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2021

(Held in 2022)

PHYSICS

(Honours)

Paper : PHY–HC–3016

(Mathematical Physics–II)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : (each question carries **one** mark) 1×7=7

   (a) Show that $P_n(-x) = (-1)^n P_n(x)$.

   (b) $L_1(x) - L_0(x) = ?$

(c) Express the one-dimensional heat flow equation.

(d) $\int_0^\infty e^{-x} x^{2n-1} dx = ?$

(e) $\beta\left(\frac{1}{2}, \frac{1}{2}\right) = ?$

(f) Square matrix = Symmetric matrix + ?

(g) If, $\mu^{-1} M \mu = M'$, then show that $Tr\, M = Tr\, M'$.

2. Answer the following questions : (each question carries **2** marks) 2×4=8

(a) Show that $x = 0$ is a regular singular print for the following differential equation :

$$2x^2 \frac{d^2y}{dx^2} + 3x \frac{dy}{dx} + \left(x^2 - 4\right) y = 0$$

(b) Can we express the one-dimensional Schrödinger's equation

$$-\frac{\hbar^2}{2m} \frac{\partial^2 \psi(x, t)}{\partial t^2} + V\psi(x, t) = i\hbar \frac{\partial \psi}{\partial t}(x, t)$$

in terms of space dependent and time independent equations if V is a function of both x and t? Explain.

(c) Show that $\beta(l, m) = \beta(m, l)$.

(d) Show that the matrix

$$\sigma_2 = \begin{pmatrix} 0 & -i \\ i & 0 \end{pmatrix}$$

is Hermitian as well as unitary.

3. Answer ***any three*** questions from the following : (each question carries **5** marks) 5×3=15

(a) By the separation of variable method, solve the t-dependent part of the following equation : 5

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

(b) If $\begin{pmatrix} x \\ y \end{pmatrix}$ transforms to $\begin{pmatrix} x' \\ y' \end{pmatrix}$ in the way —

$$\begin{pmatrix} x' \\ y' \end{pmatrix} = \begin{pmatrix} \cos\theta & \sin\theta \\ -\sin\theta & \cos\theta \end{pmatrix} \begin{pmatrix} x \\ y \end{pmatrix} \text{ then}$$

show that $x'^2 + y'^2 = x^2 + y^2$.

Verify that the transformation matrix is orthogonal. 2+3=5

(c) How many real numbers are required to express a general complex matrix of dimension 2×2? Show that a 2×2 Hermitian matrix of dimension 2×2 carries four real numbers. Also, show that a skew-Hermitian matrix of dimension 2×2 carries only the real numbers. 1+2+2=5

(d) Find the Fourier's series representing $f(x) = x, \quad 0 < x < 2\pi$, and sketch its graph from $x = -4\pi$ to $x = +4\pi$.

3+2=5

(e) Show that

$$L_n'(x) - n\, L_{n-1}'(x) + n\, L_{n-1}(x) = 0 .$$ 5

4. If, $y = \sum_{k=0}^{\infty} a_k\, x^{m+k}$ happens to be the power series solution of the equation,

$$2x(1-x)\frac{d^2y}{dx^2} + (1-x)\frac{dy}{dx} + 3y = 0$$, then show

that $a_{k+1} = \dfrac{-2m-2k+3}{2m+2k+1}$ 10

Or

Show the following : 4+3+3=10

(1) $(n+1)\, P_{n+1} = (2n+1)\, x P_n - n\, P_{n-1}$

(2) $n P_n = x P_n' - P_{n-1}'$

(3) $P_{n+1}' - P_{n-1}' = (2n+1)\, P_n$

5. Solve the equation

$$\frac{\partial^2 \psi}{\partial x \partial t} = e^{-t} \cos x$$

given that, $\psi(t=0)=0$ and $\left.\frac{\partial \psi}{\partial t}\right|_{x=0} = 0$ 10

Or

Consider a vibrating string of length l fixed at both ends, given that

$y(0, t)=0, \ \ y(l, t)=0$

$y(x, 0)= f(x), \ \frac{\partial y}{\partial t}(x, 0)=0; \ \ 0 < x < l$

Solve completely the equation of vibrating string

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

10

6. If $A = \begin{pmatrix} 1 & 0 & 1 \\ 0 & 1 & 0 \\ -1 & 0 & 1 \end{pmatrix}$, obtain A^{-1}.

From the matrix equation

$$\begin{pmatrix} 2 & 1 \\ 3 & 2 \end{pmatrix} \begin{pmatrix} a & b \\ c & d \end{pmatrix} \begin{pmatrix} -3 & 2 \\ 5 & -3 \end{pmatrix} = \begin{pmatrix} -2 & 4 \\ 3 & -1 \end{pmatrix},$$

obtain, a, b, c, d. 4+6=10

Or

Obtain the eigenvalues and eigenvectors of the matrix

$$M = \begin{pmatrix} 2 & -i \\ i & 2 \end{pmatrix}$$

and hence diagonalize the same. 4+6=10

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3 (Sem–3 /CBCS) PHY HC 2

2021

(Held in 2022)

PHYSICS

(Honours)

Paper : PHY–HC–3026

(Thermal Physics–II)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following questions : 1×7=7

   (a) What is an isobaric process ?

   (b) What is the entropy of a perfect crystalline solid at absolute zero temperature ?

Contd.

(c) Whether Maxwell-Boltzmann velocity distribution is applicable to photons.

(d) Joule-Kelvin coefficient of a perfect gas is infinite. *(State True or False)*

(e) At what temperature, does all molecular motion cease ?

