



**2022/TDC (CBCS)/EVEN/SEM/
PHSHCC-402T/114**

TDC (CBCS) Even Semester Exam., 2022

PHYSICS

(Honours)

(4th Semester)

Course No. : PSHHCC-402T

(Elements of Modern Physics)

Full Marks : 50

Pass Marks : 20

Time : 3 hours

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

SECTION—A

Answer any ten of the following questions :

2×10=20

1. State Planck's quantum hypothesis.
2. What is quantum theory of light?
3. What is matter wave? Whose variations give rise to matter wave? 1+1=2
4. State Heisenberg uncertainty principle. Mention its mathematical expression. 1+1=2



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5. Does the uncertainty in quantum mechanics arise because of some errors in measurements? Justify your answer.
6. What is the uncertainty in momentum for a single monochromatic wave?
7. What do you mean by stationary state?
8. What is the importance of normalizing a wave function?
9. Can the wave function $\psi(r) = A \sin(kn - \omega t)$ represent a free particle? Justify your answer.
10. What is called zero point energy of a particle in one-dimensional box?
11. What is quantum mechanical tunnel effect?
12. What do you mean by dynamical evolution of a quantum state?
13. Write the full form of LASER. Mention some of its uses. 1+1=2
14. Why can fusion take place only at very high temperature?
15. Define mean life and half life in the context of radioactivity. 1+1=2

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(3)

SECTION - B

Answer any five of the following questions : $6 \times 5 = 30$

16. Define phase velocity and group velocity. Show that if phase velocity is constant, then group velocity is equal to the phase velocity. 2+4=6
17. Explain Davisson and Germer experiment in detail with necessary diagrams.
18. (a) How does the concept of Bohr orbit violate the principle of uncertainty? 2
(b) Using uncertainty relation, show that electrons cannot reside within a nucleus. 4
19. (a) Obtain the expression of ground state energy of hydrogen atom using uncertainty relation. 4
(b) If the uncertainty in the location of a particle is equal to the de Broglie wavelength, then find its uncertainty in velocity. 2

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(Turn Over)



(4)

20. (a) What are the fundamental postulates of quantum mechanics? 3
(b) Normalize the wave function
$$\psi(x) = Ae^{-\alpha x^2}$$
where A and α are constants. 3
21. (a) Deduce the orthogonality condition of wave functions. 3
(b) Show that the probability current density for the wave function
$$\psi(x, t) = Ae^{i\phi(x, t)}$$
 is $A^2 \frac{\hbar}{m} \frac{\partial \phi}{\partial x}$ where A is a constant. 3
22. (a) Why should wave function be single-valued everywhere? 2
(b) Deduce the one-dimensional Schrödinger equation for a particle of mass m in time-dependent form. 4
23. (a) A particle cannot exist in one-dimensional infinitely rigid box if its energy is zero. Justify. 3
(b) For a potential step, write down the two Schrödinger equations corresponding to the regions $x < 0$ and $x > 0$ for the case $E > V_0$. Also write the boundary conditions at the junction between two regions. 1+1+1=3

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(5)

24. (a) What is radioactivity? 1
(b) State the radioactive decay laws. Using these laws, deduce the equation
$$N = N_0 e^{-\lambda t}$$
where symbols have their own meanings. 2+3=5
25. (a) Distinguish between nuclear fission and nuclear fusion. 3
(b) Mention three differences between spontaneous emission and stimulated emission. 3

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