3 At time t seconds, a force $(4t + 3\,e^{-2t})$ N acts on a particle of mass 3 kg.

The particle can only move in the direction of the force.

When $t = 0$, the particle has velocity 5 m s^{-1}.

Find the velocity of the particle after 4 seconds. *(5 marks)*

3	$F = 4t + 3e^{-2t}$ Using change in momentum $= \int F\,dt$ change in momentum $= \int \left(4t + 3e^{-2t}\right)dt$ $= 2t^2 - \frac{3}{2}e^{-2t} + c$ When $t = 0$, $c = \frac{3}{2}$ New momentum $mv = mu + 2t^2 - \frac{3}{2}e^{-2t} + \frac{3}{2}$ $3v = 3\times5 + 2\times4^2 - \frac{3}{2}e^{-8} + \frac{3}{2}$ $v = \frac{97}{6} - \frac{1}{2}e^{-8}$ m/s	M1 M1 M1 A1 A1		
	Total		**5**	

4 A shell lying at rest on the ground explodes into two parts, one of mass $8m$ and the other of mass m. Both parts move horizontally.

The relative velocity of the two parts immediately after the explosion is $36u$.

Find the speeds of the two parts immediately after the explosion. *(6 marks)*

4	$v \leftarrow (8m)\ (m) \rightarrow V$ C of Momentum $8m.v - mV = 0$ Relative velocity $v + V = 36u$ $v = 4u \quad V = 32u$ Parts move in opposite directions: shown by diagram OR by correcting – sign in velocity to give speed	 M1 A1 M1 A1 A1 B1	 **(6)**	
		TOTAL	**(6)**	

1 A squash ball, of mass 40 grams, is travelling horizontally at 12 m s^{-1}. It strikes a wall which is perpendicular to its velocity and rebounds directly with speed 8 m s^{-1}.

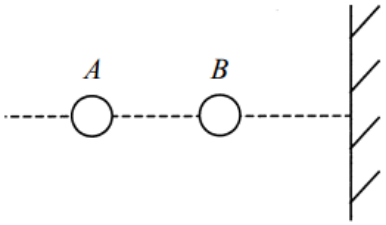
(a) Calculate the impulse acting on the ball. *(4 marks)*

(b) The ball is in contact with the wall for 0.05 seconds. Find the magnitude of the average force acting on the ball during the time that it is in contact with the wall. *(2 marks)*

Question number and part	Solution	Marks	Total marks	Comments
1(a)	Change in momentum is $0.04 \times 12 - 0.04 \times -8$ Impulse is 0.8 Ns	 B1 M1 B1 A1	 4	 Conversion to kg Correct signs – 0.8 B2 M1
(b)	Using Force × time = impulse Force = $\frac{0.8}{0.05}$ = 16 N	 M1 A1√	 2	 ft
	Total		**6**	

5 Two spheres, A of mass $2m$ and B of mass m, are at rest on a smooth horizontal surface.

The centres of the spheres lie on a straight line which is perpendicular to a fixed smooth vertical wall. All motion takes place in the direction of this line.



Sphere A is hit by a blow of impulse J and moves with a speed of $3u$ directly towards the wall.

Model the spheres as particles.

(a) Find J in terms of m and u. *(2 marks)*

(b) Sphere A collides directly with sphere B which is at rest.

The coefficient of restitution in this collision is $\frac{3}{5}$.

Find the speeds of A and B after this impact in terms of u. *(6 marks)*

(c) Sphere B now hits the wall.

The coefficient of restitution between the sphere and the wall is $\frac{1}{2}$.

Find the speed of B after it strikes the wall. *(2 marks)*

(d) Initially sphere B is a distance $4a$ from the wall.

Find the distance of B from the wall when B and A collide again. *(7 marks)*

Question Number and part	Solution	Marks	Total	Comments
5(a)	Impulse = change in momentum	M1		
	$J = 2m \times 3\mu$			
	$J = 6mu$	A1	2	
(b)	Conservation of momentum	M1		
	$6mu = 2mv_a + mv_b$	A1		
	Restitution	M1		
	$3u \times e = 3u \times \frac{3}{5} = v_a - v_a$	A1		
	$6u = 2v_a + v_b$			
	Subtracting $\frac{21}{5}u = 3v_a$			
	$\frac{7}{5}u = v_a$	A1		
	$6u + \frac{18}{5}u = 3v_b$			
	$v_b = \frac{16}{5}u$	A1	6	
(c)	Velocity after impact is $e \times$ velocity before impact	M1		
	$= \frac{1}{2} \times \frac{16}{5}u$			
	$= \frac{8}{5}u$	A1√	2	ft [from (b)]
(d)	Time taken for B to strike wall after collision is $\frac{4a}{\frac{16u}{5}}$	M1		
	$= \frac{5a}{4u}$	A1√		ft [from (b)]
	In this time A has travelled $\frac{7}{5}u \times \frac{5a}{4u}$			
	$= \frac{7}{4}a$	B1		
	Two spheres are $\frac{9}{4a}$ apart	B1√		ft [from above]
	Speeds of spheres are (A) $\frac{7}{5}u$ and (B) $\frac{8}{5}u$	A1		
	Distance from the wall is $\frac{8}{15} \times \frac{9}{4}a$	M1		
	$= \frac{6}{5}a$	A1	7	
	Total		**17**	