This question paper contains **4+2** printed pages]

Roll No. | | | | | | | 2 | 0 | 1 | 9 |

S. No. of Question Paper : **7483** 18

Unique Paper Code : **32221301**

Name of the Paper : **Mathematical Physics-II**

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

Semester : **III**

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

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

Section-A

1. (*a*) Write a general expression for the Fourier series of a function $f(x)$, such that $f(x) = f(x + 2L)$, $-L < x < L$. Which terms will be missing if $f(x)$ is an even function ? Justify mathematically. 6

Or

Evaluate $\int_{-L}^{L} \cos \frac{p\pi x}{L} \cos \frac{q\pi x}{L}\, dx$ for : 6

(*i*) $p = q \neq 0$

(*ii*) $p \neq q$.

(*b*) Plot the periodic function defined by : 2,6,4

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

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

Find the Fourier series of this function and hence prove that :

$$\frac{\pi^2}{8} = \frac{1}{1^2} + \frac{1}{3^2} + \frac{1}{5^2} + \ldots$$

(*c*) What is the period of sin nx and that of tan x. 2

Or

If $f(t + T) = f(t)$, then show that :

$$\int_a^b f(t)dt = \int_{a+T}^{b+T} f(t)dt.$$

Section-B

2. (*a*) Classify the point $x = 0$ as a regular or irregular singular point for the differential equation : 3

$$x^2 \frac{d^2y}{d^2x} + \sin x \frac{dy}{dx} + e^{-x} y = 0.$$

(*b*) Solve the following differential equation about $x = 0$, using Frobenius method : 12

$$x \frac{d^2y}{dx^2} + 2\frac{dy}{dx} + xy = 0.$$

Or

$$x^2 \frac{d^2y}{dx^2} + x\frac{dy}{dx} + \left[x^2 - \frac{1}{4}\right]y = 0$$

3. Attempt any *two* parts : 2×7.5=15

(*a*) Prove that :

$$J_n(x) = \frac{1}{\pi}\int_0^\pi \cos(n\theta - x\sin\theta)d\theta, \; n = 0, 1, 2 \ldots$$

(*b*) Expand $f(x) = x^2 - 3x + 2$ in a series of the from $\sum_{k=0}^{\infty} A_k P_k(x)$, using $P_0(x) = 1$, $P_1(x) = x$, $P_2(x) = \frac{3x^2 - 1}{2}$.

(*c*) Using the generating function for Bessel's Polynomials or otherwise, prove that :

$$xJ'_n(x) = -nJ_n(x) + xJ_{n-1}(x)$$

(*d*) Obtain an expression for $P_4(x)$ using appropriate formula.

Section-C

4. Attempt any *one* part : 1×5=5

(*a*) Evaluate :

$$\int_0^1 \frac{dx}{\sqrt{-\ln x}}$$

(*b*) Evaluate :

$$\int_0^a y^4 (a^2 - y^2)^{1/2} dy$$

(*c*) Prove that :

$$\int_0^\infty \frac{x^{m-1}}{(a+bx)^{m+n}} dx = \frac{1}{a^n b^m} \beta(m, n).$$

Section-D

5. (*a*) The solutions to 2-D wave equation are obtained as trigonometric functions as well as in terms of Bessel functions. Explain how trigonometric cosine function is different from the Bessel Function of Order Zero. Compare them in terms of :

(*i*) Periodicity

(*ii*) Amplitude

(*iii*) Zeros.

Indicate differences using a plot. 5

Or

Using the method of separation of variables, solve : 5

$$\frac{\partial u}{\partial y} = 2\frac{\partial^2 u}{\partial x^2}; \quad 0 < x < 3, \quad y > 0$$

Given $u(0, y) = u(3, y) = 0$, and $u(x, 0) = 5 \sin 4\pi x - 3 \sin 8 \pi x$.

