

Bs/PHYM-5(T)

2025

(FYUGP)

(5th Semester)

PHYSICS

(MINOR)

Paper Code : PHYM-5(T)

(Elements of Modern Physics)

Full Marks : 75

Pass Marks : 40%

Time : 3 hours

(PART : B—DESCRIPTIVE)

(Marks : 50)

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

Answer **five** questions, taking **one** from each Group

GROUP—A

1. (a) Prove that the rest mass of a photon is zero. 3
- (b) What is threshold frequency? With a neat graph explain the effect of frequency on stopping potential. 4

26L/201a

(Turn Over)

(2)

- (c) Determine the phase and group velocity of an electron with $1.2 \text{ \AA}$ de Broglie wavelength. 3
2. Derive an expression of Planck's law for blackbody radiation in terms of wavelength. 10

GROUP—B

3. (a) With a suitable diagram derive the Heisenberg's uncertainty principle from the hypothetical gamma ray microscope. 7
- (b) What is an eigenfunction and eigenvalue? 3
4. (a) Derive an expression for the wave function associated with a free particle. 4
- (b) Prove that the linear combination of the solution of Schrödinger equation is also the solution of the same equation. 6

GROUP—C

5. Explain the classical and quantum interpretation for the quantum mechanical scattering across a potential step for energy less than the step height. 10

26L/201a

(Continued)

(3)

6. (a) With the application of tunnelling effect explain the emission of an alpha particle. 4
- (b) For a particle of mass m confined in a region inside the well $0 < x < L$, determine the solution of the wave function associated with the particle by applying the boundary condition. 6

GROUP—D

7. (a) Derive the semi-empirical mass (Bethe-Weizsacker) formula. 5
- (b) State the law of radio-active decay. Show that radio-active decay is exponential in nature. 5
8. (a) Discuss various properties of nuclear forces. 5
- (b) What is the difference between β^- decay, β^+ decay and electron capture? 5

GROUP—E

9. (a) What is thermonuclear energy? Explain its importance in the universe. $2+4=6$
- (b) Explain the function of moderator in Uranium fed nuclear reactor. 4

26L/201a

(Turn Over)

10. (a) Describe the nuclear fission on the basis of liquid drop model. 5
- (b) With a suitable diagram, explain the working of a breeder reactor. 5

Subject Code : Bs/PHYM-5(T)

Booklet No. A

71

Date Stamp

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To be filled in by the Candidate

BA / BSc / BCom / BBA / BCA
5th Semester End Term
Examination, 2025 (FYUGP)

Subject

Paper

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Roll No.

Regn. No.

Subject

Paper

DESCRIPTIVE TYPE

Booklet No. B

INSTRUCTIONS TO CANDIDATES

1. The Booklet No. of this script should be quoted in the answer script meant for descriptive type questions and vice versa.
2. This paper should be ANSWERED FIRST and submitted within 1 (one) Hour of the commencement of the Examination.
3. While answering the questions of this booklet, any cutting, erasing, overwriting or furnishing more than one answer is prohibited. Any rough work, if required, should be done only on the main Answer Book. Instructions given in each question should be followed for answering that question only.

Signature of
Scrutiniser(s)

Signature of
Examiner(s)

Signature of
Invigilator(s)



2025

(FYUGP)

(5th Semester)

PHYSICS

(MINOR)

Paper Code : PHYM-5(T)

(Elements of Modern Physics)

(PART : A—OBJECTIVE)

(Marks : 25)

The figures in the margin indicate full marks for the questions

SECTION—I

(Marks : 15)

Put a Tick (✓) mark against the correct answer in the brackets provided : $1 \times 15 = 15$

1. A 10 kilowatt radio transmitter operates at a frequency of 880 kHz. How many photons per second does it emit?

- (a) 1.231×10^{31} ()
(b) 1.440×10^{31} ()
(c) 1.716×10^{31} ()
(d) 1.921×10^{31} ()

2. Photoelectrons are emitted from a metal surface only when the incident light exceeds a certain minimum

(a) intensity ()

(b) wavelength ()

(c) velocity ()

(d) frequency ()

