Using F=ma without Kinematics

Question Paper 9

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 - 9

Time Allowed: **59 minutes**

Score: **/49**

Percentage: **/100**

Grade Boundaries:

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

Q1. A van has mass 1200 kg. It travels with constant acceleration up a slope inclined at 4° to the horizontal. The length of the slope is 250 metres. At the bottom of the slope the van has a speed of 20 m s^{-1} and at the top its speed has dropped to 15 m s^{-1}.

(a) Show that the acceleration of the van while it is on the slope is –0.35 m s^{-1}

(3)

(b) A simple model assumes that no external resistance forces act on the van. A constant force of magnitude P newtons parallel to the slope acts on the van.

Find P.

(4)

(c) A more realistic model assumes that a resistance force does act on the van. This force has magnitude 300 newtons and acts parallel to the slope. Revise your answer to part (b) to take account of this extra force.

(2)

(d) In reality the resistance force will not be constant. Explain why.

(2)

(Total 11 marks)

Q2. A skier slides in a straight line directly down a slope inclined at 30° to the horizontal. The coefficient of friction between her skis and the slope is 0.3. The skier and her equipment are to be modelled as a particle of mass 80 kg. Assume that there is no air resistance present.

(a) Draw a diagram to show the forces acting on the skier.

(1)

(b) (i) Find the magnitude of the normal reaction force acting on the skier.

(2)

(ii) Show that the magnitude of the friction force acting on the skier is 204 N to three significant figures.

(2)

(c) Find the acceleration of the skier.

(4)

(Total 9 marks)

Q3. After a collision, a car and a van, of combined mass 3000 kg, slide together along a straight horizontal road. The coefficient of friction between the road and the tyres of the vehicles as they slide is 0.7.

(a) Model the car and the van as a single particle.

(i) Show that the magnitude of the frictional force acting is 20 580 N.

(3)

(ii) Find the acceleration of the car and van after the collision.

(2)

(iii) The car and the van slide together for a distance of 5 metres before coming to rest.

Using the result from part (a)(ii), show that just after the collision the car and van were moving at 8.28 m s^{-1} to three significant figures.

(3)

(b) The mass of the car is 1200 kg and the mass of the van is 1800 kg. Before the collision, the van was stationary.

Find the speed of the car just before the collision.

(3)
(Total 11 marks)

Q4. A car accelerates uniformly along a straight horizontal road for 20 seconds. In this time its speed increases from 8 m s^{-1} to 34 m s^{-1}.

(a) Calculate the acceleration of the car.

(3)

(b) Find the distance that the car travels in this time.

(2)

(c) The car has mass 1250 kg and a resistance force of magnitude 400 N acts on the car. Find the magnitude of the forward driving force that acts on the car.

(3)
(Total 8 marks)

Q5. A particle moves on a horizontal plane subject to the following three forces:

$\mathbf{F}_1 = (2\mathbf{i} + 3\mathbf{j})$N, $\mathbf{F}_2 = (6\mathbf{i} - 8\mathbf{j})$N and $\mathbf{F}_3 = (-2\mathbf{i} + 10\mathbf{j})$N

The unit vectors **i** and **j** are perpendicular and lie in the horizontal plane.

Do not include any other forces in your calculations.

(a) Find the resultant force on the particle.

(2)

(b) The mass of the particle is 8 kg. Find the acceleration of the particle.

(1)

(c) At time $t = 0$, the particle is at the origin and has velocity $(3\mathbf{i} - 2\mathbf{j})$ms^{-1}.

(i) Find the velocity of the particle when $t = 40$ seconds.

(2)

(ii) Find the distance of the particle from the origin when $t = 40$ seconds.

(5)
(Total 10 marks)