(*b*) Find the steady state temperature, $u(x, y)$ of a rectangular plate $(0 < x < 1; 0 < y < 2)$ subject to the boundary conditions : $u(x, 0) = 0$, $u(0, y) = 0$, $u(1, y) = 0$, and $u(x, 2) = x$. 10

Or

Using the method of separation of variables, solve 1-D wave equation :

$$\frac{\partial^2 y}{\partial t^2} = c^2 \frac{\partial^2 y}{\partial x^2}$$

Subject to conditions $y(0, t) = 0$, $y(L, t) = 0$ and

$$y(x,0) = \begin{cases} x, & 0 < x < \frac{L}{2} \\ L - x, & \frac{L}{2} \le x \le L \end{cases}, \; y_t(x, 0) = 0$$

where $y_t = \dfrac{\partial y}{\partial t}$. 10

(c) Show that $u(x, t) = e^{-8t} \sin 2x$ is a solution to $\dfrac{\partial u}{\partial t} = 2\dfrac{\partial^2 u}{\partial x^2}$ with the conditions $u(0, t) = u(\pi, t) = 0$, $u(x, 0) = \sin 2x$.

Or

Using the method of separation of variables, prove that the general solution of $\dfrac{\partial f}{\partial t} = 4\dfrac{\partial f}{\partial x}$ is given by :

$$f(x,t) = Ae^{k\left[\left(\frac{x}{4}\right)+t\right]}$$

where A and k are some constants 5

[This question paper contains 8 printed pages.]

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Your Roll No. 2019

Sr. No. of Question Paper : 7484A **J**

Unique Paper Code : 32221302

Name of the Paper : Thermal Physics

Name of the Course : **B.Sc. (Hons.) 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. Question No. 1 is compulsory.
4. Answer any **four** of the remaining **six**, attempting any **two** parts from each question.

1. Attempt **all** parts.

(a) Which of the two, an isothermal or an adiabatic, has greater slope? Prove mathematically. (2)

(b) A Carnot's engine whose sink is at 27°C has an efficiency of 50%. By how much the temperature of the source be changed to decrease its efficiency to 40%? (2)

(c) One kilogram of water is heated from 0°C to 100°C and converted into steam at the same temperature. Calculate the increase in entropy. Given that specific heat of water is $4.18 \times 10^3\ \mathrm{Jkg^{-1}K^{-1}}$ and latent heat of vaporisation is $2.24 \times 10^6\ \mathrm{Jkg^{-1}}$. (3)

(d) Using Carnot's cycle derive Clausius-Clapeyron latent heat equation. (4)

(e) A substance has volume expansivity = 2bT/V and isothermal compressibility = a/V, where 'a' and 'b' are constants. Find the equation of state. (3)

(f) Define Boyle Temperature. Give relation between Boyle temperature, Temperature of inversion and Critical temperature. (2)

(g) What is Brownian motion? Give its characteristics. (3)

2. (a) (i) State first law of thermodynamics. What are its physical significance and limitations? Write first law of thermodynamics for an adiabatic, isobaric and isochoric processes. (4)

(ii) Derive the work done by an ideal gas in expanding adiabatically from initial state (P_i, V_i, T_i) to the final state $(P_f, V_f, T_f\})$. (3)

(b) Using first law of thermodynamics, prove that

(i) $\left(\frac{\partial U}{\partial P}\right)_V = \frac{C_V K_T}{\beta}$

(ii) $\left(\frac{\partial U}{\partial V}\right)_P = \frac{C_P}{\beta V} - P$

Where β and K_T are volume expansion coefficient and isothermal compressibility respectively. (3.5,3.5)

(c) Find ΔW and ΔU for an iron cube of side 6 cm as it is heated from 20°C to 300°C. For iron C = 0.11 cal/g°C and volume coefficient of expansion is $\beta = 3.6 \times 10^{-5}\,{}^{\circ}C^{-1}$. Given, Mass of the cube is 1700 gm. (7)