(f) Name the transport phenomenon present in a gas that involves momentum transfer.

(g) How does the diameter of a gas molecule affect mean free path ?

2. Answer the following questions : 2×4=8

(a) Is temperature a microscopic or macroscopic concept ? Explain.

(b) Differentiate between extensive and intensive variables with examples.

(c) Calculate the average thermal energy of a helium atom at 27°c.

[Given $k_B = 1{\cdot}38 \times 10^{-23}\, m^2\, kg\, s^{-2} K^{-1}$]

(d) How do viscosity and temperature affect Brownian motion of gas molecules ?

3. Answer **any three** questions : 5×3=15

(a) A reversible engine takes in heat from a reservoir of heat at 527°*C* and gives out heat to sink at 127°*C*. How many calories per second must it take from the reservoir to produce useful mechanical work at the rate of 750 watts ?

(b) Derive an expression for work done during an adiabatic process considering *n* moles of an ideal gas.

(c) Explain an experimental method to verify velocity distribution of gas molecules.

(d) The van der Waals constants of oxygen are $a = 1.382\ L^2\, bar/mol$ and $b = 0{\cdot}03186\ L/mol$. Calculate its Boyle's temperature and temperature of inversion. 2½+2½=5

(e) Derive Clausius-Clapeyron equation.

4. Answer the following questions : 10×3=30

(a) Using Maxwell's thermodynamic relations, derive T_{ds} equations. 10

Or

What is Gibbs free energy ? Using Gibbs free energy G, show that

$$G = -T^2 \left[\frac{\partial}{\partial T} \left(\frac{G}{T} \right) \right]_P$$

where the symbols have their usual meanings. 1+9=10

(b) Define coefficient of diffusion. Discuss the theory of diffusion in a gas and show that coefficient of diffusion is directly proportional to square root of temperature. 1+2+7=10

Or

Derive the van der Waals equation of state and calculate the value of critical constants. 5+5=10

(c) What do you mean by thermodynamic scale of temperature? Show that the thermodynamic scale of temperature is identical with the perfect gas scale of temperature. 3+7=10

Or

Write short notes on the following : ***(any two)*** 5×2=10

(i) Carnot cycle

(ii) Degrees of freedom

(iii) Joule-Thomson cooling

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2021

(Held in 2022)

PHYSICS

(Honours)

Paper : PHY–HC–3036

(Digital Systems and Applications)

Full Marks : 60

Time : Three hours

The figures in the margin indicate full marks for the questions.

1. Answer the following as directed : 1×7=7

(i) The active components of an IC are ________. *(Fill in the blank)*

Contd.

(ii) Which of the following gates cannot be used as an inverter ?

(a) NOR

(b) NAND

(c) X-NOR

(d) AND

(Choose the correct option)

(iii) The intensity of the spot in a cathode ray tube can be controlled by changing the positive potential on the control grid. *(State True* **or** *False)*

(iv) 8421 code is ________ code. *(Fill in the blank)*

(v) A flip-flop can store —

(a) one bit of data

(b) two bits of data

(c) three bits of data

(d) any number of bits of data

(Choose the correct option)

(vi) Each term in the standard SOP form is called a ________. *(Fill in the blank)*

(vii) How many buses are connected as part of the 8085 A microprocessor ?

(a) 3

(b) 4

(c) 5

(d) 6

2. Answer the following questions is brief : 2×4=8

(i) What are linear and digital ICs ? Give examples of them.

(ii) Convert the following decimal numbers into BCD code :

(a) 2579

(b) 29·6

(iii) Write down the Boolean expression for 4 to 1 multiplexer and draw the function table for it.

(iv) What are low and high level languages ? Give examples.

3. Answer ***any three*** questions from the following : 5×3=15

(i) Convert the following as directed :

(a) Octal 526 to decimal

(b) Octal 356·52 to binary

(c) Hexadecimal 12A to decimal

(ii) Distinguish between combinational circuits and sequential circuits with examples.

(iii) Design a circuit that gives an output $A\overline{B}+\overline{A}B$ using discrete electronic circuits.

(iv) What is race around condition of a JK flip-flop ? How can it be eliminated?

(v) State De Morgan's theorem. Apply De Morgan's theorem to the following expressions :

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

(b) $\overline{(\overline{AB}+\overline{CD})(CD+\overline{E}F)}$

4. Answer ***any three*** of the following questions: 10×3=30

(i) Draw the block diagram and truth table of a full subtractor. Design a full subtractor logic circuit by using K-map. 5+5=10

(ii) (a) Use the K-map to minimise the following expressions : 6

i. $X = A\overline{B}+B\overline{C}+\overline{A}C+AB$

ii. $X = \overline{A}\overline{B}\overline{C}+\overline{A}BC+A\overline{B}C+ABC$

(b) Express the Boolean function $F = BC+\overline{B}A$ in a product of maxterms (POS). 4

(iii) (a) Draw the logic diagram of a master-slave JK flip-flop and explain its operation with the help of a truth table. 6

(b) Distinguish between an encoder and a decoder. 4

(iv) (a) Write down the function of CPU and ALU of a computer.

(b) Distinguish between dynamic RAM and static RAM.

(c) What is a cache memory ? What is its function ?

4+3+3=10

(v) (a) Draw the block diagram of a microprocessor.

(b) Explain the function of a program counter in a 8085 microprocessor.

(c) Write different flag registers of a 8085 microprocessor.

(d) What are different types of addressing mode in 8085 microprocessor ?

(e) Give an example of a 3-byte instruction.

2+3+2+2+1=10
