16/12/2015

DOON UNIVERSITY, DEHRADUN

End Semester Examination, First Semester, 2015

Department of Physics, School of Physical Sciences

M.Sc. Physics 2 Years

Course: PHC-402: Classical Mechanics

Time Allowed: 3 Hours *Maximum Marks: 30*

Note: Attempt All Questions from Sections A,B,C.

SECTION: A *(Marks:2 X 4 =8)*

1. (i) What are normal coordinates?
   (ii) What are normal frequencies of vibrations of a parallel pendula?
2. (i) Two bodies of mass m and 2m are connected by a spring k. What is the frequency of normal mode?
   (ii) From Lagrangian formulation of central force motion, write down the equation of orbit (statement only) in terms of total energy E, potential V and angular momentum *l*. Further, write down the conditions for trigonometric relationship between *r* (distance) and θ with proper explanation.
3. Derive the Virial theorem. Hence, establish the relation between time average of kinetic energy and potential energy for the inverse-square law forces.
4. (i) For Kepler-problem (inverse-square law of forces), Express the term for effective potential for one body problem assuming frame of reference located at centre of mass. Hence, plot it against the distance (not vector) r.
   (ii) Comment on the dependence of upper and lower bounds upon total energy.

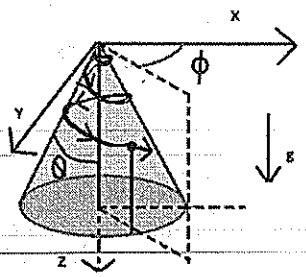
SECTION: B *(Marks: 3 X 4=12)*

5. The potential of a diatomic molecule as a function of distance r between the atoms is given by $V(r)=\frac{a}{r^8}+\frac{b}{r^{16}}$.
   Then, what is the value of the potential at equilibrium separation between the atoms?
6. Derive the Hamiltonian from the Lagarangian. Write down the points of algorithm of the procedure.
7. In a central force field problem, derive the evolution equation of motion in terms of total energy, angular momentum and a general central potential V.
8. Establish the Rutherford scattering formula from the Lagrangian formulation.

SECTION: C *(Marks: 5 X 2=10)*

9. Discuss the vibrations of a linear tri-atomic molecule. Derive the normal frequencies of vibrations for any tri-atomic molecule.

10. A particle is sliding on a cone as shown in the figure. Here, Z- axis is pointing downwards and parallel to the axis of the cone with origin at the vertex of the cone. The X and the Y axes are shown for clarity of the picture. A particle is shown sliding on the surface of this cone under the effect of gravitational acceleration g. The motion is friction-less. The angle of the cone is θ with respect to its principle axis the "Z-axis".



(a) Express the generalized coordinates of the system in terms of spherical polar coordinates.
(b) Express the constraint of the motion.
(c) Hence, express the Lagrangian in terms of the generalized coordinates.
(d) Hence, solve the equation of motion using the Lagrange's equation.