3.1 Further Mechanics: Momentum, Impulse and Collisions: Test Pack

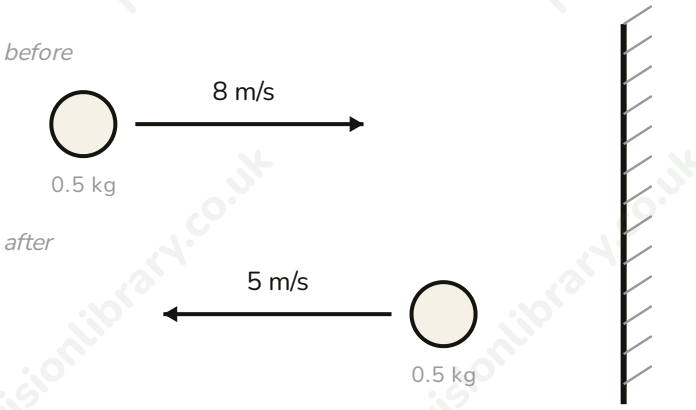
AQA 7367 · Calculator allowed · about 60 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A small ball of mass 0.5 kg is thrown so that it travels perpendicular to a smooth vertical wall. It strikes the wall with speed 8 m/s and rebounds, moving directly back along its original path, with speed 5 m/s. Calculate the impulse exerted on the ball by the wall, giving its magnitude and direction.



(Total for Question 1 is 3 marks)

---

2 Two smooth spheres, of masses m1 and m2, collide directly. During the collision each sphere exerts a force on the other. By using Newton's third law together with the impulse-momentum principle, prove that the total momentum of the two spheres is conserved during the collision, stating clearly any assumption you make.

(Total for Question 2 is 4 marks)

© Revision Library | revisionlibrary.co.uk

3 A particle P of mass 6 kg is moving with speed 10 m/s along a smooth horizontal straight line. It collides directly with a particle Q of mass 6 kg, which is moving along the same line with velocity 2 m/s (a negative value means moving in the opposite direction to P). After the collision P and Q coalesce.

(a) Find the common velocity of the combined particle after the collision. **(3)**

(b) Find the magnitude of the impulse exerted by Q on P. **(2)**

(c) Find the kinetic energy lost in the collision. **(3)**

(d) The contact between P and Q lasts 0.1 s. Find the magnitude of the average force between them, to 3 significant figures. **(2)**

(Total for Question 3 is 10 marks)

---

4 A small ball of mass 0.3 kg hits a smooth fixed vertical wall at right angles with speed 13 m/s. The coefficient of restitution between the ball and the wall is 2/3.

(a) Find the speed of the ball immediately after it rebounds from the wall. **(2)**

(b) Find the magnitude of the impulse exerted by the wall on the ball. **(2)**

(c) Find the kinetic energy lost at the impact. **(2)**

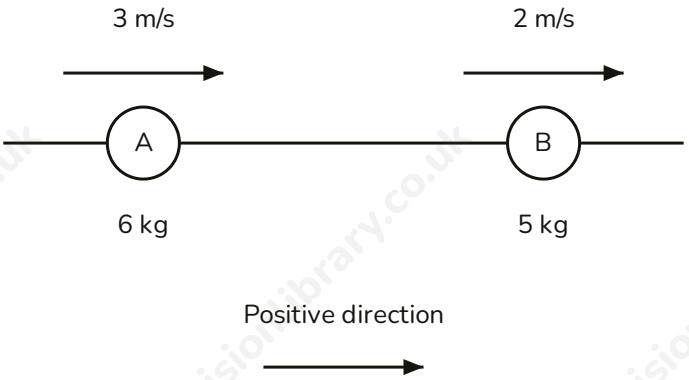
(d) The ball bounces between the wall and a second smooth wall opposite so that each bounce reduces the speed by the same factor. Find the least number of impacts after which the speed is below 2 m/s. **(4)**

(Total for Question 4 is 10 marks)

© Revision Library | revisionlibrary.co.uk

5 Two smooth spheres A and B, of masses 6 kg and 5 kg, are moving in the same straight line on a smooth horizontal table. A has velocity 3 m/s and B has velocity 2 m/s, both measured in the same direction along the line. The spheres collide directly, and the coefficient of restitution between them is 1/5.

Diagram NOT accurately drawn



(a) Find the velocities of A and B immediately after the collision. **(4)**

(b) Find the magnitude of the impulse exerted by A on B in the collision. **(2)**

(c) Find the total kinetic energy lost in the collision. **(3)**

(Total for Question 5 is 9 marks)

---

6 A small ball of mass 2 kg hits a smooth fixed vertical wall at right angles with speed 18 m/s. The coefficient of restitution between the ball and the wall is 1/2.

