[This question paper contains 6 printed pages.]

Your Roll No 2022

Sr. No. of Question Paper : 1382 C

Unique Paper Code : 32221301

Name of the Paper : Mathematical Physics – II

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

Semester : III

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. Q. No. **1** is compulsory.

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

(a) Prove that even function can have no sine terms in its Fourier expansion.

P.T.O.

(b) Determine whether the functions cos 2x and cos x are orthogonal or not in the interval $(0, 2\pi)$.

(c) Evaluate : $\int_0^{\pi/2} \cos^6\theta \, d\theta$.

(d) Find the value of $\Gamma\left(\frac{-5}{2}\right)$.

(e) Show that for integral values of n, $AJ_n(x) + BJ_{-n}(x)$ is not a general solution of Bessel equation of order n.

(f) Prove : $P_n'(1) = \frac{n(n+1)}{2}$.

(g) Find whether x = 1 is an ordinary, regular or irregular singular point of the given differential equation :

$$x^2(1-x^2)y'' + \frac{2}{x}y' + 4y = 0$$

(h) Determine whether or not $u(x, y) = 4e^{-3x}\cos 3y$ is a solution of given partial differential equation :

$$\frac{\partial^2 u}{\partial x^2} + \frac{\partial^2 u}{\partial y^2} = 0$$

2. (a) Find the Fourier series expansion of a periodic function given by : (10)

$$f(t) = \begin{cases} E_o \sin t, & 0 < t < \pi \\ 0, & \pi < t < 2\pi \end{cases}$$

(b) Evaluate : $\int_0^2 x\,(8 - x^3)^{1/3}\,dx$ (5)

3. Consider a periodic function f(x) of period 2π such that

$$f(x) = \pi - x,\ 0 < x < \pi$$

(a) Plot odd extension of f(x) in the range $(-3\pi, 3\pi)$. (3)

(b) Find its half-range Fourier Sine Series. (6)

(c) Show that $1 - \frac{1}{3} + \frac{1}{5} - \frac{1}{7} + \ldots\ldots = \frac{\pi}{4}$ (3)

(d) Also, prove that $1 + \frac{1}{4} + \frac{1}{9} + \ldots\ldots = \frac{\pi^2}{6}$ (3)

4. Consider the following differential equation :

$$4x^2\,y'' + 4xy' + (x^2 - 1)y = 0$$

(a) Find whether x = 0 is an ordinary, regular or irregular singular point. (3)

(b) Using Frobenius method, determine the roots of indicial equation and hence find the first solution. (4,5)

(c) Also, find the second solution. (3)

5. (a) Prove that orthogonality relation for Legendre polynomials is given by

$$\int_{-1}^{1} P_n(x)\, P_m(x)\, dx = \begin{cases} \dfrac{2}{2n+1}, & m = n \\ 0, & m \neq n \end{cases} \qquad (10)$$

(b) The generating function of Legendre polynomials is given by :

$$(1 - 2xt + t^2)^{-1/2} = \sum_{n=0}^{\infty} t^n\, P_n(x),$$

Using this generating function, prove that :

$$P_{n+1}(x) = \frac{2n+1}{n+1} x P_n(x) - \frac{n}{n+1} P_{n-1}(x) \qquad (5)$$

6. Given, $e^{\frac{x}{2}\left(t-\frac{1}{t}\right)} = \sum_{n=-\infty}^{\infty} t^n J_n(x)$

Verify that :

(i) $\cos(x\sin\theta) = J_0(x) + 2J_2(x)\cos2\theta + 2J_4(x)\cos4\theta + ...$

(ii) $\sin(x\sin\theta) = 2J_1(x)\sin\theta + 2J_3(x)\sin3\theta + ...$

Hence prove that :

$$J_n(x) = \frac{1}{\pi}\int_0^{\pi}\cos(n\theta - x\sin\theta)\,d\theta \qquad (3,3,9)$$

