

Using $F=ma$ without Kinematics

Question Paper 4

Level	A Level
Subject	Maths
Exam Board	AQA
Module	Mechanics 1
Topic	Newton's Law of motion
Sub Topic	Using $F=ma$ without kinematics
Booklet	Question Paper - 4

Time Allowed: 55 minutes

Score: /45

Percentage: /100

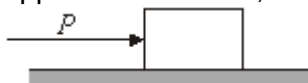
Grade Boundaries:

A*	A	B	C	D	E	U
>85%	'77.5%	70%	62.5%	57.5%	45%	<45%

- Q1.** A sphere of mass 200 grams is released from rest and allowed to fall vertically.
- (a) A student states that the acceleration of the sphere is 9.8 m s^{-2} while it is falling. What modelling assumption is this student making? (1)
- (b) The student conducts an experiment and finds that the acceleration of the ball is in fact 8 m s^{-2} . He formulates a model for the motion that assumes a constant resistance force acts on the ball as it is falling.
- (i) Calculate the magnitude of this resistance force based on this assumption. (3)
- (ii) Describe how the resistance force would vary in reality. (1)
- (c) In a revised model the resistance force is assumed to be proportional to the speed of the sphere.
- (i) State the initial acceleration of the sphere. (1)
- (ii) State what would happen to the acceleration of the sphere if it were able to fall for a long period of time. (1)
- (Total 7 marks)**

- Q2.** A small block, of mass 2 kg, is on a rough horizontal surface. The coefficient of friction

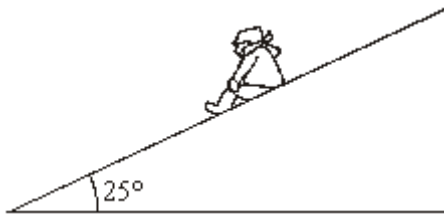
between the block and the surface is $\frac{1}{7}$. A horizontal force of magnitude P newtons is applied to the block, as shown in the diagram.



- (a) The magnitude of the frictional force that acts between the block and the surface is F newtons. Show that the maximum possible value of F is 2.8. (2)

- (b) The value of P increases gradually from 0 to 5.
- (i) When $P = 1$, state the value of F . (1)
- (ii) When $P = 5$, the block moves with constant acceleration $a \text{ m s}^{-2}$. Find the value of a . (4)
- (Total 7 marks)**

- Q3.** A children's slide is straight and inclined at 25° to the horizontal, as shown in the diagram.



Matthew, of mass 35 kg, goes down the slide at constant speed.

- (a) Draw a diagram to show the forces acting on Matthew. (1)
- (b) Find the magnitude of the normal reaction force between Matthew and the slide. (3)
- (c) Find the coefficient of friction between Matthew and the slide. (4)
- (Total 8 marks)**

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Q4. A child kicks a small toy brick in a straight line across a horizontal floor. The brick initially moves at 3.5 m s^{-1} and comes to rest in a distance of 2.5 metres.

(a) Show that the magnitude of the retardation of the brick is 2.45 m s^{-2} .

(3)

(b) The mass of the brick is 0.2 kg.

(i) Find the magnitude of the frictional force acting on the brick.

(2)

(ii) Find the coefficient of friction between the brick and the floor.

(2)

(Total 7 marks)

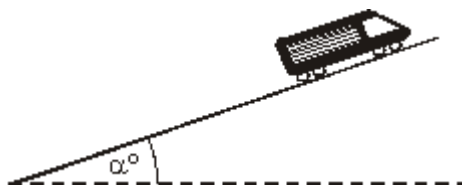
Q5. A mountain railway train moves on a straight track. The mass of the train and its passengers is 1000 kg. During its motion the train moves under the action of a variable propulsive force, P newtons, and a constant resistance force of R newtons.

(a) During the first stage of its motion, the train moves horizontally with acceleration 0.25 m s^{-2} . In this stage, the value of P is 1200.

Show that $R = 950$.

(3)

(b) During the second stage of its motion, the train moves up a slope inclined at an angle α to the horizontal, where $\sin \alpha = 0.1$.

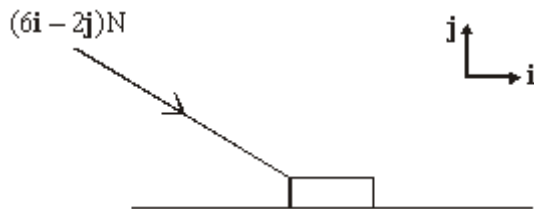


In this stage, the value of $P = 2100$, and the value of R remains at 950. Find the acceleration of the train.

(4)

(Total 7 marks)

- Q6.** A small case is moving on a rough horizontal surface. The case is being pushed with a force $(6\mathbf{i} - 2\mathbf{j})$ newtons, as shown in the diagram.



The case has mass 1.5 kg and moves with acceleration 0.6 m s^{-2} .

- (a) Draw a diagram to show the forces acting on the case. (1)
- (b) Show that the frictional force acting on the case is of magnitude 5.1 newtons. (3)
- (c) Find the normal reaction force between the case and the surface. (3)
- (d) The coefficient of friction between the case and the surface is μ . Find the value of μ . (2)

(Total 9 marks)