[This question paper contains 10 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2262A **IC**

Unique Paper Code : 32221201

Name of the Paper : Electricity and Magnetism

Name of the Course : **B.Sc. (Hons.) Physics**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

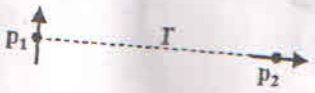
1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Question No. **1** with all its parts is compulsory.
3. Attempt any **four** questions from the remaining questions.
4. Each of the question nos. **2** to **7**, carries **14** marks.
5. Out of the **three** parts of question Nos. **2–7**, attempt any **two** parts.

1. (a) A constant electric field $\vec{E}$ passes through the surface of an open hemisphere, perpendicular to its base. Calculate the flux through the curved surface. (3)

P.T.O.

(b) Find the force per unit area on the surface of a charged conductor. (3)

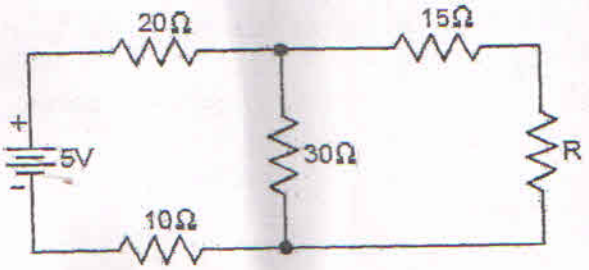
(c) Consider $\vec{p}_1$ and $\vec{p}_2$ are perfect dipoles a distance r apart as shown in figure given below. What is the torque on $\vec{p}_1$ due to $\vec{p}_2$? (3)



(d) A sphere of radius R carries a polarization $\vec{P}=k\vec{r}$ where k is a constant and $\vec{r}$ is the radial vector from the center. Find bound charge densities σ_b and ρ_b. (3)

(e) Suppose a uniform magnetic field in some region has the form $\vec{B}=B\hat{i}$. Find the force on a circular loop of radius a, lying in the yz plane, centered at the origin, which carries a current I in clockwise direction, when you look down the x-axis. (3)

(f) Determine Thevenin's equivalent circuit for the given network external to load resistance R. (3)



(g) What is displacement current? (1)

2. (a) State and prove first uniqueness theorem. Also derive Poisson's equation. (7)

(b) The electric field in a cubical region ($0 \le x, y, z \le a$) of space is given by the following expression:

$$\vec{E} = k\left[y^2\hat{i} + \left(2xy + z^2\right)\hat{j} + 2yz\hat{k}\right]$$

(i) Verify that this expression represents an electrostatic field or not.

(ii) Find charge density and

(iii) Total charge that gives rise to this electric field. (7)

(c) A hollow spherical shell inner radius a and outer radius b carries charge density $\rho = \frac{k}{r^2}$ in the region

$a \leq r \leq b$. Find the electric field in the three regions :

(i) $r < a$

(ii) $a < r < b$

(iii) $r > b$ (7)

3. (a) Evaluate the electrostatic energy of sphere of radius R and having uniform distribution of total charge Q for the following configuration

(i) Non-conducting sphere

(ii) Conducting sphere

Show that their ratio is 6/5. (7)

(b) There are two cavities of spherical shapes inside spherical conductor of radius R. The charges q_1 and q_2 are placed inside at the centers of each cavity. Then

(i) Find the surface charge densities σ_1, σ_2 and σ_R.

(ii) Find the electric field in each cavity.

(iii) What is the force on q_1 and q_2? (7)

(c) A point charge q is placed at a distance d from the centre of a grounded conducting sphere of radius a. Using the method of images, find

(i) The potential outside the sphere.

(ii) The magnitude and direction of the force acting on q. (7)

4. (a) Show that the potential due to a polarized dielectric material is given by

$$V = \frac{1}{4\pi\varepsilon_0}\left(\oint\!\!\!\oint_S \frac{\sigma_b}{r} dS + \iiint_\tau \frac{\rho_b}{r} d\tau\right)$$

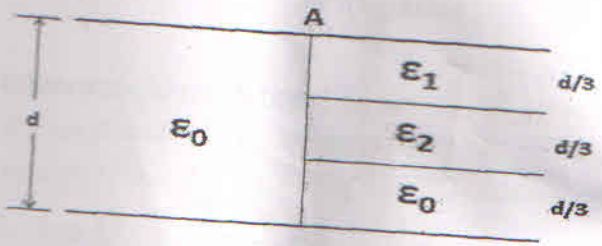
where σ_b and ρ_b are bound surface charge density and bound volume charge density respectively. Also, show that the net charge in a polarized dielectric material is zero. (7)

(b) A spherical conductor of radius a carries a charge Q and it is surrounded, out to radius b, by linear dielectric material of permittivity ε. Find the potential at the center (relative to infinity) and polarization vector $\vec{P}$. (7)

(c) Calculate the capacitance for the configuration given below, where A is the cross-sectional area

of the square metallic parallel plates separated by total distance d. One half of the volume within the plates is free space with permittivity ε_0, while the other half is filled with equal slabs of different dielectrics with permittivities ε_1, ε_2, and ε_0.

(7)



5. (a) Starting from Biot-Savart law, show that $\vec{\nabla}.\vec{B}=0$ and explain its physical significance. Hence prove that the magnetic flux through any closed surface is zero.

(7)

(b) Two long coaxial solenoids each carrying current I in the same direction having number of turns per unit length n_1 (inner solenoid) and n_2 (outer solenoid). The radii of the inner and outer solenoids are a and b respectively. Find the magnetic field in the following regions with r being the radial distance from the axis :

(i) $r < a$

(ii) $a < r < b$

(iii) $r > b$ (7)

(c) Determine the magnetic field due to a long current carrying straight wire at a distance r from it. Consider two long parallel conducting wires 1 and 2 carrying currents I in same direction. One wire is placed at $x = +a$ and another at $x = -a$. Determine the magnetic field for the point $x > a$ on positive x-axis. (7)

6. (a) Show that for a system of two coils C_1 and C_2, the mutual inductance is given by

$$M = \frac{\mu_0}{4\pi} \oint_{C_1} \oint_{C_2} \frac{\overrightarrow{dl_1} . \overrightarrow{dl_2}}{r}$$

where $\overrightarrow{dl_1}$ and $\overrightarrow{dl_2}$ are the elements of coils C_1 and C_2 respectively and r is the distance between them. (7)

(b) Let the internal dimensions of a coaxial cylindrical capacitor be $a = 1.2$ cm, $b = 4$ cm, and $L = 40$ cm.

The homogeneous material inside the capacitor has the parameters $\epsilon = 10^{-11}$ F/m and $\sigma = 10^{-5}$ S/m. If this capacitor is connected to the source $V_s = V_0 \sin(\omega t)$ and the electric field inside this capacitor is

$$\vec{E}(r) = \frac{V_S \hat{r}}{r \ln(b/a)}$$

find

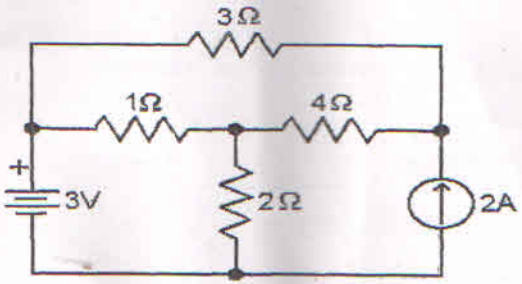
(i) The displacement current density, $\vec{J}_D$ and displacement current I_D

(ii) the conduction current density, $\vec{J}_C$ and conduction current I_c

$$\left[C = \frac{2\pi \epsilon L}{\ln(b/a)} \text{ Farad} \right] \quad (7)$$

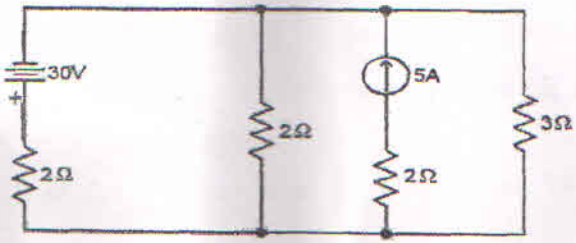
(c) Given $\vec{E} = E_o \sin(\omega t - kz)\hat{y}$ V/m in free space. Find $\vec{D}$, $\vec{B}$ and $\vec{H}$. (7)

7. (a) Use Mesh-Analysis to find the voltage across 1Ω resistance



(7)

(b) Obtain Norton equivalent circuit for the network external to the 3Ω resistance for the given network. Further determine the current through 3Ω resistor.



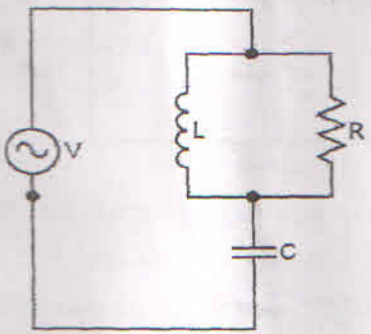
(7)

(c) A resistor 50Ω which is connected in parallel with an inductor of 30 mH, is connected in series with a capacitor C. An ac voltage of 220 V, with frequency 50 Hz is applied to the circuit. Find

(i) The value of C to give unity power factor

(ii) Total current in the circuit

(iii) The current in the inductor



(7)

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2263** **IC**

Unique Paper Code : 32221202

Name of the Course : **B.Sc. (Hons.) Physics**

Name of the Paper : Waves and Optics

Semester : II

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions in all.