3. Planck's constant has the dimension of

(a) linear momentum ()

(b) angular momentum ()

(c) energy ()

(d) force ()

4. An electron of mass 9.1×10^{-31} kg has a velocity of 1 km/s with an accuracy of 0.05%. Then the uncertainty with which the position of the electron can be located is

(a) 1.45×10^{-3} m ()

(b) 2.26×10^{-3} m ()

(c) 3.103×10^{-3} m ()

(d) 4.79×10^{-3} m ()

5. The probability of finding a particle in a distance dx around a point x is

(a) ψ^* ()

(b) $\psi\psi^*$ ()

(c) $\psi\psi^* dx$ ()

(d) ψ ()

6. Which of the following statements is true?

I. The linear momentum operator is given by $\hat{p} = i\hbar\vec{\nabla}$.

II. When the total energy operator $\hat{E}$ operates on a function, the result is the function of the system.

III. Hamiltonian operator and total energy E of the system are different.

(a) I ()

(b) II ()

(c) III ()

(d) None of the above ()

7. The energy of a particle in a one-dimensional closed box of length l is

- (a) directly proportional to l ()
- (b) directly proportional to l^2 ()
- (c) inversely proportional to l ()
- (d) inversely proportional to l^2 ()

8. The reflection coefficient for a particle incident on a potential step with energy E less than the height of the step is

- (a) 0 ()
- (b) $\frac{1}{2}$ ()
- (c) 1 ()
- (d) 2 ()

9. A particle is in the ground state of an infinite square well of width l . What will be the probability of finding the particle in a distance $\Delta x = 0.1l$ at $x = l/2$?

- (a) 0.02 ()
- (b) 0.04 ()
- (c) 0.06 ()
- (d) 0.08 ()

10. The mass of a nucleus

- (a) is always greater than the mass of its constituent particles ()
- (b) is always less than the mass of its constituent particles ()
- (c) is always equal to the mass of its constituent particles ()
- (d) can be any of the above depending on how stable the nucleus is ()

11. The nuclei ${}^{13}_6\text{C}_7$ and ${}^{14}_7\text{N}_7$ can be described as

- (a) isotones ()
- (b) isotopes ()
- (c) isobars ()
- (d) mirror nuclei ()

12. Liquid drop model of a nucleus cannot explain

- (a) nuclear fission ()
- (b) nuclear fusion ()
- (c) spin and magnetic moment of nuclei ()
- (d) None of the above ()

13. The wavelength(s) of photons contributing to lasing action of ruby laser is/are

- (a) 6943 Å ()
- (b) 6927 Å ()
- (c) Both (a) and (b) ()
- (d) None of the above ()

14. Laser beam is coherent due to

- (a) narrow line width ()
- (b) high implication ()
- (c) fixed phase relationship among the photons ()
- (d) high mono-chromaticity ()

15. Most of the breeder reactors use a mixture of

- (a) UO and PuO₂ ()
- (b) UO₂ and PuO₂ ()
- (c) UO₂ and PuO ()
- (d) UO and PuO ()

SECTION—II

(Marks : 10)

Answer any *five* questions :

2×5=10

1. Does every photon incident on a photocathode cause the emission of an electron? Justify.

2. Why de Broglie wavelength cannot be observed in a fast moving cricket ball?

2x5=10

Answer any five questions :

1. Does every photon incident on a photocathode cause the emission of an electron? Justify.

(a) Yes (b) No

(c) Avoids one to none (d)

14. Laser beam is coherent due to

(a) narrow line width

(b) high implication

(c) fixed phase relationship among the photons

(d) high mono-chromaticity

15. Most of the breeder reactors use a mixture of

(a) UO_2 and PuO_2

(b) UO_2 and PuO_2

(c) UO_2 and PuO_2

(d) UO_2 and PuO_2

3. What is meant by normalization of a wave function?

4. Applying the uncertainty principle, explain the non-existence of electrons in the atomic nucleus.

5. Explain quantum dot as an example of particle in a box.

6. What is probability current density?

7. Define mirror nuclei.

8. Define radioactivity.

9. Why lasing medium must have at least three energy levels?

10. What is meant by a mass deficit?
