1. Particle P has mass m kg and particle Q has mass $3m$ kg. The particles are moving in opposite directions along a smooth horizontal plane when they collide directly. Immediately before the collision P has speed $4u$ ms^{-1} and Q has speed ku ms^{-1}, where k is a constant. As a result of the collision the direction of motion of each particle is reversed and the speed of each particle is halved.

(a) Find the value of k.

(4)

(b) Find, in terms of m and u, the magnitude of the impulse exerted on P by Q.

(3)
(Total 7 marks)

2. A particle A of mass 2 kg is moving along a straight horizontal line with speed 12 m s^{-1}. Another particle B of mass m kg is moving along the same straight line, in the opposite direction to A, with speed 8 m s^{-1}. The particles collide. The direction of motion of A is unchanged by the collision. Immediately after the collision, A is moving with speed 3 m s^{-1} and B is moving with speed 4 m s^{-1}. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(2)

(b) the value of m.

(4)
(Total 6 marks)

3. Two particles A and B are moving on a smooth horizontal plane. The mass of A is $2m$ 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 $3u$. The magnitude of the impulse received by each particle in the collision is $\frac{7mu}{2}$.

Find

(a) the speed of A immediately after the collision,

(3)

(b) the speed of B immediately after the collision.

(3)
(Total 6 marks)

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)
(Total 9 marks)

5. Two particles A and B, of mass 0.3 kg and m kg respectively, are moving in opposite directions along the same straight horizontal line so that the particles collide directly. Immediately before the collision, the speeds of A and B are 8 m s^{-1} and 4 m s^{-1} respectively. In the collision the direction of motion of each particle is reversed and, immediately after the collision, the speed of each particle is 2 m s^{-1}. Find

(a) the magnitude of the impulse exerted by B on A in the collision,

(3)

(b) the value of m.

(4)
(Total 7 marks)

6. A particle P of mass 0.3 kg is moving with speed u m s^{-1} in a straight line on a smooth horizontal table. The particle P collides directly with a particle Q of mass 0.6 kg, which is at rest on the table. Immediately after the particles collide, P has speed 2 m s^{-1} and Q has speed 5 m s^{-1}. The direction of motion of P is reversed by the collision. Find

(a) the value of u,

(4)

(b) the magnitude of the impulse exerted by P on Q.

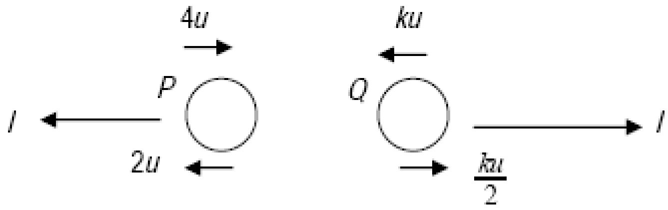
(2)

Immediately after the collision, a constant force of magnitude R newtons is applied to Q in the direction directly opposite to the direction of motion of Q. As a result Q is brought to rest in 1.5s.

(c) Find the value of R.

(4)
(Total 10 marks)

1. (a)



$4mu - 3mku = -2mu + 3mk\dfrac{u}{2}$ M1 A1

$k = \dfrac{4}{3}$ M1 A1cso 4

(b) For *P*, $I = m(2u - -4u)$ M1 A1
$= 6mu$ A1 3

OR

For *Q*, $I = 3m\left(\dfrac{ku}{2} - -ku\right)$ (M1 A1)

[7]

2. (a) $I = 2\times12 - 2\times3 = 18$ (N s) M1 A1 2

(b) LM $2\times12 - 8m = 2\times3 + 4m$ M1 A1
Solving to $m = 1.5$ DM1 A1 4

Alternative

$I = m(4-(-8)) = 18$ M1 A1
Solving to $m = 1.5$ DM1 A1

[6]

3. (a) For *A*: $-\dfrac{7mu}{2} = 2m(v_A - 2u)$ M1 A1

$v_A = \dfrac{u}{4}$ A1 3

(b) For *B*: $\dfrac{7mu}{2} = m(v_B - -3u)$ M1 A1

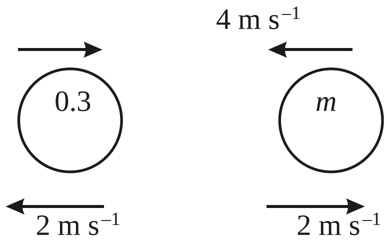
$v_B = \dfrac{u}{2}$ A1 3

OR CLM:

	$4mu - 3mu = 2m\dfrac{u}{4} + mv_B$	M1 A1	
	$v_B = \dfrac{u}{2}$	A1	
			[6]

4.	(a)	$2u \rightarrow \quad \leftarrow 4u$ $km2u - 4mu = -kmu + mv$	M1 A1	
		$km \quad m$ $u(3k - 4) = v$		
		$u \leftarrow \quad \rightarrow v$	A1	3
	(b)	$k > 2 \Rightarrow v > 0 \Rightarrow$ dir^n of motion reversed	M1A1A1 cso	3
	(c)	For B, $m(u(3k - 4) - -4u)$		
		$= 7\,mu$	M1 A1 f.t. A1	3
				[9]

5.