(c) Question **No. 1** is compulsory.

1. Answer any **five** of the following questions :

3×5=15

(a) What are Spatial and Temporal coherence ?

(b) A simple progressive wave is expressed by $y = 0.5 \sin (6.28t - 12.56x)$, where y and x are in meters and t is in seconds. Find (i) wavelength, (ii) maximum velocity and (iii) frequency of the wave.

P.T.O.

(c) Give **three** essential conditions to obtain sustained interference.

(d) Write **two** similarities and **two** differences between zone plate and convex lens.

(e) Distinguish between Fizeau's and Haidinger's fringes. Give **one** example of an experiment where each of them can be obtained.

(f) Which order will be missing for a grating having opacity b=2a, where 'a' is the slit width ? Explain.

(g) Draw a labelled ray diagram illustrating the phenomenon of interference due to a Fresnel's bi-prism.

2. (a) Draw graphically the Lissajous figure for the following : 6

$$x = 5\cos\omega t$$

$$y = 10\cos\left(\omega t + \frac{\pi}{3}\right)$$

(b) Two simple harmonic waves expressed by $y_1 = a_1\cos\omega_1 t$ and $y_2 = a_2\cos\omega_2 t$ are superimposed collinearly. How the resulting motion leads to formation of beats ? Also find the beat frequency. 9

3. (a) Derive differential equation of motion for the transverse vibration of a stretched string and establish an expression for the velocity. 6

(b) Obtain an expression for the path difference between two successive reflected rays in the case of a parallel thin film of refractive index μ and thickness t, and hence obtain conditions for bright and dark fringes. 9

4. (a) Explain with suitable diagram the formation of circular rings in Newton's rings experiment. Obtain an expression for the radius of the n^{th} ring and hence show that the rings get closer as their order increases. 9

(b) In Newton's rings experiment, the diameter of 20^{th} ring changes by 0.05 cm when a liquid is introduced between the lens and the plane glass plate. Find the refractive index of the liquid. 3

(c) In a bi-prism experiment, the eye piece is 120 cm apart from the source. The two virtual images of the source are separated by a distance of 0.075 cm. Find the wavelength of the light used if the cross-wire of the eye piece moves through a distance 1.888 cm for 20 fringes. 3

5. (a) What is Cornu's spiral and how it is formed ? Discuss Fresnel's diffraction at a straight edge using the concept of Cornu's spiral. 9

(b) What do you mean by resolving power of an optical instrument ? Obtain an expression for resolving power of a diffraction grating. 6

6. (a) With the help of necessary theory, derive expression for the intensity distribution pattern in Fraunhofer diffraction at double slit. 12

(b) Calculate the radius of the third half period element of a zone plate behaving as a convex lens of focal length 100 cm. The wavelength of light used is 4800 Å. 3

7. (a) Draw a labelled diagram showing interference due to Lloyd's single mirror. Why is the central fringe dark ? 5

(b) Explain the concept of Fresnel's half period elements and show that every zone has approximately the same area. 7

(c) Draw the intensity pattern for Fresnel's diffraction due to thin and thick wire, mentioning the difference between them. 3

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2264** **IC**

Unique Paper Code : 32221401

Name of the Course : **B.Sc. (Hons.) Physics**

Name of the Paper : Mathematical Physics-III

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt **five** questions in all.

(c) Question **No.1** is compulsory.

(d) **All** questions carry equal marks.

(e) Attempt **two** questions from **Section - A** and **B** each.

1. Attempt any **five** questions : 5×3=15

(a) Find $(1 + i)^8$.

(b) Given a complex number z, represent geometrically iz in the Argand plane.

(c) Evaluate $\oint_C \frac{4-3z}{(z-1)(z-2)}dz$; if C is the circle $|z|=\frac{3}{2}$.

P.T.O.

(d) Locate and name all the singular points of the function (in finite z - plane) $\frac{\sin\sqrt{z}}{\sqrt{z}}$.

(e) If $F(\alpha)$ is the Fourier Transform of $f(x)$, then find the Fourier Transform of $f(x)\sin ax$, where, a is any positive number.

(f) Show that derivative of unit step function is a Dirac Delta function.

(g) If the Laplace Transform of f(t) is F(s), then show that the Laplace Transform of $\int_0^t F(u)\,du$ is $\frac{F(s)}{s}$.

(h) Find the Laplace Transform of function $f(t) = (\sin t - \cos t)^2$.

Section - A

2. (a) Construct an analytic function $f(z) = u + iv$, whose $u(x, y) = x^2 - y^2 - y$. 8

(b) Using De Moivre's theorem, verify that

$\cos 5\theta = 16\cos^2\theta - 20\cos^3\theta + 5\cos\theta$, and

$\frac{\sin 5\theta}{\sin\theta} = 16\cos^4\theta - 12\cos^2\theta + 1$ 7

3. (a) Expand $f(z)=\frac{z}{z-3}$ in a Laurent's series valid for the given regions : 8

(i) $|z| < 3$, (ii) $|z| > 3$

(b) Evaluate $\oint_C \frac{ze^{zt}}{(z+1)^3}dz$, where C is circle $|z| = 2$ and $t > 0$. 7

4. Using the method of contour integration prove any **two** of the following : $7.5\times2=15$

(a) $\int_{-\infty}^{\infty} \frac{x^2}{(x^2+9)(x^2+4)}dx=\frac{\pi}{5}$

(b) $\int_0^{2\pi} \frac{d\theta}{1-2p\cos\theta+p^2}=\frac{2\pi p^2}{1-p^2}, 0<p<1$

(c) $\int_{-\infty}^{\infty} \frac{\sin x}{x}dx=\frac{\pi}{2}$

Section - B

5. (a) Find the Fourier Integral of the function : 8

$f(x)=e^{-kx}$, when $x > 0$, $k > 0$ and $f(-x) = f(x)$

Hence deduce that

$$\int_0^{\infty} \frac{\cos \pi u}{1+u^2}du=\frac{\pi}{2}e^{-x} \; ; \; x>0$$

(b) Find the Fourier Transform of Gaussian function. 7

6. (a) Using Laplace Transforms, solve the following set of simultaneous differential equations :

$$\frac{dx}{dt} - y = e^t, \quad \frac{dy}{dt} + x = \sin t$$

given that x(0) =1 and y(0) = 0. 8

(b) Find $L^{-1}\left\{\frac{1}{(s^2+a^2)(s^2+b^2)}\right\}; a^2 \neq b^2$ 7

7. (a) If $f(t) = t^a$ and $g(t) = t^b$, where a and b are integers, then using the Convolution Theorem for Laplace Transform, prove that : 8

$$\int_0^1 y^a (1-y)^b \, dy = \frac{a!\, b!}{(a+b+1)!}$$

(b) Prove that the Fourier transform of an even function is even. 7

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2265** **IC**

Unique Paper Code : 32221402

Name of the Course : **B.Sc. (Hons.) Physics**

Name of the Paper : Elements of Modern Physics

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt **five** questions in all.

(c) Question **No. 1** is compulsory.

(d) **All** questions carry equal marks.

(e) Non programmable calculators allowed.

1. Attempt any **five** of the following : 5×3=15

(a) Which of the following wave functions are physically acceptable ? Justify your answer.

(i) cos x

(ii) sec x.

(b) Calculate the de-Broglie wavelength of an electron moving with velocity $\frac{3}{5}$c, where 'c' is the velocity of the light in vacuum.

P.T.O.

(c) An electron has the speed of 600 ms^{-1} with an accuracy of 0.005%. Calculate the minimum uncertainty in determining its location.

(d) Prove that the group velocity is same as the particle velocity for a free particle.

(e) Calculate the permitted energy levels of an electron in a one dimensional box 0.1 nm wide.

(f) A certain radioactive material has a half-life of 20 days. What is the decay constant and mean life of this element ?

(g) Determine the ratio of nuclear radii of $^{12}_{6}C$ and $^{16}_{8}O$.

2. (a) What is Compton Effect ? Derive an expression for the Compton shift. If θ and φ are the angles of scattering of photon and electron respectively in the Compton Effect, then show that :

$$\cot\varphi = \left(1+\frac{E}{m_o c^2}\right)\tan\frac{\theta}{2}$$

where 'E' is the energy of the incident photon and 'm_o' is the rest mass of the electron. 10

(b) Obtain the time-independent Schrödinger equation satisfied by the monochromatic plane wave in 1-D, $\Psi(x, t) = A\exp\left(\frac{i}{h}(px-Et)\right)$, where 'A' is constant, 'p' is the momentum and 'E' is the energy of the particle. 5

3. (a) Describe the Davisson-Germer experiment. How did this experiment verify the de-Broglie hypothesis ? 7

(b) Determine the frequency of the light needed to produce electrons of kinetic energy 3eV from illumination of Li Surface. (Given work function of Li is 2.93 eV.) 5

(c) Illustrate uncertainty principle using Gamma Ray Microscope thought experiment. 3

4. (a) Consider a particle of mass 'm' and energy 'E' approaching a potential barrier of height 'V_0' and width 'L'. Assuming E < V_0, obtain an expression for the Transmission Coefficient (T). Prove that in the limit kL >> 1, where

$$k^2 = \frac{2m(V_0 - E)}{h^2},$$

the Transmission Coefficient is given by the expression

$$T = \frac{16E}{V_0}\left(1 - \frac{E}{V_0}\right)e^{-2kL}.$$

10

(b) Prove that the de-Broglie wavelength of a particle of rest mass 'm_0' and kinetic energy 'E_k' is $\frac{hc}{\sqrt{E_k\left(E_k + 2m_0c^2\right)}}$, where 'c' is the velocity of the light in vacuum. 5

5. (a) Discuss the Liquid Drop Model of the nucleus and derive the semi empirical mass formula. 10

   (b) Tritium $\left({}_{1}^{3}H\right)$ has a half -life of 12.5 years against β-decay. What fraction of a sample of tritium $\left({}_{1}^{3}H\right)$ will remain undecayed after 25 years. 2.5

   (c) Calculate the binding energy of α - particle in MeV.

