(c) The wave function of a particle is given by

$$\psi_n(x) = A \sin\frac{n\pi x}{a} \text{ when } 0 < x < a$$
$$= 0 \text{ when } x < 0 \text{ and } x > a$$

Find the normalized form of the wave function.

(d) What is matter wave? (1+3)+2+3+1=10

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TDP (General) 5th Semester Exam., 2020
(Held in 2021)

PHYSICS

(General)

FIFTH PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **two** from each Unit

UNIT—I

1. (a) Show that the plane electromagnetic waves in free space travel with the velocity *c*.

(b) What do you mean by intrinsic impedance of free space?

(c) Describe briefly the working of a ruby laser and state how population inversion has been achieved in this device. 3+2+(3+2)=10

2. *(a)* Write a BASIC program to find all the prime numbers from 1 to 100.

(b) What are the characteristics of high-level language?

(c) What is the use of the basic statement 'KILL'?

(d) What are the advantages of optical fibre over co-axial cable? 4+2+2+2=10

3. *(a)* Using Boolean algebra verify

$$A + \bar{A}B = A + B$$

(b) What is the difference between a half adder and a full adder? Construct a full-adder circuit using two-half adders and an OR gate.

(c) Discuss with truth table the working principle of a *R-S* flip-flop. 2+(2+2)+4=10

UNIT—II

4. *(a)* State Heisenberg's uncertainty principle in terms of energy and time.

(b) Write an expression for the wavelength of the matter wave associated with an electron accelerated through a potential difference *V*.

(c) From Planck's energy distribution law of black-body radiation, derive Wien's displacement law.

(d) If $i\hbar\frac{\partial}{\partial x}$ is an eigenoperator to the function e^{-ikx}, then find the corresponding eigenvalues. 2+2+3+3=10

5. *(a)* Write the physical significance of a wave function.

(b) Draw the energy-level diagram for a particle confined in a one-dimensional potential well.

(c) The lowest energy possible for a particle confined in a one-dimensional box is 40 eV. What are the next three higher energies?

(d) What do you mean by free particle? 2+3+3+2=10

6. *(a)* Write time dependent Schrödinger equation and hence solve it by the method of separation of variables.

(b) What is the need for normalization of wave function?

TDP (General) 5th Semester Exam., 2019

PHYSICS

(General)

FIFTH PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, taking **two** from each Unit

UNIT—I

1. *(a)* What is pointing vector?

(b) Explain how Maxwell generalized Ampere's circuital law.

(c) Derive the expression for energy density in an electromagnetic wave. 2+3+5=10

2. *(a)* What is a metastable state? Write down its significance in case of LASER.

(b) What do you mean by graded-index fibre? Discuss its advantage over step-index fibre.

(c) Explain the terms spontaneous emission and stimulated emission. (1+2)+(2+2)+(1½+1½)=10

3. (a) How can you design AND gate using NOR gate only?

(b) Write a basic programme to determine whether a given number is prime or not.

(c) What is the application of the basic statement 'LIST'?

(d) Write the difference between RAM and ROM. 2+4+2+2=10

UNIT—II

4. (a) Discuss the failure of classical theory in explaining black-body radiation phenomenon.

(b) Show how one can arrive at Bohr's quantization condition on the basis of de Broglie's hypothesis of matter waves.

(c) If E_k be the kinetic energy of a particle with rest mass m_0, prove that the de Broglie wavelength is given by

$$\lambda = \frac{hc}{\sqrt{E_k(E_k + 2m_0c^2)}}$$ 4+3+3=10

5. (a) Show that electron diffraction through a narrow slit takes place in accordance with Heisenberg's uncertainty principle.

(b) Show that if uncertainty in the location of a particle is equal to the de Broglie wavelength associated with the particle, the uncertainty in its velocity is equal to its velocity.

(c) Establish Schrödinger's time independent one-dimensional wave equation from the classical differential equation of wave. 4+2+4=10

6. (a) Solve the Schrödinger's wave equation for a particle confined in a one-dimensional box.