3. (a) What are reversible and irreversible processes? Give one example of each. Prove that if Kelvin-Planck statement of second law is violated then Clausius statement is also violated. (7)

(b) If, two Carnot engines R and S are operated in series such as engine R absorbs heat at temperature T_1 and rejects heat to the sink at temperature T_2, while Engine S absorbs half of the heat rejected by engine R and rejects heat to the sink at temperature T_3. If the work done in both the cases is equal, show that $T_2 = (T_3 + 2T_1)/3$. (7)

(c) (i) A refrigerator freezes 6 kg of water at 0°C into ice in a time interval of 20 min. Assume that room temp, is 25°C, calculate the power needed to accomplish it.

(ii) If coefficient of performance of a refrigerator is 5 and operates at the room temperature 27°C, find the temperature inside the refrigerator. (3.5,3.5)

4. (a) Define entropy. What is principle of increase of entropy? Find increase in entropy for reversible and irreversible processes. (7)

(b) If two bodies have equal mass *m* and heat capacity c, are kept at different temperatures T_1 and T_2 respectively, taking $T_1 > T_2$ and the first body as source of heat for reversible engine and the second as sink, find out the maximum work done. (7)

(c) (i) The temperature variation of C_P is given by the relation $C_P = 0.4\ T - 0.05\ T^2 - 0.25$, in the temperature range 50 K to 100 K in cal/K. If 4 moles of the substance is heated from 50 K to 100 K, calculate the change in entropy.

(ii) An ideal gas is confined to a cylinder by a piston. The piston is slowly pushed such that the gas temperature remains at 20°C. During compression, 730 J of work is done on the gas. Find the entropy change of the gas. (3.5,3.5)

5. (a) What are thermodynamic potentials? Why are they so called? Give relations for them. Write physical significance of Gibb's free energy. (7)

(b) Apply Maxwell's relation to prove that the difference of isothermal compressibility and adiabatic compressibility is equal to $TV\beta^2/C_P$.

(c) Minute droplets of water are slowly pushed out of an atomizer into air. The average radius of the droplets is 10^{-4} cm. If 1 kg of water is atomized isothermally at 25°C, calculate the amount of heat transferred. The specific volume of water at 25°C is 1.00187×10^{-3} m^{3}kg^{-1} and the rate of change of surface tension of water with temperature is -0.152×10^{-3} Nm^{-1}K^{-1}. (7)

6. (a) Define mean free path (λ) of molecules of a gas.

Derive the expression $\lambda = \frac{3}{4\pi\sigma^2 n}$. Where σ is the diameter of the gas molecules and n is the no. of molecules per unit volume. (Assuming that all molecules move with the same velocity i.e. the average velocity of the gas. (7)

(b) (i) Plot Maxwell distribution function for molecular speeds at temperatures T_1, T_2 and T_3 such as $T_1<T_2<T_3$. Write the necessary inference from these curves.

(ii) Calculate the value of v_x for which the probability of a molecule having x-velocity falls to half of its maximum value. (3,4)

(c) (i) Calculate the probability that the speed of oxygen molecule lies between 109.5 and 110.5 metre/sec at 300 K.

(ii) Hydrogen and Nitrogen are maintained under identical conditions of temperature and pressure. Calculate the ratio of their coefficients of viscosity if the diameters of these molecules are 2.5×10^{-10} m and 3.5×10^{-10} m respectively. (4,3)

7. (a) Discuss Joule-Thomson porous plug experiment. Obtain equation for Joule-Thomson co-efficient. (7)

(b) What are the limitations of Van der waal's equation of state. Draw and discuss similarities and dis-similarities of theoretical and experimental curves for CO_2 gas. (7)

(c) The Van der Waal's constant for Hydrogen are $a = 0.247$ *atm.* litre^{2}mol^{-2} and b = 2.65×10^{-2} *litre/mol*. Calculate

(i) The temperature of inversion

(ii) Joule Thomson coefficient for 2 atm fall of pressure, initial temp, being 100 K. Given $R = {}^{224}/_{273}$ atoms litre/mol/K. (7)

This question paper contains 8 printed pages]

Roll No. | | | | | | | 2 | 0 | 1 | 9 |

S. No. of Question Paper : 7485-A (20)

Unique Paper Code : 32221303 J

Name of the Paper : **Digital Systems and Applications**

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

Semester : **III**

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.