   (Given mass of proton (mp) = 1.007276 amu, mass of neutron (mn) = 1.008665 amu and mass of α-particle (m_α) = 4.001506 amu) 2.5

6. (a) Explain the β-decay process in the context of prediction of neutrino. 6

   (b) State differences between nuclear fusion and nuclear fission. 4

   (c) Explain the origin of solar energy. 5

7. (a) Explain the terms : 6

   (i) Spontaneous emission

   (ii) Stimulated emission

   (iii) Metastable states

   (b) Explain the phenomenon of optical pumping and population inversion. 4

   (c) Draw NZ graph. Explain why the stable nuclei have more number of neutrons than protons ? 5

[This question paper contains 7 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2266** **IC**

Unique Paper Code : 32221403

Name of the Course : **B.Sc. (Hons.) Physics**

Name of the Paper : Analog Systems and Applications

Semester : IV

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions in all.

(c) Question **NO.1** is compulsory.

(d) **All** parts of a question should preferable by attempted together.

1. Attempt any **five** of the following : 3×5=15

(a) Draw the output characteristics of a photodiode and label important parameters.

P.T.O.

(b) Mention some advantages of Schottky barrier diode over the p-n junction diode.

(c) Describe briefly CMRR and Slew rate for an op-amp.

(d) Draw the circuit and describe the working of a log amplifier.

(e) Draw the energy band diagram for insulator, conductor and semiconductor. How does doping affect the Fermi energy level of a semiconductor ?

(f) For a pnp transistor, the current amplification factor (β) is 100. What is the value of α? If I_{CBO} = 10 μA, what is the collector current (I_C) for an emitter current (I_E) of 2 mA ?

(g) An RC coupled amplifier has a voltage gain of 150 in the frequency range of 500 Hz to 50 kHz. On either side of these frequencies, the gain falls such that it is reduced by 3dB at 100 Hz and 100 kHz. Calculate gain in dB at cut of frequencies and also draw a plot of frequency response.

2. (a) Show that the depletion width for a step junction pn diode in equilibrium condition is given as :

$$W=\sqrt{2\varepsilon \frac{V_o}{q} \frac{(N_a+N_d)}{N_a N_d}}$$

where symbols have their usual meaning.

10

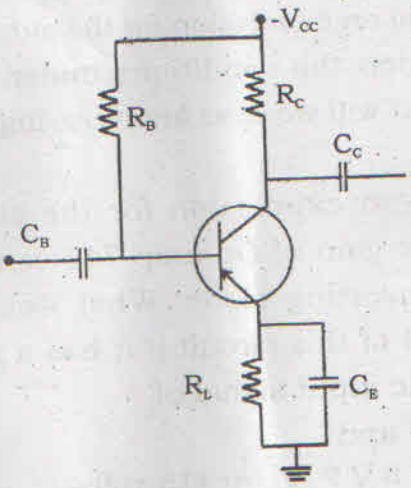
(b) The reverse saturation current at 300K of a pn junction Ge diode is 5 μA. Find the voltage to be applied across the junction to obtain a forward current of 50 mA. Given that the ideality factor for the Ge diode is 1, value of Boltzmann constant is 1.38×10^{-23} J/K and q is 1.6×10^{-19} C. 5

3. (a) Explain the working of a full wave bridge rectifier using suitable diagrams and obtain the expressions for (i) ripple factor and (ii) rectification efficiency. How this rectifier circuit is advantageous over the centre tap full wave rectifier ? 10

(b) In a Zener diode voltage regulator circuit, the source series resistance, $R_s = 20\,\Omega$ Zener voltage $V_z = 18V$ and load resistance $R_L = 200\,\Omega$. How load current is related to the values of current flowing through zener diode ? If source voltage V_s is varied from 20V to 30V, find the maximum and minimum current flowing through the zener diode. 5

4. (a) Draw the circuit for a transistor amplifier in CE configuration using voltage divider bias circuit and derive the expressions for I_c and V_{CE}. Explain the origin of phase difference between the input and output voltages in a transistor amplifier in CE configuration. 10

(b) A pnp transistor having a DC current gain of 100 in CE configuration is to be biased at I_c = 5mA and V_{CE} = 3.8 V. The collector load has a resistance of 500Ω. If V_{cc} = – 10V and V_{BE} = – 0.3 V. Calculate the values of R_B and R_E for the figure given below 5



P.T.O.

5. (a) Using the h-parameter equivalent circuit for a transistor amplifier in CE configuration, derive the expressions for voltage gain and input impedance. 10

(b) Explain negative and positive feedback using block diagrams ? Discuss the effect of negative feedback on the input impedance of the amplifier. 5

6. (a) Draw the circuit of an Op-amp as a non inverting summing amplifier for three voltage input signals (V_1, V_2 and V_3) and obtain an expression for the output voltage. Mention the conditions under which the circuit will work as an averaging amplifier. 10

(b) Write an expression for the closed loop voltage gain of Op-amp 741 configured in non-inverting mode. What would be the output of this circuit if it has a gain of 10 for a dc input signal of

(i) +1V and

(ii) + 2.5 V ? (V_{cc} = ±15 volts). 5

7. (a) Explain the working of a Hartley oscillator and write the expression for its frequency of oscillation. Determine the value of involved capacitor for obtaining f_o = 100 kHz using inductors of equal inductance of 10 mH.

10

(b) In a R-2R binary ladder based D/A convertor input reference voltage of + 10 V is applied. Find the equivalent analog output voltage for the following digital input states (i) 1001 and (ii) 1011. What should be the value of full scale analog output voltage for the 8-bit D/A converter ?

5

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2267** **IC**

Unique Paper Code : 32221601

Name of the Course : **B.Sc. (Hons.) Physics**

Name of the Paper : Electromagnetic Theory

Semester : VI

Time : 3 Hours ***Maximum Marks : 75***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions.

(c) Question **No.1** is compulsory.

(d) **All** questions carry equal marks.

(e) Scientific calculator is allowed.

1. Answer any **five** of the following questions : 3×5=15

(a) In a lossy dielectric of relative permittivity 12 the displacement current is 25 times greater than the conduction current at 100MHz. Calculate the conductivity of dielectric.

(b) Mention any two differences between half and quarter wave plates.

P.T.O.

(c) Calculate the minimum thickness of calcite plate which would convert plane polarized light into circularly polarized light. Given $n_0=1.568$, $n_e=1.468$ and $\lambda=5890\ \text{Å}^0$.

(d) In an optical fibre the core refractive index is 1.5 and cladding refractive index is 1.47. Determine critical angle at core clad interface and numerical aperture.

(e) Using Faraday's law, find the intrinsic impedance of free space.

(f) In what respect does an electrically anisotropic medium differ from an isotropic medium. Mention at least **two** points.

(g) Show that in plasma electron current lags the electric field by $\pi/2$.

(h) Can perfectly static fields possess momentum and angular momentum ?

2. (a) Show how Maxwell modified Ampere's law to make it consistent with the equation of continuity. 3

(b) Show that the Maxwell's equations can be expressed as two coupled second order differential equations in term of scalar and vector potentials. How does these two equations get modified after Lorentz gauge ? 8,4

3. (a) Derive wave equation for E of an em wave in a conducting medium. 4

(b) Show that the amplitude of electric field of em wave attenuates as it propagates in a conducting medium. 8

(c) Find the expression for skin depth. 3

4. (a) Show that in an electrically anisotropic dielectric medium the permittivity tensor is symmetric. 6

   (b) Show that in anisotropic dielectric medium the electric field, magnetic field and the Poynting's vector on one hand and the electric displacement, magnetic field and the wave normal on the other hand form orthogonal triplets. 9

5. (a) Derive Fresnel's relations for reflection and refraction of plane em wave at an interface between dielectric media when the electric field vector of the incident wave is normal to the plane of incidence. Also find the expressions for R and T. 8

   (b) If a parallel polarized em wave is incident from air onto distilled water with $\mu_r = 1$ and $\epsilon_r = 81$, find the Brewster angle θ_B. 3

6. (a) How would you optically distinguish between circularly polarized light and plane polarized light ? 4

   (b) Explain the construction and working of a Nicol prism. 8

   (c) What is graded index optical fibre ? Give its one advantage over step index fibre in optical communication. 3

7. (a) Derive wave equation for E of em wave in a symmetric planar dielectric wave guide whose refractive index [$n^2 = n^2(x)$] profile is :

$n = n_1$, $-d/2 < x < d/2$

$= n_2$, $x < -d/2, x > d/2$.