(a)	A: $I = 0.3(8 + 2)$	M1A1	
	$= 3$ (Ns)	A1	3
(b)	LM $0.3 \times 8 - 4m = 0.3 \times (-2) + 2m$	M1A1	
	$m = 0.5$	DM1A1	4
	Alternative		
	B: $m(4 + 2) = 3$	M1A1	
	$m = 0.5$	DM1A1	4
	The two parts of this question may be done in either order.		
			[7]

6	(a)	CLM $0.3u = 0.3 \times (-2) + 0.6 \times 5$	M1A1	
		$u = 8$	M1A1	4
	(b)	$I = 0.6 \times 5 = 3$ (Ns)	M1A1	2

(c)	$v = u + at \Rightarrow 5 = a \times 1.5$ ($a = \frac{10}{3}$)	M1A1	
	N2L $R = 0.6 \times \frac{10}{3} = 2$	M1 A1	4

[10]

1. This question produced very many correct responses. In part (a) most candidates were able to apply the conservation of momentum principle with few problems, with many candidates achieving all four marks. As usual a significant number, maybe fewer than in previous years, made sign errors, with the occasional candidate missing the odd '*m*'s or '*u*'s. Very few put '*g*'s into the equation while others had difficulty in manipulating the fractions Arithmetic errors in working out the value of *k* were not uncommon and negative values obtained for *k* seldom alerted the candidates to a possible error in their work. In the second part, the majority of candidates chose to use the change in momentum of *P* with many correct answers being obtained. However there were the inevitable errors with signs, more than in part (a), with too many candidates thinking that a negative answer was acceptable, misunderstanding the meaning of 'magnitude'.

2. This proved to be a good starter and was well-answered by the majority of candidates. In part (a), most knew that impulse = change in momentum and almost all errors were with the signs. Candidates would be well-advised to put impulses, with arrows, on their diagrams as well as velocities. There are still some candidates giving a negative answer for a magnitude which always loses a mark. Most used conservation of momentum in part (b) which was preferable since it did not rely on their answer from the previous part. Those who used impulse = change in momentum again, applied to the other particle, could lose two marks if their answer to part (a) was wrong.

3. Impulses continue to cause problems and a correct solution to part (a) was rarely seen. Most candidates know that impulse = change in momentum but few can cope with the signs correctly and the impulse in the first part almost always had the wrong sign. The second part produced more success and if the impulse-momentum principle was used again, this part was independent of part (a) and so full marks could be scored. Some tried to use the conservation of momentum principle in part (b), but this relied on using their possibly incorrect answer to part (a).

4. Almost all candidates attempted to use a conservation of momentum equation in part (a) but there were many who either did not draw a diagram at all or else drew one which did not show the directions of motion of each particle after the collision. This lead to problems in all three parts of the question. Few realised the significance of the question asking for the speed of B, and gave a negative answer $u(4 - 3k)$. There were also sign errors in the momentum equation and general problems dealing with the algebra. The second part required the significance of the range of values of *k* to be explicitly referred to in the identification of direction and there were a number of fully correct and often well-expressed solutions. However, many did not mention *k* at all and scored little. In part (c), many knew the relevant impulse-momentum equation and attempted to apply it to one of the particles but there was often confusion over direction and substitution of values and some gave a negative answer, losing the final mark.

5. Notwithstanding the usual sign errors, this question was more successfully answered than in some previous years.

(a) Sign errors were frequent for this part with $I = 0.3(8 - 2) = 1.8$ being frequently seen. An extra g was not often seen but knowledge of the units for impulse – although not separately marked this time – was tenuous, with N or even N/s being proffered. The requirement for “magnitude” demands a positive answer [“(–)3” was marked down, as being an attempt to have it both ways].

(b) Almost all candidates were able to write down a momentum equation (even if with sign errors) but $6m = 3$ far too often led to the deduction $m = 2$. Sign errors could lead to a negative mass, an outcome which should have alerted candidates to a problem; just dropping the negative sign should not be an option!

6. This was also a good source of marks for many candidates. Most candidates knew to use conservation of momentum in the first part, but there were often sign errors leading to an incorrect value of “12” for u. In part (b), diagrams are advisable so that candidates can clearly define direction when using the Impulse–momentum equation. Some candidates threw away a mark for not giving a positive answer, as a magnitude was required. For the final part, most were able to find the acceleration, but often an extra force appeared when applying $F = ma$.