Answer any *four* of the remaining six,

attempting any *two* parts from each question.

1. Attempt *all* parts of this question :

(*i*) Why two state operations is preferred for designing digital circuits ? Name *two* devices that you see around which exhibit two states. 3

(*ii*) Draw the circuit of a NOT gate using transistor and explain its working. 3

(*iii*) What do you understand by an instruction cycle and a machine cycle in 8085 microprocessor ? 3

(*iv*) Apply the duality theorem to the following expression : 2

(*a*) $A(B + C) = AB + AC$

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

(*v*) Subtract 11001101 from 10110101 using 2's complement method. 3

(*vi*) What is the role of control voltage pin in IC 555 timer ? 2

(*vii*) Draw block diagram of a RAM chip and explain the role of each pin. 3

2. (*i*) (*a*) What do you understand by Digital and Linear ICs ? Give *two* examples of each. 4

(*b*) In an oscilloscope, a 100 V signal produces a deflection of 2 cm corresponding to a certain setting of vertical gain control. If another voltage produces 7.3 cm deflection for the same setting of the vertical gain control, what is the value of the voltage ? 3

(*ii*) Perform the following conversions :

(*a*) $(198.25)_{10}$ into Binary number and Hexadecimal number. 4

(*b*) $(324.24)_{10}$ into Octal number. 3

(*iii*) A three variable truth table produce logic 1 output when the number of 1s in the input variables is even. Generate the Truth Table for the problem considering the output as don't care for the terms for which the decimal equivalent of the input variables is 0, 1 and 2. Determine the simplest SOP equation for this truth table using K-Map method and design the logic circuit for the function using NAND gates and XOR gates only. 7

3. (*i*) (*a*) Draw truth table and block diagram of a full subtractor circuit using half subtractors. 4

(*b*) The SUB input control signal of a full adder/subtractor circuit is connected to the output of a 4-input XOR gate. Tabulate the combinations of the XOR gate input variable for which the adder/ subtractor circuit perform the task of (*i*) Addition and (*ii*) Subtraction. 3

(*ii*) Design an encoder which generates the following truth table : 7

Input	Output
Y_1	A B C
0	0 0 0
3	0 0 1
1	0 1 0
7	0 1 1
2	1 0 0
6	1 0 1
5	1 1 0
4	1 1 1

(*iii*) Design a 4-bit serial-in-parallel-out shift right register using negative edge triggered D flip-flops. Display the timing diagram to store 4-bit binary number $(1101)_2$ assuming the register is initially all clear. How many number of clock pulses are required to store the number ? 7

4. (*i*) Draw the circuit of a clocked SR latch using NAND gates and explain its working. Why the S = 1 and R = 1 is called the forbidden condition ? 7

(*ii*) (*a*) Draw circuit diagram of a JK latch (using NAND gates) and discuss its truth table. 4

(*b*) Mention the methods by which the race around condition is avoided in JK latch. 3

(*iii*) Design a MOD-8 asynchronous down counter using negative edge triggered JK flip-flops. Draw the timing diagram of the counter assuming the initial state as 0000 and that the propagation delay of each flip-flop is 10 ns. The time period of the input clock pulse is 100 ns. 7

5. (i) An instruction (MOV C, A) with the hex code 4F H is stored in the memory location 2006 H. Discuss the steps taken by the microprocessor in order to execute this instruction. What would be the content of the program counter (PC) register after the execution of this instruction ? 7