Using the boundary conditions, obtain the eigenvalue equation for symmetric TE modes. 8,4

(b) Show that there exists only one symmetric TE mode for $0 < V < \pi$, where V denotes the dimensionless wave guide parameter. 3

8. (a) A long straight conducting wire of radius b and conductivity σ is kept along z-axis and it carries a direct current I in +z-direction. Calculate the Poynting's vector on the surface of this wire. 5

(b) Calculate the reflection coefficient at normal incidence for a plane em wave incident on silver from vacuum ($f = 10^{15}$ Hz, $\sigma = 6 \times 10^7$ mho/m). 5

(c) Find the maximum usable frequency for em waves to be transmitted through a distance of 1.5×10^6m by reflection from the ionosphere at a height of 300 km. (number of electrons per unit volume in ionosphere is $6 \times 10^{11} m^{-3}$) 5

7. (a) Derive wave equation for E of em wave in a symmetric planar dielectric wave guide whose refractive index [$n^2 = n^2(x)$] profile is :

$n = n_1$, $-d/2 < x < d/2$

$= n_2$, $x < -d/2, x > d/2$.

Using the boundary conditions, obtain the eigenvalue equation for symmetric TE modes. 8,4

(b) Show that there exists only one symmetric TE mode for $0 < V < \pi$, where V denotes the dimensionless wave guide parameter. 3

8. (a) A long straight conducting wire of radius b and conductivity σ is kept along z-axis and it carries a direct current I in +z-direction. Calculate the Poynting's vector on the surface of this wire. 5

(b) Calculate the reflection coefficient at normal incidence for a plane em wave incident on silver from vacuum ($f = 10^{15}$ Hz, $\sigma = 6 \times 10^7$ mho/m). 5

(c) Find the maximum usable frequency for em waves to be transmitted through a distance of 1.5×10^6m by reflection from the ionosphere at a height of 300 km. (number of electrons per unit volume in ionosphere is $6 \times 10^{11} m^{-3}$) 5

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2268A **IC**

Unique Paper Code : 32221602

Name of the Paper : Statistical Mechanics

Name of the Course : **B.Sc. (H) Physics**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Non-programmable Scientific Calculators are Allowed.

SECTION A

Question No. **1** *is compulsory.*

1. Attempt all parts of this question :

   (a) Find out the total number of ways of filling 3 particles in two energy groups of 4 cells each

P.T.O.

so that 2 particles are placed in one energy group and one particle in the other. Particles here are (i) identical and distinguishable (ii) identical indistinguishable and (iii) identical indistinguishable and obeying Pauli exclusion principle.

(b) Find out the condensation temperature for He II given that the volume occupied by 1 g mole of the gas is 27.4 cm^3.

(c) Find the Fermi energy of the electrons in silver. Given that atomic weight is 108, density being 10.5 gm/cm^3.

(d) Given a Fermi gas, what is the mean occupation number for a state with energy 3kT/2 above the Fermi energy?

(e) A cavity of volume V, and at temperature T is filled with radiation. If the radiation pressure is 1 atm, what is its temperature? (1 atm = 1.01×10^5 N/m^2)

(f) Consider a system of three distinguishable particles with particle energies 0, σ, 2ε, 3ε ..... Let the total energy of the system be 3ε. Enumerate all macrosates and microstates of the system. What is the probability that at least one particle has energy ε. (3×5,4)

SECTION B

Answer any **four** *questions from the following.*
Attempt any **two** *parts from each question.*
Each part carries 7 *marks.*

2. (a) Derive Sackur-Tetrode equation for the entropy of an ideal monoatomic gas. How does it resolve the Gibbs paradox?

(b) A system of N weakly interacting, distinct particles is such that each particle can be visualised as a three-dimensional harmonic oscillator with energy

$$E = \frac{1}{2m}\left(p_x^2 + p_y^2 + p_z^2\right) + \frac{1}{2}m\omega^2\left(x^2 + y^2 + z^2\right).$$

Assuming that the system is in thermal equilibrium at temperature T, compute (a) the mean square speed v^2 and (b) mean square displacement r^2 of a particle, where $r^2 = x^2 + y^2 + z^2$.

(c) For a system of N particles, distributed in 2 non-degenerate energy states $-\epsilon$ and ϵ, find the internal energy and entropy at temperature T? Show graphically the variation of internal energy and entropy with temperature.

3. (a) Show that the single particle partition function for an ideal monatomic gas enclosed in volume V and at temperature T is

$$Z = \left(\frac{2\pi mkT}{h^2}\right)^{3/2}.$$

Find the average energy and pressure for a system of N such distinguishable particles.

(b) For a system of N particles distributed in 2 energy states and degeneracies given by

$\epsilon_1 = 0$, $g_1 = 1$ and $\epsilon_2 = 2\epsilon$, $g_2 = 4$.

Find the ratio of particles in the ground and excited state at a temperature T. Also calculate the internal energy of such a system at temperature T.

(c) Consider a system of N particles accommodated in non-degenerate states of energy 0, ϵ, 2ϵ, ... Calculate thermodynamic probability for the system for (i) $E = \epsilon$ and (ii) $E = 2\epsilon$, where E is the total energy of the system. What is the temperature of the system as E changes from e to 2ϵ?

4. (a) Derive Saha's ionisation formula for the degree of ionisation of gas in a star.

(b) Using Planck's law of black body radiation

$$u_\nu \, d\nu = \frac{8\pi h \nu^3 d\nu}{c^3\left(e^{\frac{h\nu}{kT}} - 1\right)}$$

derive an expression for the total energy density of radiation. Compare the specific heat of black

body radiation in a cavity of volume V at temperature T, with the specific heat of a monoatomic gas of N particles at same temperature and volume.

$$\left(\text{Given } \int_0^\infty \frac{x^3}{e^x - 1} = \frac{\pi^4}{90}\right).$$

(c) A planet of radius R_p is in a circular orbit around a star of radius R_0. The obital radius is r. The star can be assumed to be emitting radiation at a constant rate as a black body. Assuming the planet too to be a black-body, which both absorbs the radiation from the star and emits it into the space, find its equilibrium temperature as a function of star temperature T_0. The planet can be approximated to be a disk of radius R_P.

5. (a) Give Bose's derivation of Planck's black body radiation formula.

(b) A system of five non-interacting spin-less Bosons in equilibrium is such that each particle can be in the ground state with energy $E_0 = \varepsilon$ or in an excited state with energy $E_1 = 3\varepsilon$. The ground state is

non-degenerate and the excited state is four-fold degenerate. If the total energy of the system is $E = 11\varepsilon$, what is the entropy of the system?

(c) Show that a system of bosons undergoes BE condensation when the number density of bosons exceeds $\xi\left(\frac{3}{2}\right)(2\pi mkT)^{\frac{3}{2}}/h^3$.

6. (a) What are the contents of a white dwarf star? Show that electrons in a white dwarf star behave like a strongly degenerate relativistic gas.

(Parameters of a white dwarf star: $M = 2 \times 10^{30}$ kg, $\rho = 10^{10}$ kg/m^3 and $T = 10^7$ K.)

(b) For a completely degenerate Fermi Dirac gas of N molecules the density of states is given by :

$$g(\in)d\in = \alpha g_s V \in^n$$

where a, and n are constants, g_s is spin degeneracy and V is the volume. Calculate the Fermi energy and total energy of the system at zero Kelvin temperature.

(c) Calculate the Fermi momentum for 4.2×10^{21} electrons in a box of volume 1 cm^3. How will the Fermi momentum and Fermi temperature change if number of electrons in the same volume is doubled.

Constants

$k = 1.38 \times 10^{-23}$ J/K

$m = 9.11 \times 10^{-31}$ Kg

$b = 2.898 \times 10^{-3}$ m-K

$\sigma = 5.67 \times 10^{-8}$ $J/m^2/s\text{-}K^4$

$h = 6.626 \times 10^{-34}$ J-s

Avogadro No. = 6.023×10^{23} particles

[This question paper contains 6 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2333 **IC**

Unique Paper Code : 42221201

Name of the Paper : Electricity, Magnetism and EMT

Name of the Course : **B.Sc. (Prog.)**

Semester : II

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question No. **1** is compulsory. Attempt **four** questions from the rest of the paper.
4. Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following :

   (a) If $\varphi(x,y,z) = 3x^2y - y^3x^2 + z^2$, calculate gradient of φ at the point $(1, -2, -1)$.

   (b) Can the following be a possible electrostatic field?

$$\vec{E} = xy\hat{i} + 2yz\hat{j} + 3xz\hat{k}$$

P.T.O.

(c) State Poynting theorem and explain what do you understand by the Poynting vector.

(d) If $\vec{A}$ and $\vec{B}$ are irrotational, prove that $\vec{A}\times\vec{B}$ is solenoidal.

(e) Prove that $\vec{\nabla}.\vec{B}=0$ and explain its physical significance.

(f) Distinguish between dia-, para- and ferro-magnetic materials.

(g) Discuss the difference between induced electric field and electric field due to static charges.

(5×3=15)

2. (a) Find the work done in moving a particle in the force field

$$\vec{F}=\left(2x+y^2\right)\hat{i}+\left(3y-4x\right)\hat{j}$$

along the straight lines from (0,0) to (2,0), then to (2,1), then to (0,0).

(b) Show that the following function is a sink field

$$\vec{V}=\frac{-x\hat{i}-y\hat{j}}{\sqrt{x^2+y^2}}$$

(c) Prove that $\vec{\nabla}.\left(\vec{\nabla}\times\vec{A}\right)=0$. (6,6,3)

3. (a) Use Gauss's law to find the electric field inside, outside and on the surface of a uniformly charged solid sphere having charge density ρ.

