1. Two smooth uniform spheres S and T have equal radii. The mass of S is 0.3 kg and the mass of T is 0.6 kg. The spheres are moving on a smooth horizontal plane and collide obliquely. Immediately before the collision the velocity of S is $\mathbf{u}_1$ m s^{-1} and the velocity of T is $\mathbf{u}_2$ m s^{-1}. The coefficient of restitution between the spheres is 0.5. Immediately after the collision the velocity of S is $(-\mathbf{i} + 2\mathbf{j})$ m s^{-1} and the velocity of T is $(\mathbf{i} + \mathbf{j})$ m s^{-1}. Given that when the spheres collide the line joining their centres is parallel to $\mathbf{i}$,

(a) find

(i) $\mathbf{u}_1$,

(ii) $\mathbf{u}_2$.

(6)

After the collision, T goes on to collide with a smooth vertical wall which is parallel to $\mathbf{j}$. Given that the coefficient of restitution between T and the wall is also 0.5, find

(b) the angle through which the direction of motion of T is deflected as a result of the collision with the wall,

(5)

(c) the loss in kinetic energy of T caused by the collision with the wall.

(3)

(Total 14 marks)

1. (a)

$\uparrow 2$ $\quad$ $\uparrow 1$

$1 \leftarrow$ $\quad$ $\rightarrow 1$

S 0.3 kg $\quad$ T 0.6 kg

$2 \uparrow$ $\quad$ $\uparrow 1$

$\rightarrow v$ $\quad$ $w \leftarrow$

$0.3v - 0.6w = 0.3$ M1 A1

$v - 2w = 1$

$\frac{1}{2}(v + w) = 2$ M1 A1

$v + w = 4$

$w = 1, v = 3$

(i) $\mathbf{u}_1 = 3\mathbf{i} + 2\mathbf{j}$ (ii) $\mathbf{u}_2 = -\mathbf{i} + \mathbf{j}$ A1 A1 6

(b)

$\uparrow 1$

$v \leftarrow$

$v = 0.5$ B1

$1 \uparrow$

$\rightarrow 1$

$\tan\theta = 0.5$ tan θ = their v M1

$\theta = 26.6$ A1

their θ + 45° M1

Defln angle $= 45 + 26.6 = 71.6^{o}$ A1 5

(c) KE Loss = $\frac{1}{2}$ x 0.6 x $\left\{(1^2 + 1^2) - (1^2 + v^2)\right\}$ M1 A1

$= 0.225$ J A1 3

[14]

1. In part (a) many candidates were able to obtain correct equations by applying the conservation of momentum and Newton's experimental law parallel to the line of centres. A common mistake, however, was to solve the equations and give the speed of the spheres rather than the velocities as required in the question.

The need to move from a question posed in vectors to scalar equations caused difficulties for some candidates. Many produced a momentum equation in **i** and **j**, rather than confining themselves to consideration of the components parallel to the line of centres. The j component did not always cancel out. Those candidates who introduced vectors to Newton's Experimental law were penalised for this significant error.

In part (b) the majority of candidates were able to use the coefficient of restitution to find the velocity of the sphere after the collision with the wall and to find the angle between the wall and the path after impact. Far fewer identified and found the correct angle of deflection.

In part (c) the majority of candidates found the loss in kinetic energy correctly. Errors were usually due to failure to find v^2 correctly from their vectors, or the use of v rather than v^2 in attempting to find the kinetic energy.