(a) Find the speed of the ball immediately after it rebounds from the wall. **(2)**

(b) Find the magnitude of the impulse exerted by the wall on the ball. **(2)**

(c) Find the kinetic energy lost at the impact. **(2)**

(d) The ball bounces between the wall and a second smooth wall opposite so that each bounce reduces the speed by the same factor. Find the least number of impacts after which the speed is below 1 m/s. **(4)**

(Total for Question 6 is 10 marks)

© Revision Library | revisionlibrary.co.uk

Mark scheme · 3.1 Further Mechanics: Momentum, Impulse and Collisions: Test Pack

Question 1

uses impulse = m(v - u), taking the direction towards the wall as positive so that u = 8 and v = -5 (oe) **M1**

correct unsimplified expression, e.g. 0.5 x (-5 - 8) **A1**

magnitude of impulse = 6.5 Ns (or 6.5 kg m/s), cao **A1**

Answer: 6.5 Ns (directed away from the wall)

Question 2

lets the spheres exert forces F and -F on each other during the contact time t (Newton's third law) **M1**

applies the impulse-momentum principle to each sphere separately: -Ft = m1(v1-u1) and Ft = m2(v2-u2) **M1**

adds the two equations to eliminate F: 0 = m1(v1-u1) + m2(v2-u2), rearranging to m1 u1 + m2 u2 = m1 v1 + m2 v2 (cso) **A1**

states the assumption clearly: no external horizontal force acts on the system of two spheres during the (brief) collision, e.g. surfaces are smooth and the collision is direct along the line of centres **B1**

Answer: m1 u1 + m2 u2 = m1 v1 + m2 v2 (momentum conserved), assuming no external force acts on the two-sphere system during the collision

Question 3

(a) conservation of momentum: m1 u1 + m2 u2 = (m1 + m2) v **M1**

(a) 60 + (12) = 12v **A1**

(a) v = 6 m/s **A1**

(a) Answer: 6 m/s

(b) change of momentum of P **M1**

(b) 6(6 - 10) = -24 N s **A1**

(b) Answer: 24 N s

(c) KE before - KE after **M1**

(c) 312 - 216 **A1**

(c) 96 J **A1**

(c) Answer: 96 J

(d) force = impulse/time **M1**

(d) 240 N **A1**

(d) Answer: 240 N

Question 4

(a) uses the restitution law: speed after = e x speed before **M1**

(a) 2/3 x 13 = 8.667 m/s **A1**

(a) Answer: 8.667 m/s

(b) impulse = change in momentum, with the velocity reversing **M1**

(b) 0.3(13 + 8.667) = 6.50 N s **A1**

(b) Answer: 6.50 N s

(c) KE before - KE after **M1**

(c) (1/2)(0.3)(13^2)(1 - 4/9) = 14.1 J **A1**

(c) Answer: 14.1 J

(d) forms 13 x $(2/3)^n$ < 2 **M1**

(d) takes logarithms (or tests values of n) **M1**

(d) n > 4.616 **A1**

(d) n = 5 **A1**

(d) Answer: 5

Question 5

(a) conservation of momentum: m1 u1 + m2 u2 = m1 v1 + m2 v2 **M1**

(a) Newton's experimental law: v2 - v1 = e(u1 - u2) **M1**

(a) v1 = 27/11 m/s **A1**

(a) v2 = 146/55 m/s **A1**

(a) Answer: v_A = 27/11 m/s, v_B = 146/55 m/s

(b) impulse = change in momentum of B **M1**

(b) 5(146/55 - (2)) = 36/11 N s **A1**

(b) Answer: 36/11 N s

(c) KE before - KE after **M1**

(c) before 37 J, after 1963/55 J **A1**

(c) loss = 72/55 J **A1**

(c) Answer: 72/55 J

Question 6

(a) uses the restitution law: speed after = e x speed before **M1**

(a) 1/2 x 18 = 9.000 m/s **A1**

(a) Answer: 9.000 m/s

(b) impulse = change in momentum, with the velocity reversing **M1**

(b) 2(18 + 9.000) = 54.0 N s **A1**

(b) Answer: 54.0 N s

(c) KE before - KE after **M1**

(c) (1/2)(2)(18^2)(1 - 1/4) = 243 J **A1**

(c) Answer: 243 J

(d) forms 18 x $(1/2)^n$ < 1 **M1**

(d) takes logarithms (or tests values of n) **M1**

(d) n > 4.170 **A1**

(d) n = 5 **A1**

(d) Answer: 5

© Revision Library | revisionlibrary.co.uk