the Poisson ratio of the rod is 0.5, the modulus of rigidity in (GPa) is  
(a) 0.1GPa      (b) 1.0GPa      (c) 10.0GPa      (d) 100.0GPa
- Q41. Strain due to two equal tensile stresses will be zero only if the value of Poisson ratio is  
(a) less than 1      (b) greater than 1      (c) equal to 1      (d) equal to  $-1$
- Q42. In an acoustic resonance experiment, if the distance between the adjacent positions of the piston at which resonance is observed at a frequency 2000 Hz is equal to 8.5 cm, the velocity of sound is  
(a) 3.4 km/s      (b) 0.34 km/s      (c) 34.0 cm/s      (d) 0.34 cm/s
- Q43. Consider a sonometer wire made by soldering two wires of radii  $r$  and  $2r$  and kept under tension  $T$ . Stationary vibrations are setup in the wire such that the soldered joint is midway between the two bridges and is a node. The ratio of the number of loops formed in the wires is  
(a) 1      (b) 2      (c)  $\frac{1}{2}$       (d)  $\frac{1}{4}$
- Q44. Consider that a source of sound vibrations with frequency 1700 Hz and a receiver are located on the same normal to the wall. With both the source and the receiver stationary, the wall recedes from the source with velocity 6.0 m/s. If the velocity of sound is 340 m/s, the best frequency measured by the receiver will be  
(a) 0.6 Hz      (b) 6.0 Hz      (c)  $\frac{1}{6}$  Hz      (d) 1.6 Hz
- Q45. An electromagnetic wave of frequency 3 MHz passes from vacuum into a dielectric medium with permittivity = 4.0. The change in wave length is  
(a) 100 m      (b) 0 m      (c) +50 m      (d) -50 m

Q46. A simple harmonic oscillator of mass  $m$  and frequency  $\omega_0$  is initially described by the equation:

$$\ddot{x} + \omega_0^2 x = 0.$$

A forcing force  $mf_0 e^{i\omega t}$  is now applied to drive the oscillator. The particular solution for  $x$  can in general be written as

(a)  $\frac{f_0 e^{i\omega t}}{(\omega_0^2 + \omega^2)}$       (b)  $\frac{f_0 e^{i\omega t}}{(\omega_0^2 + i\omega^2)}$       (c)  $\frac{f_0 e^{i\omega t}}{(\omega_0 + i\omega)^2}$       (d)  $\frac{f_0 e^{i\omega t}}{(\omega_0^2 - \omega^2)}$

Q47. The electron in an excited atom behaves like a damped harmonic oscillator when the atom radiates light. The lifetime of an excited atomic state is  $10^{-8} s$  and the wavelength of the emitted light is  $500 nm$ . The quality factor is given by

(a)  $4 \times 10^7$       (b)  $4 \times 10^9$       (c)  $4 \times 10^5$       (d)  $4 \times 10^3$

Q48. Consider that idealized Sun and Earth both are black bodies. The Sun's surface temperature  $T_s$  is  $6000 K$ . The radius of the earth is  $6 \times 10^8 cm$  and the radius of the Sun is  $7 \times 10^{10} cm$ . Distance to Sun from earth is  $1AU = 1.5 \times 10^{13} cm$ . Assume that heat transfer by ocean and atmosphere on earth is so efficient as to keep earth's surface at uniform temperature. What is the temperature of earth?

(a)  $12^\circ C$       (b)  $17^\circ C$       (c)  $20^\circ C$       (d)  $15^\circ C$

Q49. A pin-hole camera forms an image of a distant object on a screen at a distance  $d$  from the pin-hole. If  $R$  is the pin-hole radius and  $\lambda$  is the wavelength of light the value of  $R$  that gives the sharpest image is

(a)  $\sqrt{0.61\lambda d}$       (b)  $0.61\lambda d$       (c)  $\sqrt{\lambda d / 0.61}$       (d)  $0.61 / \lambda d$

Q50. A plane wave of  $500 nm$  wavelength is incident normally on a mask containing a  $1 mm$  diameter hole. The farthest distance from the mask at which one can observe a diffraction pattern with zero intensity at the center is

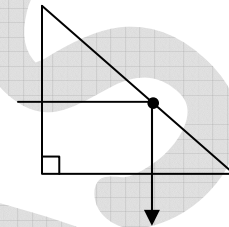
(a)  $25 mm$       (b)  $500 mm$       (c)  $250 mm$       (d)  $50 mm$

Q51. A lens corrected for spherical aberration is used to image a distant axial point source of wavelength  $\lambda$ . The lens has diameter  $d$  and length  $f$ . How close to the focal point, on the axis, will it be possible to detect that the image is out of focus?

