

STELLA MARIS COLLEGE (AUTONOMOUS) CHENNAI – 600 086
(For candidates admitted from the academic year 2023 – 2024)

B.Sc. DEGREE EXAMINATION, APRIL 2026
BRANCH III - PHYSICS
SIXTH SEMESTER

COURSE : MAJOR CORE
PAPER : QUANTUM MECHANICS AND RELATIVITY
SUBJECT CODE : 23PH/MC/QR64
TIME : 3 HOURS **MAX. MARKS: 100**

Q. No.	SECTION A Answer ALL the questions 20 x 1 = 20 marks	CO	KL
1	The uncertainty in the location of a particle is equal to its de-Broglie wavelength. Then the uncertainty in its velocity will be equal to: (a) its velocity (b) half of its velocity (c) twice its velocity (d) four times of its velocity	1	1
2	Matter waves are significant only for (a) Macroscopic objects (b) Microscopic particles (c) massless objects (d) atomic particles	1	1
3	The De Broglie wavelength of a particle is given by a) $\lambda = hv$ b) $\lambda = h/p$ c) $\lambda = mv^2$ d) $\lambda = hc$	1	1
4	The wave nature of electrons was experimentally proved by (a) Davisson and Germer (b) Niels Bohr and Albert Einstein (c) Max Planck and Werner Heisenberg (d) Erwin Schrödinger and Paul Dirac	1	1
5	The values of energy for which Schrodinger equation can be solved, are called (a) wave function (b) eigenvalues (c) probable values (d) none of these.	1	1
6	Schrodinger equation can be written as (a) $H\Psi + E\Psi=0$ (b) $H\Psi - E\Psi =0$ (c) $H\Psi= 0$ (d) $E\Psi = 0$	1	1
7	Electrons with energy E are incident on a potential step of height V such that $E > V$. Which of the following is wave mechanically true? (a) electrons will be transmitted (b) electrons will be reflected (c) partial reflection and partial transmission will take place (d) all the above.	1	1
8	The tunnelling effect is a (a) classical phenomenon (b) quantum mechanical phenomenon (c) classical as well as quantum mechanical (d) none of the above.	1	1

9	The Hamiltonian operator represents (a) Energy (b) Momentum (c) Force (d) Velocity	1	1
10	The eigenvalue equation is written as (a) $A\psi = a\psi$ (b) $A\psi = \psi A$ (c) $A\psi = 0$ (d) $A = \psi$	1	1
11	The commutator of two operators A and B is defined as (a) $AB+BA$ (b) $AB-BA$ (c) $BA-AB$ (d) A/B	1	1
12	Special theory of relativity deals with the events in the frames of reference which moves with constant (a) velocity (b) speed (c) acceleration (d) momentum	1	1
13	Under Galilean transformations which of the following is variant? (a) torque (a) time (c) angular momentum (d) none of these	1	1
14	A reference frame attached to the earth (a) is an inertial frame by definition (b) is an inertial frame because the earth is the frame (c) cannot be inertial frame because the earth is revolving round the sun. (d) cannot be an inertial frame because the earth is rotating about it own axis	1	1
15	The special relativity shows that Newtonian mechanics is valid at (a) velocities much smaller than that of light (b) velocities nearer to that of light (c) all velocities (d) velocities much greater than that of light	1	1
16	An astronaut moves in a super spaceship travelling at a speed of 0.8 c. The astronaut observes a photon approaching him from space. The speed of photon with respect to the astronaut is (a) c (b) 1.8 c (c) 0.9 c (d) 0.2 c	1	1
17	Decay of u-meson supports (a) length contraction (b) time dilation (c) relativity of mass (d) relativity of energy	1	1
18	The Michelson Morley experiment was designed to measure (a) relativistic mass of electron (b) relativistic energy of electron (c) velocity of earth relative to ether. (d) acceleration of gravity on earth's surface.	1	1
19	Rest mass of a particle is defined as (a) zero mass (b) mass when particle is absolutely at rest (c) mass when moving with speed of sound (d) mass when moving with speed of light.	1	1

20	Of the two twin brothers, one goes on a relativistic tour and come back. The brother on tour will (a) become older (b) become younger (c) will be of the same age (d) none of these	1	1
Q. No.	SECTION B Answer ALL the questions 10 x 2 = 20 marks	CO	KL
21	What is meant by matter waves?	2	2
22	State Heisenberg uncertainty principle.	2	2
23	Define degeneracy of energy levels.	2	2
24	What is quantum tunnelling?	2	2
25	Define an operator.	2	2
26	Obtain the commutation relation between parity and symmetry Hamiltonian operator.	2	2
27	State Newtonian relativity.	2	2
28	What is meant by ether drift?	2	2
29	What is relativistic momentum?	2	2
30	Give the significance of Einstein's mass energy relation.	2	2
Q. No.	SECTION C Answer any TWO questions 2 x 10 = 20 marks	CO	KL
31	Derive the relation between particle velocity, group velocity, and phase velocity.	3	3
32	Establish time independent schrodinger equation.	3	3
33	Explain the Michelson morley experiment dicuss the results.	3	3
34	Derive Lorentz transformation equations.	3	3
Q. No.	SECTION D Answer any TWO questions 2 x 10 = 20 marks	CO	KL
35	Explain the Davisson–Germer experiment and how it confirms the wave nature of electrons.	4	4
36	Solve the Schrodinger equation for a particle in a one dimensional rigid box and obtain its eigen values.	4	4
37	Derive the commutation relation between position and momentum operators.	4	4
38	Explain meson paradox using the concept of time dilation.	4	4
Q. No.	SECTION E Answer any FOUR questions 4 x 5 = 20 marks	CO	KL
39	From a sodium surface light of wavelength 3125Å and 3650 Å causes emission of electrons whose maximum kinetic energy is 2.128 eV and 1.595 eV, respectively. Estimate Planck's constant and work function of sodium.	5	5
40	If A and B are Hermitian operators, show that (AB+BA) is Hermitian and (AB-BA) is not Hermitian.	5	5

41	A particle is in motion along a line between $x = 0$ and $x = a$ with zero potential energy, and at points for which $x < 0$ and $x > a$ the potential energy is infinite. The wave function for the particle in the n th state is given by: $\Psi_n = A \sin (n\pi x/a)$ Find the expression for the normalized wave function.	5	5
42	A certain particle called meson has a life time 2×10^{-6} sec. (a) What is the mean life time when the particle is travelling with a speed of 2.994×10^8 m/sec? (b) How far does it go during one mean life? (c) What distance would be travelled without relativistic effects?	5	5
43	In Michelson-Morley experiment the length of the paths of the two beam is 11 meter each. The wavelength of the light used is 6000 \AA . If the expected fringe-shift is 0.4 fringe. Calculate the velocity of earth relative to ether.	5	5
44	(a) Find the lowest energy of an electron confined in a cubical box of each side 1 \AA . (b) Find the temperature at which the average energy of the molecules of a perfect gas would be equal to the lowest energy of the electron. (Given $= 1.38 \times 10^{-23} \text{ J/}^\circ\text{K}$).	5	5
