Physics I
ISI B.Math
Backpaper Exam : December 28, 2011

Total Marks: 100
Answer all questions

1. A particle of mass m and charge e moves in a uniform magnetic field $\mathbf{B} = B_0\mathbf{k}$. It is acted upon by a force $\mathbf{F} = e\,(\mathbf{v} \times \mathbf{B})$. If the particle is projected from the origin with a velocity $\mathbf{v_0}$ at $t = 0$, find its trajectory.**(20)**

2. Consider a block of mass m sliding on a smooth wedge of mass M and an angle α which itself slides on a smooth horizontal floor as shown in Fig 2.
(i)Write down the Lagrangian for this system in terms of the coordinates x , y and their time derivatives and from it find the Euler-Lagrange equations for the wedge-mass system **(5)**
(ii) Find the acceleration of the wedge **(5)**
(iii)Find the acceleration of the block relative to the wedge.**(5)**
(iv) Identify the cyclic coordinate and find the corresponding conserved momentum.**(5)**

3.(a) A billiard ball with speed v approaches an identical stationary one. The balls bounce of elastically, in such a way that the incoming one gets deflected by an angle θ and the stationary one gets deflected by an angle ϕ. Show that $\phi + \theta = \frac{\pi}{2}$ **(5)**
(b) In an elastic collision between an electron with kinetic energy E and an electron at rest, the incoming electron is observed to be deflected through an angle of 30°. What are the energies of the two electrons after the collision?**(5)**
(c) A mass M, initially moving at speed V, collides and sticks to a mass m,initially at rest. Assume $M \gg m$, and work in this approximation. What are the final energies of the two masses and how much energy is lost to heat, in :(i) the lab frame (ii)the frame in which M is initially at rest ? **(10)**

4. (a) A cylinder of mass m, radius r and moment of inertia $I = \frac{1}{2}mr^2$ rolls without slipping down a plane inclined at an angle θ. What is the acceleration of the centre of the cylinder ?[Hint: use conservation of energy]**(10)**
(b) A stick of length l slides perpendicular to itself (without rotating) across a frictionless horizontal table and collides elastically at one of its ends with a stationary ball. Both stick and ball have mass m. The mass of the stick is distributed in such a way that the moment of inertia around the CM, (which is at the centre of the stick) is $I = Aml^2$, where A is some number. What should A be such that the ball moves at the same speed as the centre of the stick after the collision ?**(10)**

5. (a) Given a collection of particles with positions $\mathbf{r_i}$, let the force on the ith particle due to all the others be $\mathbf{F}_i^{int}$. Assuming that the force between any two particles is directed along the line joining them, use Newton's third law to show that $\sum_i \mathbf{r}_i \times \mathbf{F_i}^{int} = 0$ **(10)**
(b) A particle sliding along a radial groove along a rotating turntable has polar coordinates at time t given by $r = ct$, $\theta = \Omega t$, where c and Ω are positive constants. Find the velocity and acceleration vectors at time t and hence deduce that the angle between the velocity and acceleration vectors is always acute for $t > 0$.**(10)**

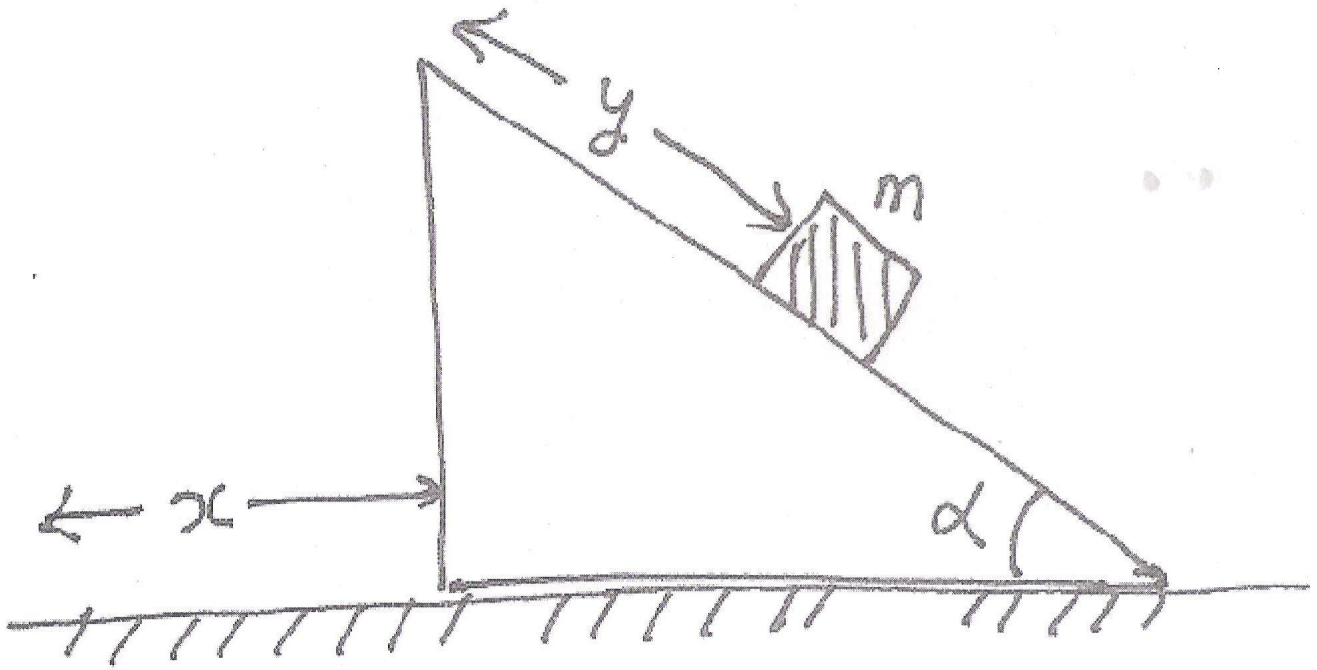

Fig. 2