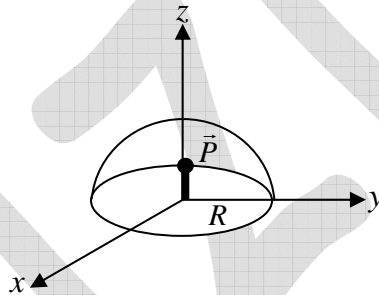
- (a)  $2\lambda\left(\frac{f^2}{d^2}\right)$       (b)  $2\lambda\left(\frac{f}{d}\right)$       (c)  $\frac{\lambda}{2}$       (d)  $\frac{\lambda}{2}\left(\frac{d^2}{f^2}\right)$

Q52. Consider a right-angle triangle prism ( $45^\circ - 45^\circ - 90^\circ$ ) made of  $MgF_2$  of refractive index 1.38. A right circular polarized light beam incident on the hypotenuse and reflected by  $90^\circ$  via total internal reflection (as shown) becomes

- (a) linearly polarized parallel to the plane of incidence  
 (b) right circularly polarized  
 (c) left circularly polarized  
 (d) linearly polarized perpendicular to the plane of incidence



Q53. A electric dipole  $\vec{p}$  is kept at the origin of the upper hemisphere of radius  $R$  as shown in the figure



The electric flux through the surface of the upper hemisphere is given by

- (a)  $\frac{p}{2\epsilon_0 R}$       (b)  $\frac{p}{\epsilon_0 R}$       (c)  $\frac{p}{4\pi\epsilon_0 R}$       (d)  $\frac{3p}{4\pi\epsilon_0 R}$

Q54. Consider a capacitor consisting of two coaxial cylinders of height  $h$  and radii  $r_1$  and  $r_2$ . The capacitance of this capacitor is proportional to

- (a)  $h \ln\left(\frac{r_2}{r_1}\right)$       (b)  $\frac{1}{h} \ln\left(\frac{r_2}{r_1}\right)$       (c)  $\frac{h}{\ln\left(\frac{r_1}{r_2}\right)}$       (d)  $\frac{h}{\ln\left(\frac{r_2}{r_1}\right)}$

Q55. Consider a parallel plate capacitor with circular plates each of radius  $r$ . The separation between the plates is  $d$  ( $r \gg d$ ). The capacitor is charged to a potential  $V$  and then disconnected from the charging circuit. The separation of the plates is now slowly changed from  $d$  to  $d'$ . The work done in this process is proportional to

- (a)  $\frac{r^2(d'-d)V^2}{d^2}$                       (b)  $\frac{r(d'-d)V^2}{d^2}$   
 (c)  $\frac{r(d'-d)V^2}{d}$                       (d)  $\frac{r^2dV^2}{(d'-d)^2}$

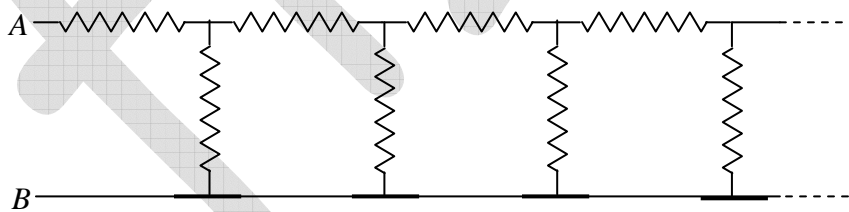
Q56. Consider a uniformly charged circular ring of radius  $a$ . The electric field at a point on the axis of the ring at a distance  $x$  from the centre of the ring is proportional to

- (a)  $\frac{x}{(a^2+x^2)^{3/2}}$               (b)  $\frac{x^4}{(a^2+x^2)^3}$               (c)  $\frac{x^2}{(a^2+x^2)^2}$               (d)  $\frac{1}{(a^3+x^3)^{2/3}}$

Q57. An air spaced coaxial cable has an inner conductor  $0.5\text{ cm}$  in diameter and an outer conductor  $1.5\text{ cm}$  in diameter. The inner conductor is at a potential  $8000\text{ V}$  with respect to the grounded outer conductor. What is the electric field at  $r = 1\text{ cm}$ ?

