QQQ – Further Mechanics 1 - Chapter 1 – Impulse and Momentum (v1)

Total Marks: 26

(26 = Platinum, 23 = Gold, 20 = Silver, 17 = Bronze)

1.

A particle of mass 0.25 kg is moving with velocity $(3\mathbf{i} + 7\mathbf{j})$ m s^{-1} when it receives the impulse $(5\mathbf{i} - 3\mathbf{j})$ N s.

Find the speed of the particle immediately after the impulse.

(5)

2.

A small ball of mass 0.3 kg is released from rest from a point 3.6 m above horizontal ground. The ball falls freely under gravity, hits the ground and rebounds vertically upwards.

In the first impact with the ground, the ball receives an impulse of magnitude 4.2 N s. The ball is modelled as a particle.

(a) Find the speed of the ball immediately after it first hits the ground.

(5)

3.

A particle P of mass 0.4 kg is moving on rough horizontal ground when it hits a fixed vertical plane wall. Immediately before hitting the wall, P is moving with speed 4 m s^{-1} in a direction perpendicular to the wall. The particle rebounds from the wall and comes to rest at a distance of 5 m from the wall. The coefficient of friction between P and the ground is $\frac{1}{8}$.

Find the magnitude of the impulse exerted on P by the wall.

(7)

4.

Two particles A and B are moving on a smooth horizontal plane. The mass of A is km, where $2 < k < 3$, and the mass of B is m. The particles are moving along the same straight line, but in opposite directions, and they collide directly. Immediately before they collide the speed of A is $2u$ and the speed of B is $4u$. As a result of the collision the speed of A is halved and its direction of motion is reversed.

(a) Find, in terms of k and u, the speed of B immediately after the collision.

(3)

(b) State whether the direction of motion of B changes as a result of the collision, explaining your answer.

(3)

Given that $k = \frac{7}{3}$,

(c) find, in terms of m and u, the magnitude of the impulse that A exerts on B in the collision.

(3)

1.

$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$

$5\mathbf{i} - 3\mathbf{j} = \frac{1}{4}\mathbf{v} - \frac{1}{4}(3\mathbf{i} + 7\mathbf{j})$ M1A1

$\mathbf{v} = 23\mathbf{i} - 5\mathbf{j}$ A1

$|\mathbf{v}| = \sqrt{23^2 + 5^2} = 23.5$ M1A1

(5 marks)

2.

Speed just before impact: $v^2 = u^2 + 2as = 2\times 9.8\times 3.6 (= 70.56)$	M1	3.4	Use the model and *suvat* or energy to find speed before impact
$v = 8.4$ (m s^{-1})	A1	1.1b	Correct answer. Accept $\sqrt{70.56}$, $\sqrt{7.2g}$
Use of $I = mv - mu$: $4.2 = 0.3(w - (-8.4))$	M1	3.1b	A complete strategy to find w: Use the model and impulse-momentum equation using given impulse and their speed of impact. Must be using a difference in velocities. Be vigilant for sign fudges that make the original equation incorrect.
Follow their 8.4	A1ft	1.1b	Correct unsimplified equation using their speed
$w = 5.6$ (m s^{-1})	A1	1.1b	Correct positive answer
	(5)		

3.

$F = \frac{1}{8}\times 0.4g$ M1

$-\frac{1}{8} \leftarrow 0.4g = 0.4a$ M1 A1

$0 = u^2 + 2\left(-\frac{1}{8}g\right) \leftarrow 5$ M1 A1

$I = 0.4\times(3.5 - -4) = 3\text{Ns}$ M1 A1

7

4.

(a)

$2u \rightarrow \quad \leftarrow 4u$ $\qquad km2u - 4mu = -kmu + mv$ M1 A1

$km \quad m$ $\qquad u(3k-4) = v$ A1 (3)

$u \leftarrow \quad \rightarrow v$

(b)

$k > 2 \Rightarrow v > 0 \Rightarrow$ dir^{n} of motion reversed M1A1A1 cso (3)

(c)

For B, $m(u(3k-4) - -4u)$

$= 7mu$ M1 A1 f.t. A1 (3)

[9]