(b) Derive an expression for an electrostatic potential due to a uniformly charged spherical shell at a point inside and outside the shell.

(c) The electric potential at any point (x,y,z) is given by $V = x(3y^2 - x^2 + z)$. Find the electric field at that point. (6,6,3)

4. (a) Derive $Q_p = Q\left(1-\frac{1}{k}\right)$ for a capacitor with dielectric between the parallel plates, where Q_p is the induced charge and k is dielectric constant. Calculate the capacitance of a parallel plate capacitor of plate area 5 cm^2 and separated by dielectric of dielectric constant 4 and thickness 1 cm.

(b) What is meant by polarization of a dielectric? Obtain generalized form of Gauss's law for a polarized dielectric.

(c) The magnetic field $\vec{B}$ due to a current carrying circular loop of radius 10 cm at its centre is 0.2×10^{-4} T. Find the magnetic field due to this loop at a point on the axis at a distance of 6 cm from the centre. (6,6,3)

5. (a) State and explain Biot-Savart's law. Derive an expression for the magnetic field at a point due an infinitely long straight current carrying conductor using Biot-Savart's law.

(b) State and prove Ampere's Circuital law. Starting from Ampere's circuital law, establish the relation

$$\vec{\nabla} \times \vec{B} = \mu_0 \vec{J}.$$

(c) Define $\vec{B}$, $\vec{M}$ and $\vec{H}$. Establish the relation

$$\vec{B} = \mu_0 \left(\vec{H} + \vec{M} \right).$$ (6,6,3)

6. (a) State the Faraday's law of electromagnetic induction. Show that

$$\vec{\nabla} \times \vec{E} = -\frac{\partial \vec{B}}{\partial t}$$

(b) Show that if the two coils having coefficient of self inductance L_1 and L_2 are mutually coupled together so that the whole of the flux from one coil links with the other, then the mutual inductance between the two coils is given by

$$M = \sqrt{L_1 L_2}\ .$$

(c) Derive the expression for the energy stored in the magnetic field of an inductor. Find the energy stored in the magnetic field of a 50 mH coil carrying a current of 2 A. (6,6,3)

7. (a) The magnetic field in a region is given by $\vec{B} = 3\hat{i} + 4\hat{k}$ tesla. Calculate the magnetic flux across the surfaces each of area 2 m^2 in

(i) $x - y$ plane (ii) $y - z$ plane (iii) $z - x$ plane.

(b) Write the four Maxwell's equations in an isotropic dielectric medium.

(c) Derive the wave equation for electric field and magnetic field vectors in an isotropic dielectric medium and hence obtain the velocity of electromagnetic wave in this medium.

(6,3,6)

Physical Constants:

$\varepsilon_0 = 8.854 \times 10^{-12}$ $C^2/N\text{-}m^2$

$\mu_0 = 4\pi \times 10^{-7}$ Wb/A-m

$e = 1.6 \times 10^{-19}$ C

$c = 3 \times 10^8$ m/s

[This question paper contains 4 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2347 **IC**

Unique Paper Code : 42224412

Name of the Paper : Wave and Optics

Name of the Course : **B.Sc. (Prog.)**

Semester : IV

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt **Five** questions in all.
3. Question Number **1** is compulsory.

1. Attempt any **five** parts from the following : (5×3=15)

   (a) Two narrow parallel slits of 0.5×10^{-8} m apart are illuminated by a monochromatic light of wavelength 5890Å. Calculate the width of the fringes which are obtained on a screen distant 0.5 m from the slit.

   (b) Why are Newton's rings circular?

P.T.O.

(c) Why there is need of extended source in the interference by division of amplitude.

(d) Find the radius of first half period element on a zone plate behaving like a convex lens of focal length 50 cm. The wavelength of light is 5000Å.

(e) What is the condition for absent spectra in a diffraction grating?

(f) What are sound waves? How can they be produced?

2. (a) What do you understand by Lissajous figure? A Particle is subjected to two perpendicular SHM's simultaneously

$x = A_1\cos(2\omega t + \alpha)$ $y = A_2\cos(\omega t)$

obtain Lissajous figure analytically and graphically if $\alpha = \Pi/2$ and Π.

(b) Define simple harmonic motion (SHM). Show that the differential equation of motion for SHM is linear and homogenous. Hence, prove that the principle of superposition hold for SHM. (9,6)

3. (a) What are beats? What is the necessary conditions to obtain them?

(b) Two vibrations along the same line are described by $x(1) = 0.05 \cos 8\pi t$, $x(2) = 0.03 \cos 10\pi t$, where x is in meters, t in seconds. Obtain the equation describing the resultant motion. Hence find the beat period. (5,10)

4. (a) Explain the formation of standing waves on a stretched String. Sketch first three harmonics.

(b) What are progressive waves? How they differ from standing waves. Derive an expression for displacement in the progressive wave in terms of wavelength and velocity. Prove

$$y(x, t+T) = y(x,t)$$ (5,10)

5. (a) In Fresnel's Biprism experiment with a source of light of wavelength 5890 Å, a thin mica sheet of refractive index 1.6 is placed normally in the path of one of the interfering beams and the central bright fringe is shifted to a position of third bright fringe from the centre. Calculate the thickness of the mica sheet.

(b) Derive the conditions of constructive and destructive interference for Young's double slit experiment. (10,5)

6. (a) Explain the determination of difference in wavelengths of two waves using Michelson's Interferometer. How Michelson's Interferometer can be used to measure the refractive index of a thin transparent sheet.

(b) In an experiment for determining the refractive index of a gas using Michelson's interferometer a shift of 148 fringes is observed, when all the gas is removed from the tube. If wavelength of light used is 589.3 nm and length of the tube is 20 cm, calculate the refractive index of the gas.

(10,5)

7. (a) Each slit of a double slit has a width of 0.15 mm and the distance between their centers is 0.75 mm. Find the missing orders in the diffraction pattern.

(b) Derive an expression for intensity distribution for Fraunhofer diffraction due to double slit.

(5,10)

8. (a) What is zone plate? Show that a zone plate has multiple foci. Compare the zone Plate with a convex lens.

(b) What is polarization of light? Explain elliptical and circular polarization. (10,5)

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : 2850

Unique Paper Code : 32227613 IC

Name of the Paper : Communication Systems

Name of the Course : B.Sc. (Hons.) Physics-DSE-4

Semester : VI

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Question No. 1 is compulsory.

Attempt *five* questions in total.

Symbols have their usual meaning.

1. Attempt any *five* questions from the following : 5×3

(*a*) What do you mean by communication ? Draw the block diagram of communication system.

(*b*) What is the deviation ratio of TV sound if the maximum deviation is 25 kHz and the maximum modulating frequency is 15 kHz ? What is the maximum modulating frequency that can be used to achieve a modulation index of 2.2 with a deviation of 7.48 kHz ?

P.T.O.

(c) Explain the path loss and satellite visibility.

(d) What are the advantages of pulse modulation over analog modulation ?

(e) Explain Amplitude Shift Keying (ASK) with proper waveforms.

(f) Explain the significance of SIM number and IMEI number.

2. (a) What are the main characteristics of Amplitude Modulation ? Show mathematically that the amplitude modulated wave consists of carrier and two sidebands of constant amplitude. How is total power in amplitude modulated wave related to unmodulated carrier power ? 8

(b) How can FM wave be generated using Voltage Controlled Oscillator (VCO) ? To achieve 75 percent modulation of a carrier of $V_c = 50$ V, what amplitude of the modulating signal V_m is needed ? 7

3. (a) Explain the filter and phase shift methods of Single Side Band (SSB) generation. 10

(b) Describe the working of diode detector for amplitude demodulation with relevant waveforms. 5

4. (a) Discuss the difference between Pulse Width Modulation (PWM) and Pulse Position Modulation. Explain with the help of waveforms, how PPM is derived from Pulse Width Modulation. 8

(b) State and prove the Sampling Theorem. A video signal contains light variations that change at a frequency as high as 3.5 MHz. What is the minimum sampling frequency for A/D conversion ? 7

5. (a) What is the need of digital transmission ? Explain the three basic operations performed in Pulse Code Modulation (PCM). Explain the advantages and disadvantages of PCM. 8

(b) Explain the function of regenerative repeaters with the help of a block diagram. What do you mean by Binary Phase Shift Keying (BPSK) ? 7

6. (a) Discuss the advantages and disadvantages of satellite communication in detail. Explain the main features of geostationary satellites. 7

(b) Explain the working of earth station with the help of a block diagram. 8

7. (a) Draw the block diagram and explain the components of a mobile handset. 7

(b) Explain the advantages and disadvantages of 2G, 3G and 4G. 8

This question paper contains 7 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : **2724**

Unique Paper Code : **32227626** **IC**

Name of the Paper : **Classical Dynamics**

Name of the Course : **B.Sc. (Hons.) Physics : DSE-3**

Semester : **VI**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all including Question No. **1** which is compulsory. Attempt at least *one* question from Sections A and B each.

1. Attempt any *five* of the following : 5×3=15

   (*a*) Write down the Hamilton's equations of a one-dimensional harmonic oscillator.

   (*b*) Show that the conjugate momenta of the cyclic coordinates are constants of motion.

P.T.O.

(*c*) What are stable and unstable points for a potential energy function ?

