Newton's laws and kinematics: Horizontal

Question Paper 2

Level	A Level
Subject	Maths
Exam Board	AQA
Module	Mechanics 1
Topic	Newton's Laws of motion
Sub Topic	Newton's laws and kinematics: horizontal
Booklet	Question Paper - 2

Time Allowed: **57 minutes**

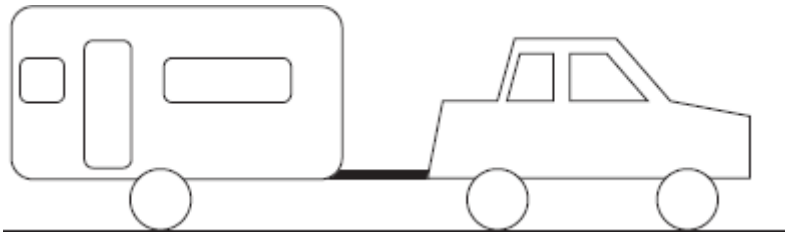
Score: **/47**

Percentage: **/100**

Grade Boundaries:

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

Q1. A car, of mass 1200 kg, tows a caravan, of mass 1000 kg, along a straight horizontal road. The caravan is attached to the car by a horizontal tow bar, as shown in the diagram.



Assume that a constant resistance force of magnitude 200 newtons acts on the car and a constant resistance force of magnitude 300 newtons acts on the caravan.
A constant driving force of magnitude *P* newtons acts on the car in the direction of motion.
The car and caravan accelerate at 0.8 m s^{-2}.

(a) (i) Find *P*.

(3)

(ii) Find the magnitude of the force in the tow bar that connects the car to the caravan.

(3)

(b) (i) Find the time that it takes for the speed of the car and caravan to increase from 7 m s^{-1} to 15 m s^{-1}.

(3)

(ii) Find the distance that they travel in this time.

(3)

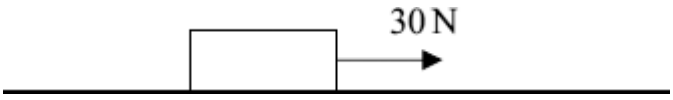
(c) Explain why the assumption that the resistance forces are constant is unrealistic.

(1)

(Total 13 marks)

Q2. A wooden block, of mass 4 kg, is placed on a rough horizontal surface. The

coefficient of friction between the block and the surface is 0.3 . A horizontal force, of magnitude 30 newtons, acts on the block and causes it to accelerate.



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

(1)

(b) Calculate the magnitude of the normal reaction force acting on the block.

(1)

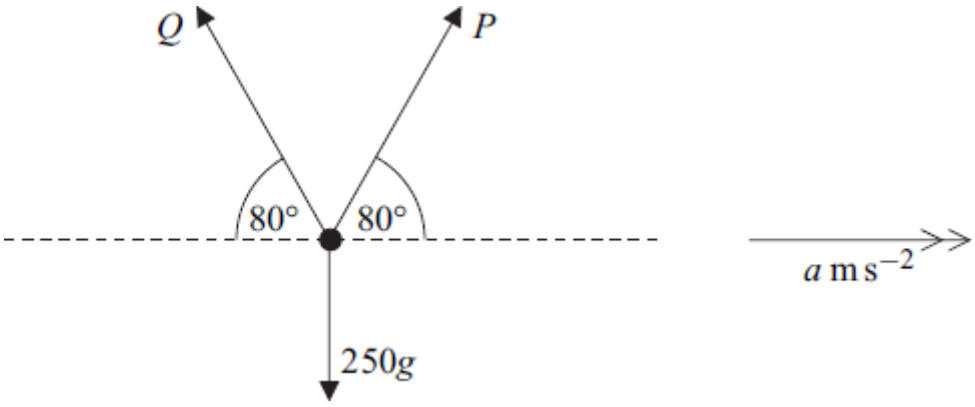
(c) Find the magnitude of the friction force acting on the block.

(2)

(d) Find the acceleration of the block.

(3)
(Total 7 marks)

Q3. Three forces act in a vertical plane on an object of mass 250 kg, as shown in the diagram.



The two forces P newtons and Q newtons each act at 80° to the horizontal. The object accelerates horizontally at a m s^{-2} under the action of these forces.

(a) Show that

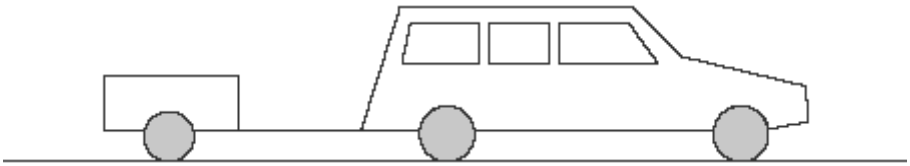
$$P = 125\left(\frac{a}{\cos 80°} + \frac{g}{\sin 80°}\right)$$

(5)

(b) Find the value of a for which Q is zero.

(3)
(Total 8 marks)

Q4. A car, of mass 1400 kg, is towing a trailer, of mass 600 kg. The two vehicles accelerate together at 1.3 m s^{-2} along a straight horizontal road.



(a) Find the distance that the car and trailer would travel while accelerating from rest to 13 m s^{-1}.

(3)

(b) A forward driving force, of magnitude 3900 N, acts on the car. A resistance force, of magnitude 800 N, also acts on the car.

(i) A resistance force, of magnitude P newtons, acts on the trailer. Find P.

(3)

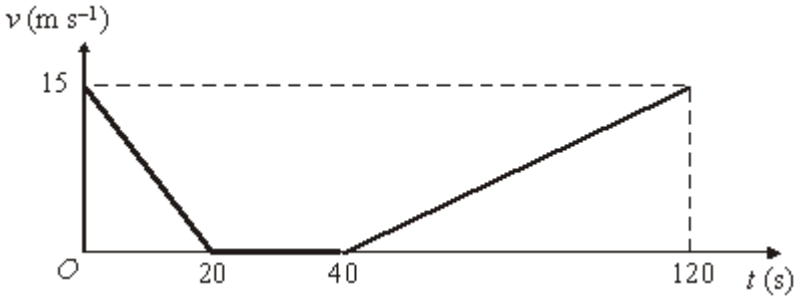
(ii) Find the magnitude of the force that the car exerts on the trailer.

(3)
(Total 9 marks)

Q5. A train travels along a straight horizontal track between two points A and B.

Initially the train is at A and moving at 15 m s^{-1}. Due to a problem, the train has to slow down and stop. At time t = 40 seconds it begins to move again. At time t = 120 seconds the train is at B and moving at 15 m s^{-1} again.

The graph below shows how the velocity of the train varies as it moves from A to B.



(a) Use the graph to find the total distance between the points A and B.

(4)

(b) The train should have travelled between A and B at a constant velocity of 15 m s^{-1}.

(i) Calculate the time that the train would take to travel between A and B at a speed of 15 m s^{-1}.

(1)

(ii) Calculate the time by which the train was delayed.

(1)

(c) The train has mass 500 tonnes. Find the resultant force acting on the train when $40 < t < 120$.

(4)

(Total 10 marks)