Bachelor of Science Examination, 2018
(2nd Year, 1st Semester)
Physics (Honours)

Paper-HO-6

Time: 2 hours **Full Marks: 50**
(25 marks for each group)

Use separate Answer Script for each group

GROUP-A

Answer any five questions

1. What are constraints? Explain with examples scleronomic and rheonomic constraints. Explain in which aspects Lagrangian formulation is advantageous to Newtonian mechanics. Explain Principle of Virtual work. 1+2+1+1

2. State Hamilton's Variational Principle and derive Lagrange equations of motion for conservative systems. What is the importance of Lagrangian undetermined multiplier? 1+3+1

3. Consider a pendulum made out of a spring with a mass m on the end. The equilibrium length of the spring is l. Write the Lagrangian of the system and determine the equations of motion using Lagrangian mechanics. Show that if a co-ordinate is cyclic in Lagrangian, it is also cyclic in Hamiltonian. 4+1

4. A one-dimensional harmonic oscillator has Hamiltonian $H = \frac{1}{2}p^2 + \frac{1}{2}\omega^2 q^2$. Write down Hamiltonian's equation and find the general solution. Show whether $Q=l/p$ and $P=qp^2$ are canonical transformation or not. 3+2

5. If **F** be the net force acting on a particle in fixed frame of reference then what is the expression for effective force $\mathbf{F}_{eff}$ appeared in a uniformly rotating frame of reference? Explain each terms. If an object is projected vertically up with speed of 20 m/sec then how far and where it will land? given angular velocity of earth to be 0.7×10^{-4} rad/sec. 2+3

6. What is meant by Principal axes of a rigid body? Write Euler's equation of motion for a rigid body. Applying the equations on a free symmetric top show that angular velocity describes a cone about a body axis. 1+1+3

7. Distinguish between stable and unstable equilibrium. Consider a coupled parallel pendula each having mass m and length l connected by a massless spring of force constant k. Obtain the normal frequencies of vibration. 2+3

Ref No. :

BACHELOR OF SCIENCE EXAMINATION, 2018

(2nd Year, 1st Semester)

Physics (Honours)

Paper - HO6

Group B

(Modern Physics-I)

Answer any *Five* questions.

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; $\epsilon_0 = 8.85 \times 10^{-12}$ C^2/N.m^2;
$N_A = 6.023 \times 10^{23}$ mol^{-1}; $R_H = 1.097 \times 10^7 m^{-1}$; 1 curie= 3.7×10^{10} disinte/sec

1. (a) Calculate the average energy of Planck's oscillator for $\frac{h\nu}{k_B T} = 0.01, 0.1, 1.0, 10.$

   (b) A spring mass system has a mass equal to 0.10 kg and a spring constant equal to 10 N/m. The system oscillates with amplitude of 0.10 m. Suppose that the energy of the oscillator is quantized. What is the quantum number n associated with this energy ?

   (c) A 1000 watt radio transmitter operates at a frequency of 88×10^4 Hz. How many photons per second emits from the transmitter ? [2+2+1]

2. (a) A photon of energy $h\nu$ is scattered through an angle θ by a free electron originally at rest. Show that the ratio of the kinetic energy of the recoil electron to the energy of the incident photon is $\frac{x(1-Cos\theta)}{1+x(1-Cos\theta)}$ where $x = \frac{h\nu}{m_e c^2}$.

   (b) Calculate the minimum energy of a photon so that it converts into an electron -positron pair. Find the photon's frequency and wavelength. [4+1]

3. (a) 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.

   (b) 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. [3+2]

4. (a) A beam of X-rays is incident 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.
(b) Find the shortest wavelength 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. [3+2]

5. (a) How can Moseley's law be derived from Bohr's theory ?
(b) 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 ? [3+2]

6. (a) N_{10} is 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 $t = 0$.
(b) A sample of papyrus (a kind of leaves in which ancient people used to write) from an ancient document is found to have 0.78 the C-14 activity of the living plant. If decay constant λ for C-14 is 1.25×10^{-4} per year, calculate the age of the document. [3+2]

7. (a) What might be the effects on a photoelectric effect experiment if we were to double the frequency of the incident light? If we were to double the wavelength? If we were to double the intensity?
(b) When tungsten surface is illuminated with light of wavelength 1800 A, the maximum kinetic energy of the electrons liberated is 1.5 eV. Photoelectric emission ceases when the wavelength of the incident light exceeds 2300 A. From these data, calculate the Planck's constant. [2+3]