(*d*) What do you understand by generalized coordinates and velocities ?

(*e*) Using four vector approach or otherwise, show that it is impossible for an isolated free electron to absorb a photon.

(*f*) Show that the optical frequency of a source drops if the source is receding.

(*g*) Show that $d(\gamma v) = \gamma^3 \, dv$ where the Lorentz factor $\gamma = (1 - v^2/c^2)^{-1/2}$.

(*h*) Show that the relativistic mass is given by the Minkowski metric tensor $\eta_{\mu\nu}$ as $m = (\eta_{\mu\nu} p^\mu p^\nu)^{1/2}$ where $p^\mu = (E, p)$ is the 4-momentum.

SECTION A

2. (*a*) A particle of mass m is falling vertically under gravity. Find its Lagrange's equation of motion. 6

(*b*) A point mass m glides without friction on a cycloid represented by the equation $x = a(\theta - \sin\theta)$, $y = a(1 + \cos\theta)$ with $0 \leq \theta \leq 2\pi$. The plane of the cycloid is oriented vertically in the Earth's constant gravitational field. The point mass is located by the coordinate θ.

Determine the Lagrangian and the Euler-Lagrange equation of motion of the system. 4+5

3. (*a*) Using Hamilton's principle, derive the Hamilton equations :

$$\dot{p}_j = -\frac{\partial H}{\partial q_j} \text{ and } \dot{q}_j = \frac{\partial H}{\partial p_j} \quad \forall\ j = 1, \ldots\ldots, N$$

for a system with N degrees of freedom. 8

(*b*) The Lagrangian of some mechanical system is given as :

$$L = \frac{\dot{q}^2}{4} - \frac{q^2}{9}.$$

Determine the Hamiltonian of this system and hence find the solutions q and p. 7

P.T.O.

4. (*a*) A particle of mass m moves under the influence of a central force field directed towards the origin $\vec{F} = -k\vec{r}/r^3$. Determine the Lagrangian and the Euler-Lagrangian equations of motion. Show that the orbit is a conic section of the form : 12

$$r = p/(1 + \epsilon \cos \theta).$$

(*b*) Calculate the intensity of electric field which will produce in an electron an acceleration equal to acceleration due to gravity. 3

5. (*a*) Derive Poiseuille's equation for the flow of liquid through a pipe. 6

(*b*) An array of three harmonic oscillators, each of mass m connected by four identical springs, each of spring constant k, are executing longitudinal simple harmonic oscillations. Using Lagrangian approach or otherwise, show that the three eigen frequencies are given by : 9

$\omega_1 = \omega_0\sqrt{2}$ and $\omega_{2,3} = \omega_0\sqrt{2 \pm \sqrt{2}}$ where $\omega_0 = \sqrt{k/m}$.

SECTION B

6. (*a*) Below are the space and time coordinates of two pairs of events :

	Event 1				Event 2			
	X_1	Y_1	Z_1	T_1	X_2	Y_2	Z_2	T_2
Case A	0.3m	0.5m	0	2×10^{-9}s	0.4m	0.7m	0	3×10^{-9}s
Case B	0.7m	0.5m	0	5×10^{-9}s	0.4m	0.6m	0	4×10^{-9}s

(*i*) Find the space-time interval between events 1 and 2 in any *one* of the cases A and B.

(*ii*) Is there a frame in which the two events in any *one* case (A or B) would be recorded as simultaneous in time ? If so, what is the speed of that frame ? 2+3

(*b*) Define 4-Momentum. Show that the four-momentum of photon is a null vector. 1+3

(*c*) Given a matrix $L(\beta) = \begin{pmatrix} \gamma & -\gamma\beta & 0 & 0 \\ -\gamma\beta & \gamma & 0 & 0 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{pmatrix}$.

Prove that $L(\beta)$ corresponds to a Lorentz transformation. Here $\gamma = 1/(1 - \beta^2)^{1/2}$ and $\beta = v/c$. Is it an orthogonal transformation ? 4+2

7. (*a*) Show that the rest mass of a particle is conserved if the scalar product of two four vectors **F** and **U** vanishes, where **F** and **U**, respectively, are the four-force and the four-velocity. 7

(*b*) An object A has a velocity $c/\sqrt{2}$ at 45° with the X-axis of an inertial frame S.

(*i*) Determine the components of four-velocity of the object A in the frame S.

(*ii*) Determine the components of four-velocity of the object A in another frame S' moving with a speed $c/2$ relative to S along the positive X-axis. 4+4

8. (*a*) An unstable particle of rest mass m_o and momenta p_o decays in flight into two particles of rest masses m_1 and m_2, momenta p_1 and p_2 and total energies E_1 and E_2, respectively. Show that (using 4-vector approach or otherwise)

$$m_0^2c^4 = (m_1 + m_2)^2c^4 + 2E_1E_2 - 2m_1m_2c^4 - 2p_1p_2c^2 \cos\theta,$$

where θ is the angle between the two decay particles. 7

(*b*) Starting from 4-displacement, show that in units such that $c = 1$, the 4-acceleration is given by :

$A^{\mu} = \gamma(d\gamma/dt,\ v(d\gamma/dt) + \gamma a]$ where a is the 3-acceleration.

Also find $A^{\mu}A_{\mu}$. 4+4

9. (*a*) An inertial frame S′ is moving to the right relative to S at a speed $3c/5$, and another inertial frame S″ is moving to the right relative to S at a speed $c/2$. Using Minkowski diagram or otherwise, find the velocity of S″ relative to the frame S′. 6

(*b*) Using 4-vector approach, prove that :

$$E^2 = c^2p^2 + m_0^2c^4$$

where the symbols have their usual meanings. 9

s.

[This question paper contains 8 printed pages.]

Your Roll No.....

Sr. No. of Question Paper : 2534 IC

Unique Paper Code : 42177926

Name of the Paper : ORGANOMETALLICS, BIOINORGANIC CHEMISTRY, POLYNUCLEAR HYDROCARBONS AND UV, IR SPECTROSCOPY

Name of the Course : **B.Sc. Programme Physical Science/Life Science/App. Phy. Sc. : DSE-2B**

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any **three** questions each from **Section A** and **Section B.**
3. Use separate Answer booklet for each section.

SECTION A

1. (a) Explain the magnetic behaviour of potassium ferricyanide.

P.T.O.

(b) How is $Na_3[Co(NO_2)]$ prepared?

(c) What happens when : (Give balanced chemical equation)

(i) $Na_3[Co(NO_2)]$ is treated with KCl.

(ii) $K_2Cr_2O_7$ reacs with KI.

(iii) $K_4[Fe(CN)_6]$ is treated with $FeCl_3$.

(iv) Sodium nitroprusside is treated with sodium sulphide.

(d) (i) Explain the oxidising nature of $KMnO_4$.

(ii) To an orange red solution of compound X aqueous solution of KOH is added which results in the formation of yellow solution of compound Y. On acidifying with H_2SO_4, the yellow colour changes to orange red again. Identify the componds X and Y and give the chemical reactions involved. (2,2,4,4.5)

2. (a) Mn(CO)5 dimerises. Why?

(b) Explain the synergic effect in metal carbonyls.

(c) (i) Calculate the EAN of the following :

$Mn(CO)_5Cl$ and $Fe_3(CO)_{12}$

(ii) Draw the structure of ferrocene.

(d) The CO stretching frequency in IR spectra are as follows: $[Mn(CO)_6]^+$ 2090 cm^{-1}, $[Cr(CO)_6]$ 2000 cm^{-1}, $[V(CO)_6]^-$ 1860 cm^{-1}, $[Ti(CO)_6]^{2-}$ 1750 cm^{-1}. Its value for CO (g) is 2143 cm^{-1}. Discuss.

(2,2,4,4.5)

3. (a) What are metalloporphyrins? Discuss the role played by haemoglobin and myoglobin in transporting oxygen.

(b) Discuss the biological role of magnesium.

(c) What is active transport? Explain Na/K pump.

(4,4,4.5)

4. (a) Draw the structures of the following compounds :

(i) $Co_2(CO)_8$ in solid state

(ii) $Co_2(CO)_8$ in hexane

(iii) $Fe_3(CO)_{12}$

(iv) $Fe_2(CO)_9$

(b) Explain why direct nitration of ferrocene is not possible? How can you get nitro derivative of ferrocene?

(c) Discuss the role of sodium ions present in the biological system. (4,4,4.5)

SECTION B

Attempt any **three** *questions.*

5. (a) Explain molecular orbital structure of naphthalene.

(b) What do you understand by bathochromic shift and hypsochromic shift? What shift would be observed on increasing the conjugation in the compound?

(c) Why electrophilic attack in anthracene is favoured at C-9?

(d) (i) How is ethyl acetoacetate prepared from acetaldehyde?

(ii) Why is methylene group of EAA reactive? (2,2.5,4,4)

6. (a) What is the finger print region in IR spectrum? How is it useful for structure determination?

(b) Pyridine is less reactive towards electrophiles than pyrrole and benzene. Explain.

(c) Calculate λ_{max} for the following compounds using Woodward Fieser rules :

(i) 

(ii) 

(d) How will you prepare the following from ethylacetoacetate :

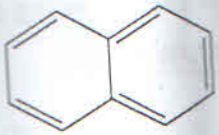
(i) 2,4-pentanedione or Acetylacetone

(ii) 2-methyl propanoic acid (2,2.5,4,4)

7. (a) Why are the peaks observed in UV spectrum broad in comparison to the peaks in IR spectrum?

