3.6 Mechanics: Forces and Newton's Laws Depth: 30-minute Pack

EDEXCEL 9MA0 · Calculator allowed · about 30 minutes

Total Marks

Name: _____ Date: ____ / ____ / _____

Answer ALL questions. Show all your working.

1 A car of mass 1000 kg tows a trailer of mass 500 kg along a straight horizontal road using a light, rigid tow-bar. The driving force is 3500 N and the total resistance to motion is 500 N. Find the acceleration of the car and trailer.

(Total for Question 1 is 2 marks)

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2 A crate of mass 14 kg is pulled along rough horizontal ground by a light rope inclined at an angle θ above the horizontal, where $\sin\theta = 12/13$. The tension in the rope is 47 N. The coefficient of friction between the crate and the ground is 0.1. The crate is modelled as a particle. Take $g = 9.8$ m/s^2.

(a) Find the normal reaction of the ground on the crate, to 3 significant figures. **(3)**

(b) Find the frictional force, and the acceleration of the crate, to 3 significant figures. **(4)**

(Total for Question 2 is 7 marks)

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3 A particle A of mass 4 kg lies on a rough horizontal table. It is attached to a particle B of mass 6 kg by a light inextensible string that passes over a smooth light pulley at the edge of the table. B hangs freely, and the system is released from rest with the string taut. The coefficient of friction between A and the table is 0.3. Take $g = 9.8\ m/s^2$.

(a) Write down equations of motion for A and for B. **(3)**

(b) Hence find the acceleration of the system and the tension in the string, each to 2 significant figures. **(4)**

(c) B is 1.5 m above the floor when released. Find the speed of B as it reaches the floor, to 2 significant figures. **(2)**

(d) After B hits the floor it does not rebound, and A continues to move along the table. Find the further distance A travels before coming to rest, to 2 significant figures, assuming the table is long enough. **(3)**

(Total for Question 3 is 12 marks)

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4 A person of mass 75 kg stands on the floor of a lift. The lift is moving downward and decelerating at $2\ m/s^2$ as it comes to rest at a floor. Take $g = 9.8\ m/s^2$. Find the magnitude of the normal reaction force exerted on the person by the lift floor while it is decelerating, and hence find the magnitude of the force that the person exerts on the floor, stating the law used.

(Total for Question 4 is 4 marks)

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Mark scheme · 3.6 Mechanics: Forces and Newton's Laws Depth: 30-minute Pack

Question 1

whole-system equation: 3500 - 500 = 1500a	**M1**
2 m/s^2 cao	**A1**

Answer: 2 m/s^2

Question 2

(a) resolves vertically: R + T sin θ = mg	**M1**
(a) R = 14 x 9.8 - 47 x 12/13	**A1**
(a) R = 93.8 N	**A1**

(a) Answer: 93.8 N

(b) F = μ R	**M1**
(b) F = 9.38 N	**A1**
(b) resolves horizontally: T cos θ - F = 14a	**M1**
(b) a = 0.621 m/s^2	**A1**

(b) Answer: F = 9.38 N, a = 0.621 m/s^2

Question 3

(a) for B: 6g - T = 6a	**M1**
(a) for A: T - F = 4a with F = 0.3 x 4g	**M1**
(a) both equations correct	**A1**

(a) Answer: B: 6g - T = 6a; A: T - 0.3 x 4g = 4a

(b) adds the two equations to eliminate T	**M1**
(b) a = 4.7 m/s^2	**A1**
(b) substitutes to find T = 6(g - a)	**M1**
(b) T = 31 N	**A1**

(b) Answer: a = 4.7 m/s^2, T = 31 N

(c) uses $v^2 = u^2 + 2as$ with u = 0, a = 4.704, s = 1.5	**M1**
(c) v = 3.8 m/s	**A1**

(c) Answer: 3.8 m/s

(d) deceleration of A is μ g	**M1**
(d) uses $v^2 = u^2 + 2as$ with final speed zero: $0 = 3.757^2 - 2(2.940)s$	**M1**
(d) s = 2.4 m	**A1**

(d) Answer: 2.4 m

Question 4

decelerating downward motion means acceleration is upward: R - mg = ma with a=+2	**M1**
R = 885 N cao	**A1**
invoke Newton's third law	**B1**
force on floor = 885 N (equal magnitude, opposite direction to the force on the person)	**A1**

Answer: R = 885 N; by Newton's third law, the person pushes on the floor with a force of 885 N

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