7. Using the method of separation of variables, find the general solution of 2-D wave .equation for the case of symmetrical circular membrane (radius = a):

$$\frac{1}{r}\frac{\partial}{\partial r}\left(r\frac{\partial u}{\partial r}\right) = \frac{1}{c^2}\frac{\partial^2 u}{\partial t^2};\ c>0$$

subject to the conditions :

$$u(a, t) = 0,\ \left.\frac{\partial u}{\partial t}\right|_{t=0} = 0 \text{ and } u(r, 0) = u_0(r) \qquad (15)$$

8. (a) Using the method of separation of variables, solve the following differential equation :

$$\frac{\partial u}{\partial x} = 4\frac{\partial u}{\partial y}$$

when $u(0, y) = 8e^{-3y} + 4e^{-5y}$. (5)

(b) A homogeneous rod of conducting material of length 100 cm has its ends kept at zero temperature and the initial temperature is

$$u(x, 0) = \begin{cases} x, & 0 \le x \le 50 \\ 100 - x, & 50 \le x \le 100 \end{cases}$$

Using 1-D heat equation, find the temperature u(x, t) at any time. (10)

[This question paper contains 8 printed pages.]

Your Roll No. 2022

Sr. No. of Question Paper : 1411 **C**

Unique Paper Code : 32221302

Name of the Paper : Thermal Physics

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

Semester : III

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.
4. Answer any **four** of the remaining **six**.

1. Attempt any **five** :

(a) Show that heat and work are path functions but their differences are point functions.

P.T.O.

(b) Classify the following processes into reversible or irreversible processes and give their reasons

(i) isothermal expansion of gas

(ii) diffusion of gases

(c) A gas has the following equation of state :

$$P\left(V-\frac{a^4}{V}\right)=nRT$$

What is the work done by the gas when it is expanded isothermally?

(d) Two moles of an ideal gas expand isothermally to four times its initial volume. Calculate the entropy change in terms of R, the universal gas constant.

(e) The radius of argon atom is 0.128 nm. Calculate their mean free path at temperature 25°C and pressure 1 atmosphere. Given $K_B = 1.38 \times 10^{-23}$ JK.

(f) Calculate the deviation of van der Waals gas law from ideal gas law at the critical point.

(g) On the basis of third law of thermodynamics prove the unattainability of absolute zero temperature. (3×5=15)

2. (a) Give the mathematical form of the first law of thermodynamics and explain its significance. For an ideal gas, derive the relations

(i) $C_P - C_V = R/J$ for an isobaric process

(ii) $PV^\gamma =$ Constant for an adiabatic process

(b) A process for an ideal gas is defined by the relation $P = AT^b$. Calculate the isobaric coefficient of volume expansion (α) and isothermal compressibility (K).

(c) The volume of lg mole of a gas filled in a container at standard pressure (1×10^5 N/m^2) and temperature (0° C) is 22.4×10^{-3} m^3. The volume of the gas is reduced to half its original value by increasing the pressure. (i) isothermally (ii) adiabatically. In each case calculate the final pressure of the gas and amount of work done [γ=1.40 and R=8.3 J mol^{-1} K^{-1}]. (6,6,3)

3. (a) Show that the efficiency of all reversible heat engines operating between the same two temperatures is same.

(b) Give Kelvin Planck and Clausius statements of the second law of thermodynamics and hence discuss their equivalence.

(c) A reversible heat engine converts one fifth of the input heat into work. On reducing the

temperature of the sink by 50°C, its efficiency is doubled. Find the temperatures of the source and the sink. (6,6,3)

4. (a) With the help of an example for each process, show that there is always an increase in entropy during an irreversible process while it remains constant during a reversible process. Hence, discuss Clausius inequality.

(b) Obtain an expression for change in entropy of an ideal gas having n moles in terms of pressure and temperature when it's thermodynamic state changes from (P_i, V_i, T_i) to (P_f, V_f, T_f).

(c) Calculate the change in entropy when 0.01 kg of water at 288 K is mixed with 0.02 kg of water at 313 K. Take specific heat of water as 4200 J kg^{-1} K^{-1}. (6,6,3)

5. (a) Define four thermodynamic potentials and hence derive Maxwell's thermodynamic relations from them.

