Homework 12

1)

In vehicle safety trials, a car of mass 1200 kilograms and a van of mass 2000 kilograms were made to crash into each other on a skid-pan. The two vehicles locked together and moved on as one combined mass.

Before impact, taking the x-axis as the direction of the car, the velocity of the car was $18i$ m s^{-1} and the velocity of the van was $(5i + 12j)$ m s^{-1}, where i, j are the unit vectors in the directions of the rectangular axes Ox and Oy respectively.

Given that friction can be ignored, calculate the speed and direction of the combined mass immediately after the crash.   **5**

2)

Two particles, P and Q, of masses 2 kg and m kg respectively, initially lie at rest in a straight line on a smooth horizontal surface. Particle P is acted on by a constant force of 3 N for 4 seconds, causing it to accelerate towards Q. When P collides with Q the particles coalesce and begin to move with speed 3·75 m s^{-1}.

Find the value of m, the mass of particle Q.   **4**

3)

A smooth horizontal surface contains the perpendicular unit vectors i and j. A body of mass 1 kg has velocity $-2i + 4j$ m s^{-1} and collides with a second body of mass 2 kg moving in the plane.

The bodies coalesce and move with velocity $i + 4j$ m s^{-1}.

Calculate the speed of the larger mass before the collision.   **3**

4) A catapult exerts a force $F(t) = 100\cos\frac{1}{2}\pi t$ newtons on a stone for $0 \le t \le 1$, where t seconds is the time that the stone is in contact with the catapult.

Calculate the change in momentum of the stone. **3**

5) A particle of mass 3kg is acted on by a force $F = (4t\mathbf{i} - 2\mathbf{j})$ newtons for 6 seconds. The particle has an initial velocity $v = \left(3\mathbf{i} + \mathbf{j}\right)$ ms^{-1}.

Determine the speed of the particle after 6 seconds. **5**

6) Football players Ali, Billy and Carrie each stand on a different vertex of an equilateral triangle. Ali passes a football of mass m kg which reaches Billy with speed U m s^{-1}. Billy diverts the ball to Carrie with speed U m s^{-1}. Assume that the ball travels between players along the ground in a straight line.

Find an expression, in terms of m and U, for the magnitude of the impulse given to the ball by Billy. **5**