- (a)  $8000\text{ V/m}$               (b)  $4000\text{ V/cm}$               (c)  $0\text{ V/m}$               (d)  $5333.333\text{ V/m}$

Q58. In the following circuit each resistor is of resistance  $1\text{ ohm}$ . What is the net resistance between  $A$  and  $B$  if the chain is infinite length?



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

Q59. Consider an infinitely long and straight conductor carrying a current  $I$ . What is the magnetic field produced by this current at a point which is a distance  $R$  from the conductor?

- (a)  $\frac{4I}{cR}$                       (b)  $\frac{2I}{cR}$                       (c)  $\frac{cI}{2R}$                       (d)  $\frac{2I}{c^2R}$

Q60. A uniform magnetic field  $B$  has been applied in the  $z$  direction. Which of the following vector can describe the vector potential?

- (a)  $\left(-\frac{1}{2}yB, xB, 0\right)$  (b)  $(-yB, xB, 0)$   
 (c)  $\left(-\frac{1}{2}xB, \frac{1}{2}yB, 0\right)$  (d)  $(0, xB, 0)$

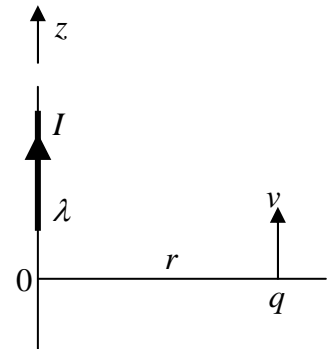
Q61. Which of the following is the correct boundary condition in magnetostatics at a boundary between two different media?

- (a) The tangential component of  $B$  is continuous  
 (b) The normal component of  $B$  is continuous  
 (c) The normal component of  $H$  is continuous  
 (d) None of the above

Q62. A very long straight solenoid of  $n$  turns per unit length carries a current  $i$  which increases uniformly with time  $i = kt$  where  $k$  is a constant. What is the magnitude of the magnetic field inside the solenoid at time  $t$ ?

- (a)  $\mu_0 nkt$  (b)  $\mu_0 n^2 kt$  (c)  $\mu_0 nkt^2$  (d)  $\mu_0 (\ln n) kt$

Q63. A particle with charge  $q$  is travelling with velocity  $v$  parallel to a wire with a uniform charge distribution  $\lambda$  per unit length. The wire also carries a current  $I$  shown in figure below. What must the velocity be for the particle to travel in a straight line parallel to the wire, a distance  $r$  away?



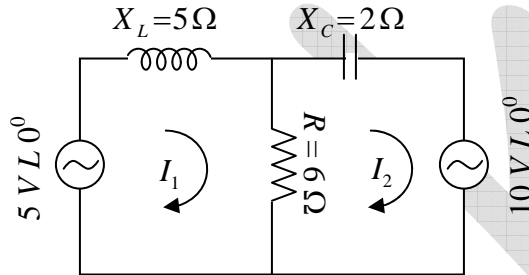
- (a)  $\frac{\lambda c I}{qv}$  (b)  $\frac{\lambda c^2}{I}$   
 (c)  $\frac{\lambda c^2}{qI}$  (d)  $\frac{\lambda c^2}{vI}$

Q64. Which of the following is a correct and simplest expression for the Boolean function ( $Y$ ) described by the Karnaugh map?

	$\bar{B}\bar{C}$	$\bar{B}C$	$BC$	$B\bar{C}$
$\bar{A}$	1			1
$A$	1		X	X

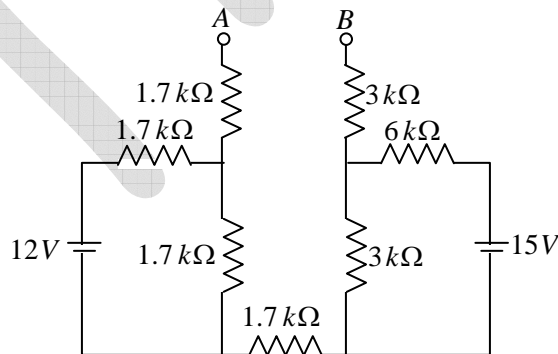
- (a)  $Y = C$                       (b)  $Y = \bar{C}$                       (c)  $Y = \bar{C} + AB$                       (d)  $Y = \bar{B}\bar{C} + \bar{A}\bar{C}$

Q65. Which of the following pair of equations is correct for the circuit shown in figure?