(b) Define tautomerism. What type of tautomerism exists in ethylacetoacetate? Draw the structures of tautomers.

(c) Give the products for the following reactions :

(i)  $\xrightarrow[\text{Nitrobenzene}]{CH_3COCl,\ AlCl_3}$

(ii)  $\xrightarrow[H^+]{K_2Cr_2O_7}$

(iii)  $+ \ NH_3 \xrightarrow[\text{Steam}]{Al_2O_3}$

(iv)  $\xrightarrow[250°C]{\text{Fuming } H_2SO_4}$

(d) What is the order of following carbonyl compounds in decreasing wavenumber? Explain by giving reasons.

butanoyl chloride; ethylbutanoate; pentanal; propanoic acid (2,2.5,4,4)

8. (a) Why electrophilic substitution in pyrrole and furan cannot be carried in presence of concentrated strong acids?

(b) Arrange furan, pyrrole and thiophene in increasing order of aromatic character. Give reason for your answer.

(c) How would differentiate the following compounds by using IR spectroscopy :

(i) $CH_3CH_2OCH_3$ and $CH_3CH_2CH_2OH$

(ii) CH_3COCH_3 and CH_3CH_2COOH

(d) (i) Give the reaction for ketonic hydrolysis of ethylacetoacete.

(ii) How would you synthesize butanone starting from ethylacetoacetate. (2,2.5,4,4)

[This question paper contains 4 printed pages.]

Your Roll No.....

IC

Sr. No. of Question Paper : 2610

Unique Paper Code : 42227637

Name of the Paper : Solid State Physics

Name of the Course : B.Sc. (Prog.) : DSE-3B

Semester : VI

Duration : 3 Hours Maximum Marks : 75

Instructions for Candidates

1. Write your Roll No. on the top immediately on receipt of this question paper.
2. Attempt any five questions.
3. Question No. 1 is compulsory.

1. Attempt any five of the following : (5×3=15)

(a) List three differences between amorphous and crystalline solids with one example of each.

(b) Show that reciprocal lattice vector $\vec{G}_{hkl}$ is normal to the plane (hkl).

(c) Calculate Einstein's frequency for copper having Einstein's temperature $\theta_E = 230K$.

P.T.O.

(d) What are phonons? Differentiate between acoustical and optical phonons.

(e) Explain Meissner effect with the help of a diagram.

(f) What do you understand by the term 'Domains'? Why do large number of domains exist in a ferromagnetic material?

(g) Distinguish between Conductors, Semiconductors and Metals on the basis of E-K curve.

(h) What are plasmons?

2. (a) What are Miller Indices? How are they defined for a plane? Name the six faces of a unit cube in terms of Miller Indices. (3)

(b) Derive Bragg's Law and express it in terms of Reciprocal lattice vector $\vec{G}$. (7)

(c) Show that Reciprocal Lattice of a bcc is fcc. (5)

3. (a) Derive the dispersion relation for a linear monoatomic lattice and discuss under what conditions it can act as a 'low pass filter'. (10)

(b) Why did the classical theory of specific heat fail to explain the behaviour of solids at low temperature? How did Einstein overcome this difficulty? (5)

4. (a) What are the characteristics of Diamagnetic materials? Derive an expression for diamagnetic susceptibility on the basis of classical theory. (3,5)

(b) Show that the area enclosed by B-H curve represents the energy loss per cycle. (5)

(c) A magnetic substance has 10^{28} atoms/m^3. The magnetic moment of each atom is 1.8×10^{-23} Am^2. Calculate the paramagnetic susceptibility at 300 K. (2)

5. (a) Explain the three types of polarizabilities. (5)

(b) Derive an expression for electronic polarizability in a time varying field. (10)

6. (a) Give a detailed account of Kronig-Penny Model. How did it lead to formation of energy bands in solids? (10)

P.T.O.

(b) Discuss three types of E-K zone-schemes and representing them diagrammatically. (5)

7. (a) What is Superconductivity? Give 4 applications of superconductors. (6)

(b) With the help of diagram discuss Type I and Type II superconductor. (5)

(c) What is the effect of magnetic field on critical temperature of a superconductor? (4)

Values of constants

$h = 6.6 \times 10^{-34}$ J-s

$k = 1.38 \times 10^{-23}$ J/K

(2000)

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2397** **IC**

Unique Paper Code : 32223904

Name of the Course : **B.Sc.(Hons.) Physics/ B.Sc. (Prog.) : SEC**

Name of the Paper : Basic Instrumentation Skills

Semester : IV

Time : 3 Hours ***Maximum Marks : 50***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt any **five** questions in **all**.

(c) Question **NO.1** is compulsory.

1. Attempt any **five** of the following : 2×5=10

(a) What are lissajous figures and how they are displayed on the screen of CRO ?

P.T.O.

(b) What do you mean by luminance and persistence in CRO ?

(c) Calculate V_{p-p} and V_{max} of a signal if V_{rms} value is 4.5V.

(d) What is (i) random error (ii) limiting error ?

(e) What do you mean by sensitivity of a digital voltmeter ?

(f) What is Distortion factor meter ?

(g) Define rise time and fall lime of a pulse.

2. (a) What is loading effect ? Discuss the loading effect of multimeter with the help of example. 6

(b) Define the terms : 4

(i) accuracy

(ii) resolution

(iii) precision

(iv) expected value

3. Draw the block diagram of CRO and explain the function of each block. 10

4. (a) What are the advantages of dual trace CRO over dual beam CRO for multipletrace ? 4

(b) What is the function of X-Y mode ? 3

(c) What is the speciality of storage oscilloscope ? 3

5. (a) Explain the working of pulse generator and mention its applications. 6

(b) What are the different applications of signal generator ? Give a brief idea of testing. 4

6. (a) Draw the block diagram of Q-meter and explain its working principle. 5

(b) Explain the working of digital LCR bridge with the help of a block diagram. 5

7. (a) State the advantage of Digital Voltmeter (DVM) over analog meter. 4

   (b) Explain the working of a digital voltmeter using a block diagram. 6

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2401** **IC**

Unique Paper Code : 32223907

Name of the Course : **B.Sc. (Hons.) Physics/ B.Sc. (Prog.) : SEC**

Name of the Paper : Radiation Safety

Semester : IV

Time : 3 Hours ***Maximum Marks : 50***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt **five** questions in **all**.

(c) Question **NO.1** is compulsory.

(d) Use of non-programmable scientific calculator is allowed.

1. Attempt any **five** of the following questions : 5×2=10

(i) Define *ionizing radiation* .

(ii) What is nuclear waste and disposal management system ?

P.T.O.

(iii) Differentiate between effective dose and equivalent dose.

(iv) Discuss the properties of alpha, beta and gamma radiation.

(v) How is the nuclear techniques used in crime detection ? Explain briefly.

(vi) What are the uses of radiation therapy ?

(vii) What do you mean by Derived Air Concentration (DAC) ?

(viii) Explain the principle and working of MRI.

2. (i) What do you understand by Photoelectric effect ? Explain it. 4

(ii) What is the law of radioactive decay ? Derive an expression for half-life of a radioactive isotope. 6

3. (i) Discuss the construction and working of Proportional Counter. 5

(ii) Explain the kinematics of nuclear reactions. 5

4. (i) Discuss the Accelerator Driven Sub-critical system (ADS) for waste management. 4

(ii) Explain the term :

(a) ionization potential,

(b) range

(c) stopping power with reference to ionizing radiation. 2,2,2

5. (i) How nuclear techniques are useful in the field of medical science ? 5

(ii) Describe Beth-Bloch Formula. Explain, using stopping power expressions and cross sections, why the energy loss due to ionization drops off so sharply with increasing energy, while radiation loss increases linearly. 5

6. (i) Calculate the binding energy, and the binding energy per nucleon, for a nucleus of the ^{238}U isotope (238.0508u), mass of proton = 1.00728u, mass of neutron = 1.00867u. 5

(ii) What are the various models used to study the types of nuclear reaction ? 5

7. (i) Discuss the Inorganic and Organic Scintillators. 5

(ii) Describe the interaction of heavy charged particles. 5

8. Write short notes on any **two** of the following : 5,5

(a) Auger electron

(b) Nuclear spin

(c) Cherenkov radiation

(d) Annual Limit of Intake (ALI)

[This question paper contains 4 printed pages]

Your Roll No. : .....

Sl. No. of Q. Paper : **2444** **IC**

Unique Paper Code : 32223903

Name of the Course : **B.Sc.(Prog.) : SEC**

Name of the Paper : Electrical Circuits and Network Skills

Semester : VI

Time : 3 Hours ***Maximum Marks : 50***

Instructions for Candidates :

(a) Write your Roll No. on the top immediately on receipt of this question paper.

(b) Attempt **five** questions in **all**.

(c) Question **NO.1** is compulsory.

(d) **All** questions carry equal marks.

1. Attempt any **five** : 2,2,2,2,2

(i) Explain Ohm's law with examples.

(ii) Discuss about different type of conductors.

P.T.O.

(iii) Draw the circuit diagram of a practical current source.

(iv) Discuss about the phase reversal.

(v) Draw the phasor diagram and waveform of voltage and current for a pure inductive circuit.

(vi) Explain about the overload devices.

(vii) The current through a 100 μF capacitor is given below. Find the sinusoidal expression for voltage across the capacitor.

