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2009–2010

B.Sc. (HONS.) (PART-III) EXAMINATION

(PHYSICS)

CLASSICAL MECHANICS & SPL. RELATIVITY

(PH – 308)

Maximum Marks : 40 Duration : Three Hours

NOTE: (i) Answer the following questions.
(ii) Symbols/notations, wherever not explained, have their usual meaning.
(iii) Use of calculator is permitted.

1. (a) Explain, giving appropriate examples, what are holonomic constraints. Explain what difficulties do the constraints of motion introduce in the solution of mechanical problems and how are these difficulties removed. (03)

(b) Express the kinetic energy of a system of particles in terms of generalized coordinates. What will be its nature if the transformation equations defining generalized coordinates do not contain the time explicitly ? (04)

OR

1'. (a) Define the terms : generalized coordinates and generalized momentum. Derive the relation which represents D'Alembert's principle. (03)

(b) Show that : $\frac{\partial \vec{r}_i}{\partial q_j} = \frac{\partial \dot{\vec{r}}_j}{\partial \dot{q}_j}$ (01)

(c) Construct the Lagrangian and hence obtain the equation of motion of a simple pendulum. (03)

2. (a) State and explain Hamilton's principle and using this principle derive Lagrange's equations of motion. (04)

(b) Show that the minimum distance between two points in a plane is a straight line. (02)

3. (a) Set up the Lagrangian and equations of motion of a particle moving under the influence of a central force. Hence obtain the differential equation of its orbit. (05)

(b) Obtain the relation which represents virial theorem. Use this theorem to derive Boyle's law for perfect gases. (02)

OR

3'. (a) Derive the equation of the orbit of a particle moving under the influence of an attractive inverse square law force. What will be the shape of the orbit for : (i) $E > 0$ and (ii) $E<0$? (05)

(b) The orbit described by a particle under a central force is given by $r = a(1+\cos\theta)$, where 'a' is a constant. Find the force law. (02)

4. (a) Derive the Rutherford scattering cross-section. Explain why does the total cross-section tend to become infinite. (05)

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(b) A proton collides elastically with a pion at rest in Lab. frame. Calculate the maximum scattering angle in the Lab. frame, $(\theta_1)_{max}$. (02)

5. Answer any THREE parts of the following : (2x3)

(a) Explain the inner and outer products of two tensors.

(b) Write the Newton's equation of motion in covariant form. Discuss the space and time parts of this equation.

(c) Calculate the threshold energy of the incident proton for the following reaction :

$$p + p \longrightarrow \pi^0 + p + n + \pi^+$$

(Take $m_p = m_n = 940$ Mev/c^2 and $m_{\pi+} = m_{\pi o} = 140$ Mev/c^2)

(d) Write the formulae for the kinetic energy and momentum of a relativistic particle in terms of its Lorentz factor. Calculate the values of these quantities for an electron of rest mass 0.51MeV/c^2 moving with a velocity $\left(\sqrt{2/3}\right)c$.

(e) Derive expressions for Lagrangian and Hamiltonian of a relativistic free particle.

6. (a) Define the electromagnetic field tensor in terms of four-potential vector. Obtain the elements of $F_{\mu\nu}$ in terms of the components of $\vec{E}$ and $\vec{B}$ vectors. (03)

OR

(a') State and explain gauge transformation and gauge invariance of fields.

(b) Show that $F'_{\mu\nu} = a_{\mu\alpha}\, a_{\nu\beta}\, F_{\alpha\beta}$ and hence obtain the transformations for the components of $\vec{E}$ and $\vec{B}$ vectors. (04)

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