Bachelor of Science Examination, 2017
(2nd Year, 1st Semester)
PHYSICS (Honours)
Paper - HO-6

Time : Two hours **Full Marks : 50**

(25 marks for each group)

Use separate Answer Scripts for each group

GROUP - A

Answer any five questions

1. (a) State D'Alembert's principle.
   (b) Use the above principle to find the equation of motion of a simple pendulum.

2+3

2. (a) Show that if a system is conservative and its Lagrangian does not contain time explicitly, then Hamiltonian of the system is equal to total energy.
   (b) What is a cyclic co-ordinate ? Give an example.

3+2

3. (a) A simple pendulum consists of mass 'm_2' at one end and with mass 'm_1' at the point of support moves in a vertical plane under gravity. Mass 'm_1' can move on a horizontal line lying in the plane in which 'm_2' moves. Find the Lagrangian and hence equations of motion of the system.
   (b) A particle of mass 'm' moves on a parabola $z = \frac{x^2}{a}$ in the z-x plane and is acted by a force of gravity in the negative z direction. Find the equilibrium position of the particle and determine the nature of equilibrium.

3+2

4. (a) Show that the Coriolis force due to the rotation of the earth deflects a vertically falling particle in the northern hemisphere towards the east and the deflection is proportional to $h^{\frac{3}{2}}$ for a given colatitude, where h is the height of the fall.

   (b) Show that angular acceleration remains same in fixed and rotating frame.

3+2

5. (a) Explain the physics behind the formation of a cyclone and hence find the linear velocity of a cyclone.

   (b) Why storms like hurricane are always low pressure systems.

3+2

6. (a) Given $L = \frac{1}{2}m(\dot{x}^2 + \dot{y}^2) - \frac{1}{2}(\mu x^2 + \mu y^2 + 2kxy)$. Find the characteristic frequencies and the ratio of the amplitudes.

   (b) What are normal modes ?

4+1

7. (a) Show that Lagrangian is arbitrary by the total time derivative of any arbitrary function of generalised co-ordinates and time.

   (b) Obtain Hamilton's canonical equations of motion.

3+2

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BACHELOR OF SCIENCE EXAMINATION, 2017

(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) Show that the Planck radiation law agrees with the Rayleigh-Jeans formula for large wavelengths.
   (b) A furnace has walls of temperature 1600°C. What is the wavelength of maximum intensity emitted when a small door is opened?
   (c) Show that Planck's radiation law resolves the ultraviolet catastrophe. [2+1+2]

2. (a) Calculate the radius and the velocity of the electron in the first Bohr orbit of Hydrogen atom. Estimate the value of fine structure constant.
   (b) Compute the Rydberg constants for H and He^+ applying the reduced mass correction. Given $m_\alpha = 6.6447 \times 10^{-27}$ kg. [3+2]

3. (a) Consider a potassium surface that is 75 cm away from a 100 watt bulb. Suppose that the energy radiated by the bulb is 5% of the input power. Treating each potassium atom a circular disk of diameter 1A, determine the time required for each atom to absorb an amount of energy equal to its work function of 2.0 eV, according to the wave interpretation of light. It is assumed that all the incident energy has been absorbed.
   (b) Light of wavelength 400 nm is incident upon lithium of work function 2.93 eV. Calculate (i) the photon energy and (ii) the stopping potential in eV.[3+2]

4. High energy photons (γ -rays) are scattered from electrons initially at rest. Assume the photons are backscatterred and their energies are much larger than the electron's rest-mass energy, $E >> m_e c^2$.
(a) Calculate the wavelength shift.
(b) Show that the energy of the scattered photons is half the rest mass energy of the electron, regardless of the energy of the incident photons.
(c) Calculate the electron's recoil kinetic energy if the energy of the incident photons is 150 MeV. [1+3+1]

5. (a) What is the minimum voltage across an X-ray tube that will produce an X-ray having (i) the Compton wavelength and (ii) a wavelength to be capable of pair production (electron and positron).
(b) The Duane-Hunt limit of a continuous spectrum, when an X-ray tube is operated at 50 kV is 0.249×10^{-10} m. Calculate the value of the Planck's constant.
(c) For tungsten the K absorption edge is 0.18 A. It is irradiated with X-rays of wavelength 0.10 A. What is the maximum kinetic energy of photo-electrons that are emitted from K shell? [2+1+2]

6. (a) "Radioactive decay law is a statistical law" —— Explain.
(b) The mean lives of a radioactive substance are 1620 and 405 years for α -emission and β -emission respectively. Find out the time during which three-fourth of a sample will decay if it is decaying both by α -emission and β -emission simultaneously.
(c) One gm of Ra^{226} has an activity of 1 curie. Determine the half-life and average life in year of radium. [2+1+2]

7. Work out the elementary theory of successive disintegration of radio-elements (take 3 successive elements and 3rd element is end-product which is stable). Hence obtain the conditions for their secular and transient equilibrium. [3+2]