Bachelor of Science Examination, 2019
(2nd Year, 1st Semester)
Physics

Paper-HO6

Time: 2 hours Full Marks : 50

Group-A

Answer any five questions

1. Write D' Alemberts Principle. Obtain Euler Lagrange equation of motion from D'Alembert's equation. 1+4

2. A body of mass *m* connected to a spring of force constant k is capable of vibrating in a linear direction on a horizontal table. Find Lagrangian of the system. Write Euler Lagrange equation and then find the angular frequency. What will be Hamiltonian of the system? Write Hamilton's canonical equation. 1+(1+1)+1+1

3. What is Canonical transformation? What are Generating Functions? What are the common four Generating Functions? What is the Poisson Bracket of [Q, P] if transformation is canonical? 1+1+1+2

4. Obtain equation of motion of a body of mass *m* in a rotating frame of reference rotating with a constant angular velocity *w*. Describe the terms in the equation. 3+2

5. What do you mean by rigid body? How many degrees of freedom are there for a rigid body?- Explain your answer. What are Euler angles?-Draw a diagram to describe them 1+2+2

6. Obtain Lagrangian of a system undergoing small oscillations about equilibrium. Then obtain equation of motion in terms of kinetic energy T and potential energy V. Write it in matrix form. 2+2+1

7. What do you mean by generalized momenta? How a generalized momenta conjugate to a cyclic co-ordinate behaves? Show that torque acting on a particle in a central force field is zero. Write the Hamiltonian of a free particle in three dimensional space. 1+1+2+1

Ref No. : Ex/int/phy/I/VI/22/19(OLD)

Inter B.Sc. 1st Semester Examination 2019 (OLD)

Paper - HO6

Group B

(Modern Physics-I)

Answer Q. No. **1 (any four)** and any **Three** from the rest.

Some physical constants and their values:
$c = 3 \times 10^8$ m/s; $h = 6.62 \times 10^{-34}$ J.s; $k_B = 1.38 \times 10^{-23}$ J/K; $e = 1.6 \times 10^{-19}$ C;
$m_e = 9.11 \times 10^{-31}$ kg; $m_p = 1.672 \times 10^{-27}$ kg; $m_\alpha = 6.6447 \times 10^{-27}$ kg;
$\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2; $N_A = 6.023 \times 10^{23}$ mol^{-1}; $R_H = 1.097 \times 10^7\, m^{-1}$

1. (i) A beam of X rays is scattered by electrons at rest. What is the energy of the X rays if the wavelength of the X rays scattered 60° to the beam axis is 0.035 A. [2.5]

   (ii) What is the approximate number of photons emitted per second by a 5.00 mW laser pointer ? [2.5]

   (iii) Compute the wavelength of the H_β spectral line, that is, the second line of the Balmer series predicted by Bohr's model. [2.5]

   (iv) The half-life of radium is 1590 years. In how many years will 1 gm of radium be reduced to 1 centigram ?

   (v) What is maximum velocity of photo-electrons emitted when 250 nm light strikes a clean aluminum plate? The work function of Al = 4.20 eV. [2.5]

   (vi) What should be the cut-off wavelength of X-ray for an accelerating voltage of 30 kV. [2.5]

2. (i) Calculate the change in minimum energy of an atomic oscillator for each case when it is sending out 540-nm light (green) and 700-nm light (red).
   (ii) Now you consider a pendulum undergoing small oscillations with length $l = 1$ m. According to classical theory, if air friction is present, the amplitude

of swing and consequently the energy decrease continuously with time. Actually, all systems vibrating with frequency ν are quantized (according to equation $E_n = nh\nu$) and lose energy in discrete packets or quanta, $h\nu$. This would lead to a decrease of the pendulum's energy in a step-wise manner. How you will show that there is no contradiction between quantum theory and the observed behavior of laboratory pendulums and springs. Calculate the fractional change in energy of the pendulum. For this purpose, you use classical physics to calculate the total energy of a pendulum having mass $m = 10$g and displacement through an angle $\theta = 10°$. [2+3]

3. (i) N_{10} be the number of parent atoms initially and λ_1 and λ_2 are the decay constant of the parent and daughter respectively. Show that the time at which the number of daughter atoms is a maximum is given by

$$t_m = \frac{\ln(\lambda_1/\lambda_2)}{\lambda_1 - \lambda_2}.$$

Assuming that there is no daughter atoms at the beginning of decay of parent atoms i.e. $N_{20} = 0$ at $t = 0$.
(ii) The half-life of a radioactive nucleus is 2.5 days. What % of the original substance will have disintegrated in 7.5 days ? [3+2]

4. (i) Find the quantum number n corresponding to the excited state of He^+ if on transition to the ground state that ion emits two photons in succession with wavelengths 108.5 and 30.4 nm.
(ii) Calculate the Rydberg's constant R, if He^+ ions are known to have the wavelength difference between the first (longest wavelength) lines of the Balmer and Lyman series equal to $\Delta\lambda = 133.7$ nm. [2.5+2.5]

5. (i) A beam of X-rays spectrometer is induced on a crystal of inter-planner spacing 2.82 A at an angle 14°. The operating voltage is gradually increased. An intense reflection appears when the operating is 9.1 kV. Find the value of the Planck's constant.
(ii) Find the wavelength of the short-wave limit of the continuous x-ray spectrum, if it shifts by 0.50 A when the voltage applied to an x-ray tube increases 2.0 times. [2.5+2.5]

6. (i) How can Moseley's law be derived from Bohr's theory ?
(ii) How many elements are there in a row of the periodic table between those whose wavelenghts of K_α line are equal to 250 pm and 179 pm ? [2.5+2.5]