QQQ – Further Mechanics 1 - Chapter 1 – Impulse and Momentum (v2)

Total Marks: 26

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

1.

[*In this question* **i** *and* **j** *are perpendicular unit vectors in a horizontal plane.*]

A ball has mass 0.2 kg. It is moving with velocity $(30\mathbf{i})$ m s^{-1} when it is struck by a bat. The bat exerts an impulse of $(-4\mathbf{i} + 4\mathbf{j})$ Ns on the ball.

Find

(*a*) the velocity of the ball immediately after the impact,

(3)

(*b*) the angle through which the ball is deflected as a result of the impact,

(2)

2.

Two particles A and B, of mass 3 kg and 2 kg respectively, are moving in the same direction on a smooth horizontal table when they collide directly. Immediately before the collision, the speed of A is 4 m s^{-1} and the speed of B is 1.5 m s^{-1}. In the collision, the particles join to form a single particle C.

(*a*) Find the speed of C immediately after the collision.

(3)

Two particles P and Q have mass 3 kg and m kg respectively. They are moving towards each other in opposite directions on a smooth horizontal table. Each particle has speed 4 m s^{-1}, when they collide directly. In this collision, the direction of motion of each particle is reversed. The speed of P immediately after the collision is 2 m s^{-1} and the speed of Q is 1 m s^{-1}.

(*b*) Find

(i) the value of m,

(3)

(ii) the magnitude of the impulse exerted on Q in the collision.

(2)

3.

A ball of mass 0.2 kg is projected vertically downwards with speed U m s^{-1} from a point A which is 2.5 m above horizontal ground. The ball hits the ground. Immediately after hitting the ground, the ball rebounds vertically with a speed of 10 m s^{-1}. The ball receives an impulse of magnitude 7 N s in its impact with the ground. By modelling the ball as a particle and ignoring air resistance, find

(a) the value of U.

(6)

After hitting the ground, the ball moves vertically upwards and passes through a point B which is 1 m above the ground.

(b) Find the time between the instant when the ball hits the ground and the instant when the ball first passes through B.

(4)

(c) Sketch a velocity-time graph for the motion of the ball from when it was projected from A to when it first passes through B. (You need not make any further calculations to draw this sketch.)

(3)

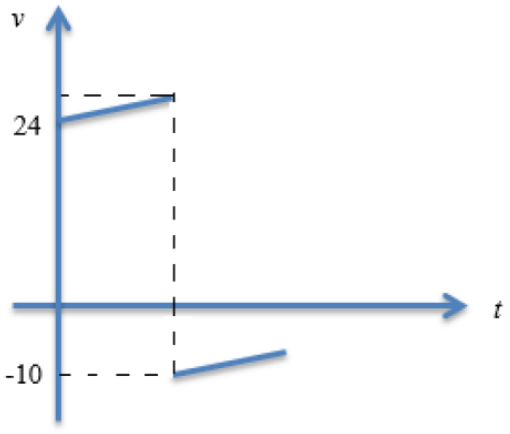
1.

(a)	$\mathbf{I} = m\mathbf{v} - m\mathbf{u}$		
	$-4\mathbf{i} + 4\mathbf{j} = 0.2\mathbf{v} - 0.2 \times 30\mathbf{i}$		M1 A1
	$\mathbf{v} = 10\mathbf{i} + 20\mathbf{j}$ (m s^{-1})		A1 3
(b)	$\tan\theta = \frac{20}{10}$		M1
	$\theta = 63.4°$	accept awrt $63°$ or 1.1^c	A1 2

2.

(a)	CLM: $3 \times 4 + 2 \times 1.5 = 5 \times v$		M1 A1
	$\Rightarrow v = \underline{3 \text{ m s}^{-1}}$		A1 (3)
(b) (i)	CLM: $3 \times 4 - m \times 4 = -3 \times 2 + m \times 1$		M1 A1
	$\Rightarrow m = \underline{3.6}$		A1 (3)
(ii)	$I = 3.6(4 + 1)$	[or $3(4 + 2)$]	M1
	$= \underline{18 \text{ Ns}}$		A1√ (2)
			8

3

(a)	$V^2 = U^2 + 2g \times 2.5$		M1A1
	Eliminate V *and* solve for U		A1 **(DM1)**
	$7 = 0.2(10 - -V)$		M1A1
	$U = 24$		A1 (6)
(b)	$1 = 10t - 4.9t^2$	**OR** e.g. $v^2 = 10^2 - 2 \times 9.8 \times 1$ and $v = 10 - 9.8t$	
	$1 = 10t - 4.9t^2$	to give $\sqrt{80.4} = 10 - 9.8t$	M1 A1
	$t = \frac{10 \pm \sqrt{100 - 19.6}}{9.8}$	so $t = \frac{10 - \sqrt{10^2 - 2 \times 9.8 \times 1}}{9.8}$	**DM**1
	$t = 0.11$ s or 0.105 s		A1 (4)
(c)			B1**ft**1st line B1 2nd line B1 ,-10 (3)
			(13)