(b) The wave function of a particle moving in a potential free region is given by $\psi(k) = A\cos kx$, where A and k are real constants. Is ψ an eigenstate of the operators $\hat{H}$ and $\hat{p}_x$? If so, find the corresponding eigenvalues.

(c) What is zero-point energy? 4+(2+2)+2=10

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(c) For an electron in a one-dimensional infinite potential well of width 1 Å, calculate the separation between the two lowest energy levels and frequency of the photon corresponding to a transition between these two levels. (2+2)+3+3=10

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TDP (General) 5th Semester Exam., 2018

PHYSICS

(General)

FIFTH PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, selecting **two** from each Unit

UNIT—I

1. (a) State and establish Poynting's theorem.

(b) From Maxwell's equation

$$\vec{\nabla}\times\vec{E} = -\frac{\partial\vec{B}}{\partial t} \quad \text{and} \quad \vec{\nabla}\times\vec{H} = \vec{j} + \frac{\partial\vec{D}}{\partial t}$$

show that $\vec{\nabla}\cdot\vec{B} = 0$ and $\vec{\nabla}\cdot\vec{D} = \rho$.

(c) How is population inversion achieved in ruby laser? (1+3)+3+3=10

2. (a) Draw a flowchart to find the smallest among N given input numbers. The value of N is to be given as an input.

(b) Illustrate the use of FOR-NEXT and IF-THEN-ELSE statements in basic programming with example.

(c) What are the basic components of lasing action? 3+4+3=10

3. (a) Draw the logic circuit of the Boolean expression $Y = AB + \overline{A}\overline{B}$. Write the corresponding truth table.

(b) What is the importance of a flip-flop in digital system?

(c) Perform the binary addition of 101 and 100 using full-adder and half-adder circuits. (2+2)+2+4=10

UNIT—II

4. (a) Derive Planck's energy distribution law of black-body radiation.

(b) State and explain de Broglie hypothesis of matter wave.

(c) Calculate de Broglie wavelength of an electron moving with velocity $\frac{3}{5}c$. 5+2+3=10

5. (a) What is matter wave? Find an expression for the wavelength of the matter wave associated with an electron accelerated through a potential difference V.

(b) Find the eigenfunction for the momentum operator.

(c) The wave function of a particle confined in a box of length a is

$$\psi(x) = \sqrt{\frac{a}{2}} \sin \frac{\pi x}{a}, \quad 0 \le x \le a$$

Calculate the probability of finding the particle in the region $0 < x < a/2$. (1+3)+3+3=10

6. (a) What is the necessity of normalizing a wave function? Give Born's interpretation regarding wave function.

(b) Show that the lowest ground-state energy of a particle in one-dimensional potential box with rigid walls is in agreement with the uncertainty principle.

6. *(a)* Explain briefly the concept of zero-point energy for motion of a free particle in a one-dimensional box.

(b) The lowest energy of a free particle entrapped in a one-dimensional box is 40 eV. What are the next two higher energies the particle can have?

(c) What do you mean by eigenvalue and eigenfunction related to quantum mechanical operator?

(d) Normalise the one-dimensional wave function for a free particle in a box of width l given by

$$\psi_n(x) = \begin{cases} A\sin\left(\frac{n\pi x}{l}\right), & \text{for } 0 < x < l \\ 0, & \text{outside} \end{cases}$$

The symbols have their usual meanings. 2+2+3+3=10

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TDP (General) 5th Semester Exam., 2017

PHYSICS

(General)

FIFTH PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, selecting **two** from each Unit

UNIT—I

1. *(a)* Write down the four Maxwell's electromagnetic field equations. Using plane wave solution, show that electromagnetic waves in free space are transverse in nature.

(b) State and mathematically express Poynting theorem. Using this expression, define Poynting vector.

(c) Calculate the magnitude of Poynting vector at the surface of a hot spherical radiating body of radius 2×10^6 m. Given, power radiated by the body = 4×10^{22} watt. (2+3)+(2+1)+2=10

2. *(a)* Define core and cladding in optical fibre.

