3.1 Further Mechanics: Momentum, Impulse and Collisions: 30-minute Pack

AQA 7367 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 During a hockey training drill, Priya strikes a hockey ball of mass 0.16 kg that is travelling towards her at 12 m/s. The impact reverses the ball's direction of travel and sends it away from her at 18 m/s. The stick is in contact with the ball for 0.025 seconds.

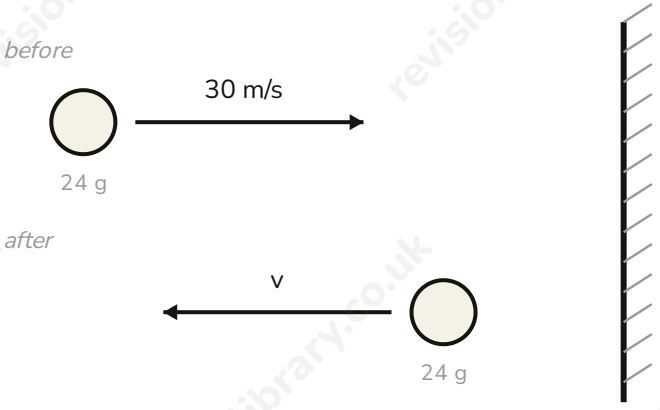
(a) Calculate the magnitude of the impulse exerted on the ball by the stick. **(3)**

(b) Calculate the magnitude of the average force exerted on the ball by the stick during the impact. **(2)**

(Total for Question 1 is 5 marks)

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2 A squash ball of mass 24 grams is served horizontally at a smooth vertical wall with speed 30 m/s. It rebounds and returns along the same horizontal line. The coefficient of restitution between the ball and the wall is e = 0.75.



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

(b) Calculate the impulse exerted by the wall on the ball, stating an appropriate direction. **(3)**

(c) Calculate the percentage of the ball's kinetic energy that is lost in the impact, giving your answer to 3 significant figures. **(2)**

(Total for Question 2 is 7 marks)

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3 A small ball of mass 1.5 kg hits a smooth fixed vertical wall at right angles with speed 6 m/s. The coefficient of restitution between the ball and the wall is 3/4.

(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 3 is 10 marks)

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Mark scheme · 3.1 Further Mechanics: Momentum, Impulse and Collisions: 30-minute Pack

Question 1

(a) uses impulse = m(v - u), taking the ball's initial direction of travel as positive so u = 12 and v = -18 (oe)	**M1**
(a) correct unsimplified expression, e.g. 0.16 x (-18 - 12)	**A1**
(a) magnitude of impulse = 4.8 Ns, cao	**A1**
(a) Answer: 4.8 Ns	
(b) uses force = impulse / time, F = 4.8 / 0.025 (ft on their impulse from part (a))	**M1**
(b) F = 192 N, cao	**A1**
(b) Answer: 192 N	

Question 2

(a) speed after = e x speed before = 0.75 x 30	**M1**
(a) 22.5 m/s, cao	**A1**
(a) Answer: 22.5 m/s	
(b) impulse = m(v-u), taking the ball's original direction as positive so u=30, v=-22.5 (ft from part (a))	**M1**
(b) 0.024 x (-22.5-30) = -1.26, magnitude 1.26 Ns	**A1**
(b) states the direction correctly: away from the wall (opposite to the ball's original direction of travel)	**A1**
(b) Answer: 1.26 Ns, directed away from the wall	
(c) KE before = $0.5(0.024)(30^2)$; KE after = $0.5(0.024)(22.5^2)$ (or uses the shortcut fraction lost = $1 - e^2$)	**M1**
(c) 43.8% (awrt 3 s.f.), cao	**A1**
(c) Answer: 43.8% (3 s.f.)	

Question 3

(a) uses the restitution law: speed after = e x speed before	**M1**
(a) 3/4 x 6 = 4.500 m/s	**A1**
(a) Answer: 4.500 m/s	
(b) impulse = change in momentum, with the velocity reversing	**M1**
(b) 1.5(6 + 4.500) = 15.8 N s	**A1**
(b) Answer: 15.8 N s	
(c) KE before - KE after	**M1**
(c) $(1/2)(1.5)(6^2)(1 - 9/16) = 11.8$ J	**A1**
(c) Answer: 11.8 J	
(d) forms $6 \times (3/4)^n < 1$	**M1**
(d) takes logarithms (or tests values of n)	**M1**
(d) n > 6.228	**A1**
(d) n = 7	**A1**
(d) Answer: 7	

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