(ii) Explain with a timing diagram the following operation : 7

Memory Location	M/Code	Mnemonic
2000	06	MVI B, 52H
2001	52	

(iii) A memory bank uses a 16-line address bus and 8-line data bus. The first 32 KB of the memory is allocated to two ROM's of 16 KB each, and the remaining space to the RAM's of 8KB each. Write down the initial and final addresses of each chip in the entire memory map. 7

6. (i) (a) What are flags ? If the accumulator contains 0BH and register C contain 05H, which flags are affected when CMP C is executed. 3

(b) If the clock frequency of a microprocessor is 5MHz, how much time is required to execute an instruction of 7 T states ? 4

(ii) What are the various general purpose registers present in microprocessor 8085 and explain their function ? What is the role of program counter (PC) and stack pointer (SP) registers ? 7

(iii) Write an assembly language program to subtract 5DH from FCH stored in memory locations 2006H and 2007H, respectively using indirect addressing mode. The difference is to be stored in the memory location 2008H and borrow in 2009H. 7

7. (*i*) Design an astable multivibrator circuit using IC 555 timer with the following specifications. The time period of the output waveform is 100 ms and duty cycle is 80%. Draw the output waveform and the voltage across the capacitor. 7

(*ii*) (*a*) Give the truth table of XOR and XNOR gates and explain their working as odd and even parity detectors. 4

(*b*) Discuss and explain the principle of error detection using parity method. What is the limitation of this method ? 3

(*iii*) A 5 MHz and 10 MHz square wave signal is fed to the J and K inputs of a JK flip-flop. Draw the timing diagram for the output Q assuming that the flip-flop is active all the time and is initially clear. 7

Sr. No. of Question Paper : B 8907

Unique Paper Code : 222181

Name of the Paper : Physics - I

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

Semester : III

21

Duration : 3 Hours

Maximum Marks: 75

Attempt any ***five*** questions from the following. All questions carry equal marks.

1. (a) Find the angle between $\vec{A} = 3\hat{i} + 2\hat{j} - 6\hat{k}$ and $\vec{B} = 4\hat{i} - 3\hat{j} + \hat{k}$. (5)

   (b) State Stoke's theorem with all symbols clearly defined. (5)

   (c) Show that : $(\vec{a} \times \vec{b}) \bullet (\vec{c} \times \vec{d}) = (\vec{a} \bullet \vec{c})(\vec{b} \bullet \vec{d}) - (\vec{a} \bullet \vec{d})(\vec{b} \bullet \vec{c})$. (5)

2. (a) If $\vec{F} = 2xz\hat{i} - x\hat{j} + y^2\hat{k}$. Evaluate $\iiint_V \vec{F}\, dV$ where V is the region bounded by the surfaces $x = 0,\ y = 0,\ y = 6,\ z = x^2,\ z = 4$. (10)

   (b) Show that: $\vec{\nabla} \bullet (\vec{\nabla} \times \vec{A}) = 0$ (5)

3. (a) Define Moment of Inertia. State and prove theorem of perpendicular axis. (9)

   (b) Show that in the absence of an external force, the total linear momentum of a system of particles is conserved. (6)

4. (a) What are conservative and non-conservative forces? Give two examples of each. (6)

   (b) Show that the areal velocity remains constant, when the particle moves under the influence of a central force (9)

. (a) What is forced harmonic oscillator? Obtain its differential equation and find its solution for the steady case. (10)

   (b) What are group and phase velocities? Give the relationship between them. (5)

6. (a) Discuss the experiment for determining the wavelength of sodium light using Newton's Rings method. (10)

(b) What is Fresnel's Biprism? How is it different from an ordinary prism? (5)

7. Derive an expression for the distribution of intensity due to Fraunhoffer diffraction of a monochromatic light incident normally on a plane transmission grating. Also, draw the the intensity pattern. (10, 5

8. (a) What is polarisation of light? (3)

(b) State and prove Brewster's law for polarisation of light. (5)

(c) Explain the construction and working of a Nicol Prism. (7)