   (b) Mention different types of loss in optical-fibre transmission.

   (c) Discuss different methods of pumping to create a population inversion.

   (d) Explain spontaneous emission and stimulated emission.

   (e) Name the active material used in Ruby laser. Which is the prominent wavelength emitted by Ruby laser? 2+2+2+2+2=10

3. *(a)* What are meant by algorithm and flowchart? Draw a flowchart to find the largest among three different numbers given as input.

   (b) Convert $(54 \cdot 75)_{10}$ into binary number.

   (c) Draw a two-input AND gate circuit using *P-N* junction diodes and explain its operation. (2+2)+2+(1+3)=10

UNIT—II

4. *(a)* Using the expression for Planck's energy distribution law for blackbody radiation, show that Wien's radiation law and Rayleigh-Jeans radiation law are the limiting cases of Planck's distribution law.

   (b) The de Broglie wavelength of an electron is 1Å in non-relativistic motion. What is its velocity?

   (c) State Heisenberg's uncertainty principle.

   (d) Prove that for rotational motion of a particle the uncertainty principle can be stated in the form

$$\Delta L \cdot \Delta \phi \geq \hbar$$

   where ΔL is the uncertainty in the angular momentum of the particle and $\Delta \phi$ is the uncertainty in its angular position. 4+2+1+3=10

5. *(a)* What should be the important properties of a well-behaved and physically acceptable wave function? Explain Born's interpretation of wave function.

   (b) A proton and deuteron have the same kinetic energy. Which of the two has longer de Broglie wavelength?

   (c) Establish Schrödinger's time-independent one-dimensional wave equation from the classical differential equation of wave. (2+2)+2+4=10

(b) Draw the energy-level diagram for a particle confined in one-dimensional box.

(c) An electron is confined in a one-dimensional box of width 4Å. Find the energy of the electron in the first excited state. 5+2+3=10

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TDP (General) 5th Semester Exam., 2016

PHYSICS

(General)

FIFTH PAPER

Full Marks : 40

Time : 2 hours

The figures in the margin indicate full marks for the questions

Answer **four** questions, selecting **two** from each Unit

UNIT—I

1. (a) Establish the equation of electromagnetic wave propagation in free space using Maxwell's electromagnetic equations.

(b) Discuss the advantages of graded index fibre over step-index fibre.

(c) What are meant by temporal and spatial coherences? 5+2+3=10

2. *(a)* Write down the differences between ROM and RAM.

(b) What is meant by machine language? How does it differ from assembly language?

(c) Draw a flowchart to find the sum of the square of first N natural numbers.

(d) Write a basic program to find the factorial of a given number N. N will be given as input. 2+(1+1)+3+3=10

3. *(a)* Simplify the Boolean expression :

$$Y = (\overline{A+B})(\overline{A}+\overline{C})(\overline{B}+\overline{C})$$

(b) Design a two-input XOR gate using only NAND gates.

(c) Give the truth table of a half-adder.

(d) Discuss with truth table the working of a D flip-flop. 2+3+2+3=10

UNIT—II

4. *(a)* Derive Planck's energy distribution law of black-body radiation.

(b) Show that the de Broglie wavelength of a particle of rest mass m_0 and kinetic energy E_k is given by

$$\lambda = \frac{h}{\sqrt{2m_0E_k}}\left(1+\frac{E_k}{2m_0c^2}\right)^{-\frac{1}{2}}$$

where h is Planck's constant and c is the velocity of light in free space.

(c) What is Bohr's complementary principle? 5+3+2=10

5. *(a)* Draw the energy distribution curves for black-body radiation at various temperatures. Hence explain the nature of the curves.

(b) Deduce the quantum mechanical operator forms of momentum and energy.

(c) Show that the function $\psi(x) = Ae^{ikx} + Be^{-ikx}$ is an eigen function of $\hat{p}^2$, where $\hat{p}$ is the momentum operator. 4+4+2=10

6. *(a)* Solve the Schrödinger's wave equation for a free particle confined in a one-dimensional box to obtain normalized wave function.