- (a)  $11I_1 - 6I_2 = 5; 6I_1 - 8I_2 = 10$   
 (b)  $(6 + 5j)I_1 - 6I_2 = 5; 6I_1 - (6 - 2j)I_2 = 10$   
 (c)  $(6 + 5j)I_1 - 6I_2 = 5; 6I_1 - (6 + 2j)I_2 = 10$   
 (d)  $I_1 - 6I_2 = 5; 6I_1 - 4I_2 = 10$

Q66. The voltage ( $V_{AB}$ ) across the terminals  $A$  and  $B$  in the circuit is equal to



- (a)  $-3.5V$                       (b)  $1.5V$                       (c)  $-3V$                       (d)  $3.5V$

- Q67. In a common emitter transistor circuit, the collector resistance ( $R_c$ ) is  $4\text{ k}\Omega$ , emitter resistance ( $R_E$ ) is zero,  $\beta$  of the transistor is 100 and the biasing voltage ( $V_{CC}$ ) is  $10\text{ V}$ . What is the collector current ( $I_C$ ). If the base current ( $I_B$ ) is  $50\text{ }\mu\text{A}$
- (a)  $5\text{ mA}$                       (b)  $20\text{ mA}$                       (c)  $100\text{ mA}$                       (d)  $2\text{ mA}$
- Q68. The relativistic momentum of a neutron (rest mass energy  $m_0c^2 = 940\text{ MeV}$ ), whose kinetic energy ( $K$ ) =  $200\text{ MeV}$  is given by
- (a)  $1050\text{ MeV}/c$                       (b)  $750\text{ MeV}/c$   
(c)  $645\text{ MeV}/c$                       (d)  $350\text{ MeV}/c$
- Q69. The diameter of Bohr's first orbit is  $1.058\text{ \AA}$ . The de Broglie wavelength of electrons in this orbit is
- (a)  $0.53\text{ \AA}$                       (b)  $1.058\text{ \AA}$                       (c)  $0.4\text{ \AA}$                       (d)  $3.33\text{ \AA}$
- Q70. The distance of closest approach of a  $5.30\text{ MeV}$   $\alpha$ -particle to a  $\text{Cu}$  ( $Z = 29$ ) nucleus in a head on collision is
- (a)  $1.57 \times 10^{-14}\text{ m}$                       (b)  $1.02 \times 10^{-14}\text{ m}$   
(c)  $2.3 \times 10^{-14}\text{ m}$                       (d)  $5.1 \times 10^{-14}\text{ m}$
- Q71. A  $\gamma$ -ray beam from  $\text{Cs}^{137}$  sample with wavelength  $0.0188\text{ \AA}$  is scattered by a free electron. If the  $\gamma$ -ray is scattered at  $90^\circ$  with respect to the incident direction, the kinetic energy of the recoiling electron is given by
- (a)  $378\text{ KeV}$                       (b)  $0.295\text{ KeV}$                       (c)  $0$                       (d)  $0.511\text{ MeV}$
- Q72. The commutator of  $[p_x, f(x)]$  is equal to
- (a)  $i\hbar$                       (b)  $-i\hbar \frac{\partial f(x)}{\partial x}$                       (c)  $i\hbar \frac{\partial f(x)}{\partial x}$                       (d)  $i\hbar f(x)$

Q73. The value of the flux density for a wave function of the form

$$\psi(x) = Ae^{ikx} + Be^{-ikx} \text{ is}$$

(a)  $\frac{\hbar k}{m}(|A|^2 - |B|^2)$

(b)  $\frac{\hbar}{m}(|A|^2 + |B|^2)$

(c)  $\frac{\hbar k}{m}(|A|^2 + |B|^2)$

(d)  $\frac{\hbar}{2m}(A^*B - B^*A)$

Q74. The ground state wave function of a particle in a three-dimensional potential is given by

$$\psi(r) = Ae^{-\alpha r^3}, \text{ where } A \text{ is the normalization constant. The value of } A \text{ is given by}$$

(a)  $\left(\frac{\alpha}{2\pi}\right)^{3/4}$

(b)  $\left(\frac{2\alpha}{\pi}\right)^{1/2}$

(c)  $\left(\frac{\alpha}{\pi}\right)^{3/4}$

(d)  $\left(\frac{\alpha}{2\pi}\right)^{3/2}$

Q75. The uncertainty product  $\Delta x \Delta p_x$  for a one-dimensional simple harmonic oscillator is

(a) equal to  $\hbar$

(b) greater than  $\hbar/2$

(c) less than  $\hbar/2$

(d) equal to  $\hbar/2$