$i = 40 \sin (500t + 60^{\circ})$

2. (a) Discuss in details about a digital multimeter. 5

(b) Explain in details about single phase and three phase ac sources. 5

3. (a) Describe the construction and working of a transformer. 5

(b) Describe the construction and working of an ac generator. Support your answer with relevant diagrams. 5

4. (a) State Thevenin's Theorem. 2

(b) Mention the steps to Thevenize an electrical circuit. 2

(c) In an electrical circuit with V_{th} as Thevenin equivalent voltage, R_{th} as Thevenin equivalent resistance, calculate the value of load resistance(R_L) to get the maximum power. Explain with circuit diagram. 2

(d) In case of electrical symbols, show the symbols for phase shifter (3-wire), bridge rectifier, dc current source, and zener diode. 4

5. (a) Discuss the basic design and working of a three phase motor with relevant diagram. 6

(b) Discuss the basic design and working of a dc motor with relevant diagram. 4

6. Describe the construction and working of half-wave and full-wave rectifiers in details. 4,6

7. Write short notes on any **two** of the following : 5,5

(i) Solid and Stranded Cables.

(ii) Cable Trays.

(iii) Extension board.

(iv) Losses across cables and conductors

This question paper contains 3 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : **2305**

Unique Paper Code : **42343601** **IC**

Name of the Paper : **Android Programming-SEC**

Name of the Course : **B.Sc. (P) (Physical Science/ Mathematical Science)**

Semester : **VI**

Duration : **2 Hours** Maximum Marks : **25**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Section A is compulsory.

Attempt any *three* questions from Section B.

Parts of a question must be answered together.

Section A

(Compulsory)

1. (*a*) Name the layout used in xml file for setting screen layout for handling vertical and horizontal scrolling. 1

(*b*) Name the android class used for starting new activity. 1

P.T.O.

(*c*) Write down the usage of @ and + in **id** names while building Android application. 2

(*d*) Write *two* ways used for generating flexible layout that can adapt to different screen sizes. 2

(*e*) How does android control the execution of multiple applications on the device ? 2

(*f*) Write *one* use of the emulator.

Also write the command used for installing new application to the emulator or any connected device. 1+1

Section B

(Attempt any *three* questions)

2. Differentiate between Explicit and Implicit Intents. Draw a flow diagram showing handling of implicit intent by the Android system. 3+2

3. How does an activity know about change in the state of the application? Write down any *three* reasons for implementing callback methods for activities. 1+4

4. Make a simple android application to accept name of the person and his willingness to participate in a survey (Yes/No). Use appropriate user interface/controls required for designing the application. Write statements to set size, font colour and font type of the text. 5

5. Name the class used for handling database in Android application. Write the code for the following :

   (*a*) Create a table with any two attributes

   (*b*) Populate data into the table by passing Content Values object. 1+2+2

6. Describe the following :

   (*a*) Interface (in Java)

   (*b*) Option and Context Menu. 2+3

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | | |

S. No. of Question Paper : 2985

Unique Paper Code : 32225201 IC

Name of the Paper : Mechanics

Name of the Course : Physics : Generic Elective for Honours

Semester : II

Duration : 3 Hours Maximum Marks : 75

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. 1 is Compulsory.

Attempt *four* questions from rest of the paper.

1. Attempt any *five* of the following :

(*a*) Find the angle between $\vec{A} = 2\hat{i} + 2\hat{j} - \hat{k}$ and $\vec{B} = 6\hat{i} - 3\hat{j} + 2\hat{k}$.

(*b*) Solve the differential equation :

$$\frac{d^2y}{dx^2} - 5y = 0.$$

P.T.O.

(c) Does the centre of mass of solid body necessarily lie within the body ? Give examples.

(d) State Kepler's laws of planetary motion.

(e) Define simple harmonic motion. Write differential equation for simple harmonic motion.

(f) What is Poisson's ratio ? Can it be more than 0.5 ?

(g) What are the *two* postulates of special theory of relativity ?

5×3=15

2. (a) If $\vec{A} = 5t^2\hat{i} + t\hat{j} - t^3\hat{k}$ and $\vec{B} = \sin t\hat{i} - \cos t\hat{j}$, find $\frac{d}{dt}(\vec{A} \cdot \vec{B})$.

5

(b) Solve :

5

$$\frac{dy}{dx} = \frac{2x^3 + y^3}{3xy^2}.$$

(c) Solve :

5

$$\frac{d^2x}{dt^2} + 4\frac{dx}{dt} + 4x = 0.$$

3. (a) State and prove work energy theorem.

1,5

(*b*) Find the total work done in moving a particle in a force field given by $\vec{F} = 3xy\hat{i} - 5z\hat{j} + 10x\hat{k}$ along the curve $x = t^2 + 1$, $y = 2t^2$, $z = t^3$, from $t = 1$ to $t = 2$. 3

(*c*) Define centre of mass. Show that in the absence of the external forces, the velocity of centre of mass remains constant. 1,5

4. (*a*) Explain the principle of a rocket. Establish the following relation for a rocket :

$$V = V_0 + v \log e \frac{M_0}{M},$$

where v is the exhaust velocity of the gases relative to rocket, M_0, V_0 are initial mass and velocity of rocket respectively. M and V are mass and velocity of the rocket at any time 't'. 3,7

(*b*) A particle of mass m, is moving in x-y plane and the components of its velocity along x and y directions are v_x and v_y. Show that its angular momentum has only a z component. 5

5. (*a*) What are central forces ? Give *two* examples. Show that in a central force field :

(*i*) the angular momentum is conserved.

(*ii*) the particle moves in a fixed plane. 1,1,3,3

(*b*) What is satellite ? Derive expressions for the velocity and time period of a satellite orbiting around earth. 2,2½,2½

6. (*a*) What is simple harmonic motion ? Give *two* examples. Deduce the differential equation of simple harmonic motion and find its solution. 1,1,3,4

(*b*) Show that for a harmonic oscillator, mechanical energy remains constant and it is proportional to the square of the amplitude. 6

7. (*a*) Find the work done in stretching the wire. 5

(*b*) Define Young's modulus (Y), bulk modulus (K) and modulus of rigidity (η). Prove the relation :

$$Y = \frac{9K\eta}{3K + \eta}.$$ 1,1,1,7

8. (*a*) Write down the Lorentz space-time transformation equations. Discuss the time dilation in special theory of relativity. 2,4

(*b*) Obtain the formula for relativistic addition of velocities. 6

(*c*) A spacecraft is moving relative to earth. An observer on the earth finds that, according to her clock, 3601 s elapse between 1 p.m. and 2 p.m. on the spacecraft's clock. What is the spacecraft's speed relative to the earth ? 3

This question paper contains 4 printed pages]

Roll No. | | | | | | | | | | |

S. No. of Question Paper : **3110**

1C

Unique Paper Code : **32225415**

Name of the Paper : **Generic-IV : Thermal Physics**

Name of the Course : **Physics G.E. for Honours**

Semester : **IV**

Duration : **3 Hours** Maximum Marks : **75**

(Write your Roll No. on the top immediately on receipt of this question paper.)

Attempt *five* questions in all.

Question No. **1** is compulsory.

All questions carry equal marks

1. Attempt any *five* of the following : 5×3=15

(*a*) State the Zeroth Law of thermodynamics. Give its significance.

(*b*) Why a Carnot engine cannot have 100% efficiency ?

(*c*) Air is compressed adiabatically to half its volume. Calculate the change in the temperature.

P.T.O.

(*d*) What are degrees of freedom? State the law of equipartition of energy.

(*e*) How does the coefficient of viscosity change with temperature and pressure ?

(*f*) Distinguish between reversible and irreversible processes. Give conditions of reversibility.

(*g*) State the third law of thermodynamics. What do you understand by principle of unattainability of absolute zero ?

2. (*a*) State Kelvin-Planck and Clausius statements of second law of thermodynamics and hence prove their equivalence. 2,6

(*b*) State and prove Carnot's theorem. 2,5

3. (*a*) Define entropy. Show that entropy remains constant during a reversible process whereas it increases during an irreversible process. 2,3,3

(*b*) Calculate the change in entropy when temperature of 1 Kg of water is raised from 0°C to 100°C. Specific heat capacity of water is 1 Cal/gm K. 3

(*c*) Find the entropy of a perfect gas in terms of temperature and volume. 4

4. (*a*) Explain the four thermodynamic potentials. Derive Maxwell's thermodynamic relations from them. 4,6

(*b*) Prove the following

$$C_P - C_V = TE\alpha^2 V,$$

where T is absolute temperature, E is the modulus of isothermal elasticity, and α is the coefficient of volume expansion. 5

5. Explain Joule-Thomson effect for van der Waal's gases. Obtain the relation for temperature of inversion. 12,3

6. (*a*) Derive Planck's radiation formula for the distribution of energy in the spectrum of a black body. 10

(*b*) Show that Wien's law and Rayleigh-Jean's law are special cases of Planck's law. 5

7. Derive Maxwell's law of distribution of velocities of molecules of a gas, give its experimental verification. 10,5

8. (*a*) Distinguish between Classical, Fermi-Dirac and Bose-Einstein Statistics.

(*b*) Obtain an expression for thermodynamic probability distribution of particles governed by Fermi-Dirac statistics.

(*c*) Three Fermions are to be distributed in four energy levels *a, b, c* and *d*. Calculate all possible ways of this distribution. 5,5,5