MECH1 **Problem Sheet 3** **Due Friday March 6**

Mandatory problems: 1,3,4,5 and one out of 6–8.

Dynamics continued, momentum conservation, mass centre

Do all problems

1. (a) A driver going with velocity v slams his breaks. Find the distance the car travels before it stops if the friction coefficient is μ.
   (b) A driver is going along a curve with constant speed v. Find the minimum radius of the curve so that the car does not skid if the friction coefficient is μ.
   (c) A driver suddenly sees a long wall perpendicular to the direction of travel. He can either break or try to avoid collision by turning at the same speed. Use the results of (a) and (b) to argue that he should break (all that counts as failure/success is whether the collision does or does not take place).
   (d) If the wall has a finite length $2l$, and the driver is originally facing its midpoint, find the minimum l when the driver is better off turning away.
2. A particle of mass m_1 collides with another particle of mass m_2, whereupon they form a single particle of mass m. Suppose, the same scenario is viewed in a "rest frame" K and another inertial frame K' which is moving with constant velocity with respect to K. Use the conservation of momentum and Galileo's relativity principle to show that $m = m_1 + m_2$.
3. A man of mass m slowly walks from one end of the boat of mass M to the other. Find the boat's displacement by the time the man reaches the other end of the boat. Do not assume that the boat's mass is distributed uniformly along its length. HINT: use conservation of momentum.
4. A bee sits on the bottom of a small sealed test tube of length l. The test tube is hung vertically over a table by a thread, so that its bottom is at height l above the table. The thread is cut, and as the test tube falls (there is no air resistance), the bee flies up to the tube's sealed top. Assuming that the mass of the bee equals the mass of the test tube, find the time it takes for the lower end of the tube to hit the table.
5. Three particles, of masses $1, 2, 3$ start at the origin and are moving with velocities $3, 2, 1$, along the x, y, and z-axes respectively. Find the trajectory, velocity, and momentum of the mass centre and particles' velocities in the mass centre frame. Verify that the total momentum in the mass centre frame is zero.
6. Show that the mass centre of three unit mass particles A, B, C not lying on the same line is located at the intersection of the medians in the triangle ABC. This point is called the triangle's *centroid*.
7. Show that given a triangle ABC of uniformly distributed mass, its mass centre is located at the centroid.
8. Given three rods of the same material and uniformly distributed mass, forming the triangle ABC, the mass centre lies at the point, where the bisectors of the triangle DEF intersect, where D is the midpoint of the edge AB, E is the midpoint of BC, and F is the midpoint of CA. This is the centre of the circle, inscribed into the triangle DEF.