3.4 Mechanics and Materials: 30-minute Pack

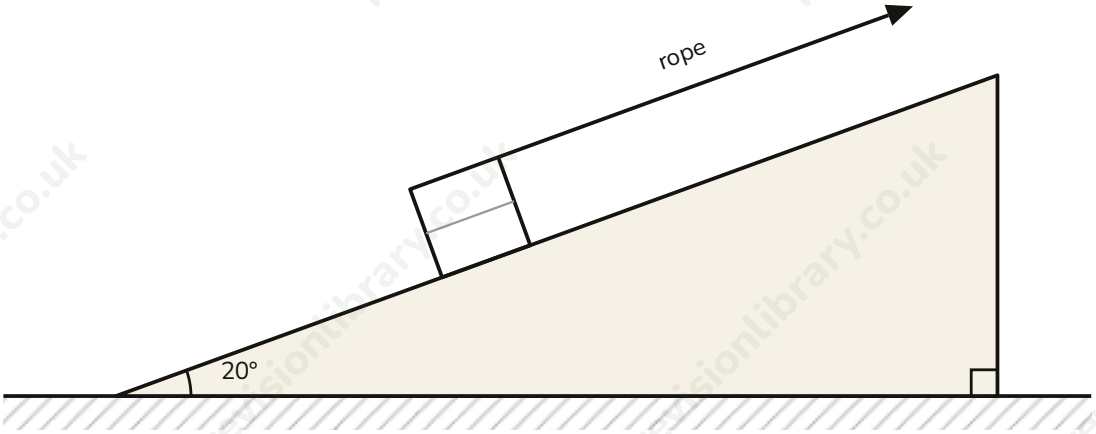
AQA 7408 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A crate of mass 25 kg is pulled at constant velocity up a rough ramp inclined at 20 degrees to the horizontal, using a rope parallel to the slope. The coefficient of friction between the crate and the ramp is 0.15. Take $g = 9.81$ m/s^2.



(a) Calculate the component of the crate's weight acting parallel to the slope. **(2)**

(b) Calculate the normal reaction force acting on the crate. **(2)**

(c) Calculate the frictional force acting on the crate as it moves up the slope. **(2)**

(d) The crate moves up the slope at constant velocity. Calculate the tension in the rope. **(3)**

(Total for Question 1 is 9 marks)

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2 A person of mass 70 kg stands on bathroom scales inside a lift in a shopping centre. Take g = 9.81 m/s^2. Use the Physics Equations Sheet where needed.

(a) The lift accelerates upwards from rest at 2.0 m/s^2. Calculate the reading on the scales (the normal reaction force on the person) during this acceleration. **(3)**

(b) The lift then travels at a constant velocity. Calculate the reading on the scales during this stage. **(2)**

(c) As the lift approaches the top floor it decelerates at 1.5 m/s^2 while still moving upwards. Calculate the reading on the scales during this deceleration. **(3)**

(d) Explain, in terms of Newton's laws, why the person feels lighter while the lift decelerates in part (c). **(2)**

(Total for Question 2 is 10 marks)

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3 A ball of mass 0.16 kg travelling at 12 m/s strikes a wall at right angles and rebounds at 9.0 m/s. The ball is in contact with the wall for 0.050 s.

(a) Calculate the change in momentum of the ball during the collision, taking the direction of the initial velocity as positive. **(2)**

(b) Calculate the magnitude of the average force exerted by the wall on the ball. **(3)**

(Total for Question 3 is 5 marks)

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Mark scheme · 3.4 Mechanics and Materials: 30-minute Pack

Question 1

(a) correct substitution into W sin(20), using W = mg = 245 N (or 245.25 N), oe	**M1**
(a) 83.9 N (accept 83.6-84.0 N), cao	**A1**
(a) Answer: 83.9 N	
(b) correct substitution into N = W cos(20), oe	**M1**
(b) 230 N (accept 229-231 N), awrt	**A1**
(b) Answer: 230.5 N	
(c) correct substitution into F = μ N, using N from part (b), ft	**M1**
(c) 34.6 N (ft from (b)), cao	**A1**
(c) Answer: 34.6 N	
(d) recognise equilibrium along the slope: T = weight component (a) + friction (c)	**M1**
(d) correct substitution using values from (a) and (c), ft	**M1**
(d) 118.5 N (accept 118-119 N, ft), cao	**A1**
(d) Answer: 118.5 N	

Question 2

(a) resultant force equation: R - mg = ma, oe	**M1**
(a) correct substitution: R = 70(9.81 + 2.0)	**M1**
(a) 827 N (accept 826-828 N), awrt	**A1**
(a) Answer: 827 N	
(b) recognise a = 0, so R = mg	**M1**
(b) 687 N (awrt), cao	**A1**
(b) Answer: 687 N	
(c) resultant force equation for deceleration: mg - R = ma, oe, i.e. R = m(g - a)	**M1**
(c) correct substitution: R = 70(9.81 - 1.5)	**M1**
(c) 582 N (accept 580-583 N), awrt	**A1**
(c) Answer: 582 N	
(d) resultant force on the person acts downwards, so the normal reaction (support) force from the scales is smaller than the person's weight	**B1**
(d) by Newton's third law the scales push up on the person with this smaller force, which is sensed as feeling lighter, oe	**B1**
(d) Answer: The reduced normal reaction force during deceleration is felt as a reduced sensation of weight.	

Question 3

(a) change in momentum = m(v - u) = 0.16 x (-9.0 - 12)	**M1**
(a) = -3.36 kg m/s (magnitude 3.36 kg m/s) cao	**A1**
(a) Answer: -3.36 kg m/s (magnitude 3.4 kg m/s)	
(b) quote impulse = change in momentum = F x t	**M1**
(b) substitute F = 3.36 / 0.050	**M1**
(b) F = 67.2 N cao	**A1**
(b) Answer: 67.2 N	

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