(b) Using Maxwell's relations prove

$$(\partial Cv/\partial V)_T = T(\partial^2 P/\partial T^2)_V$$

Hence show that it is equal to zero for both ideal and van der Waals gases.

(c) Calculate the change in melting point of ice at STP, when it is subjected to a pressure of 90 atmosphere. For ice, density = 0.92 g/cm^3 and latent heat of fusion = 80 cal/g. (6,6,3)

6. (a) Derive the Maxwell's law of distribution of velocity. Discuss briefly its graphical representation.

(b) State and explain the law of equipartition of energy and hence show that the value of $\gamma=C_P/C_V$ for monoatomic, diatomic and triatomic gases are 1.66, 1.4, 1.33, respectively.

(c) Calculate the root mean square speed and most probable speed of a gas whose density is 1.4 g/ litre at a pressure of 10^5 N/m^2. (6,6,3)

7. (a) Describe Joule-Thomson's porous-plug experiment. Derive an expression for Joule-Thomson's coefficient (μ) and inversion temperature for a real gas obeying van der Waals equation. Explain the significance of inversion temperature.

(b) Obtain the relation between the critical temperature, Boyles temperature and the temperature of inversion for a van der Waals gas. Also write law of corresponding state.

(c) The critical Temperature of CO_2 is 31°C and its critical pressure is 73 atmospheres. Assuming that CO_2 obeys van der Waals equation, compute the critical volume of CO_2. (6,6,3)

[This question paper contains 4 printed pages.]

Your Roll No. 2022

C

Sr. No. of Question Paper : 1429

Unique Paper Code : 32221303

Name of the Paper : Digital Systems and Applications

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

Semester : III

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 in all. Q. No. **1** is compulsory. **All** questions carry equal marks.

Attempt any **five** questions

1. Attempt any five parts (all parts carry equal marks) : (5×3=15)

(a) Represent $(-56)_{10}$ in signed magnitude and 1's complement representation limited to 8-bits.

P.T.O.

(b) Define deflection sensitivity in Cathode Ray Oscilloscope?

(c) The accumulator of 8085 microprocessor contains AAH and carry is set. What will accumulator and carry contain after the execution of 'XRA A' instruction?

(d) Realize OR gate using diodes and resistors.

(e) Why is D Flip-flop referred to as transparent latch?

(f) Draw the circuit for 4-bit even parity generator.

(g) Subtract 23_{10} from 39_{10} using 2's complement method.

2. (a) Draw the labelled block diagram of a Cathode Ray Tube (CRT)? Explain the role of the following : (8)

(i) Aqua Dag coating

(ii) Control Grid

(b) Minimize the following logic expression using K – map and realize it using NAND gates only

$F(A, B, C, D) = \Sigma m(1, 3, 7, 11, 15) + d(0, 2, 5)$ (7)

3. (a) Draw the circuit diagram of Serial Shift Register and hence describe its working in serial in serial out (SISO) and serial in parallel out (SIPO) modes. (8)

(b) Distinguish between a 4-bit multiplexer and an encoder using appropriate diagrams. Using block diagrams realise 8×1 multiplexer using two 4×1 multiplexers and an OR gate and explain its functioning? (7)

4. (a) Write an assembly language program to multiply two 8 bit numbers, one of which is stored in memory location 2050H and other one in memory location 2051H. Store the product in memory locations 2053H and 2054H. (8)

(b) Explain the working of a 2's complement 4-bit adder - subtractor with an appropriate logic circuit diagram. (7)

5. (a) Describe the phenomena of racing in JK flip-flop. Hence explain how this condition can be avoided with the use of master-slave JK flip-flop. (8)

(b) Describe the working of a decade counter (MOD-10) with a suitable diagram? (7)

6. (a) Draw the circuit diagram of 555 timer IC in Astable configuration and hence explain its working in terms of the charging and discharging of its timing capacitor by drawing the relevant wave diagrams. (8)

(b) Write an assembly language programme to divide two hexadecimal numbers. (7)

7. (a) Draw the logic pin out diagram of 8085 microprocessor wherein all the different signals are depicted and classified in different groups. (8)

(b) What are flags? Describe various flags (in detail) for 8085 microprocessor. (7)