

Applications of Dynamic Friction

Question Paper 4

Level	A Level
Subject	Maths
Exam Board	AQA
Module	Mechanics 1
Topic	Newton's Laws of motion
Sub Topic	Applications of dynamic friction
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%

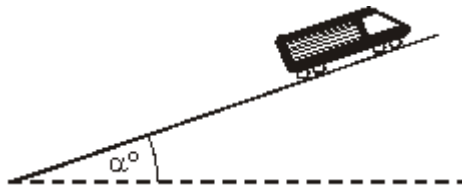
Q1. A mountain railway train moves on a straight track. The mass of the train and its passengers is 1000 kg. During its motion the train moves under the action of a variable propulsive force, P newtons, and a constant resistance force of R newtons.

- (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)

Q2. Two particles, A and B , of masses $3m$ kg and m kg respectively, are moving in the same straight line and in the same direction on a horizontal surface. The particles collide directly. As a result of the collision, the particles coalesce to form a single particle C .

Immediately before the collision, A is moving with speed $v \text{ m s}^{-1}$ and B is moving with speed 2 m s^{-1} . Immediately after the collision, C is moving with speed 1.5 m s^{-1} .

- (a) Find the value of v .

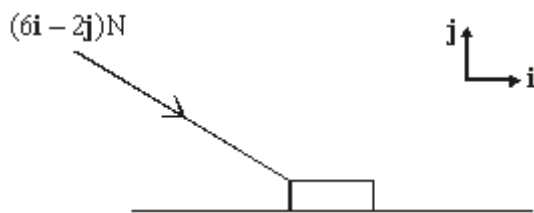
(3)

- (b) The surface on which the particles move is rough. After the collision, C moves with constant retardation and comes to rest at a distance of 3 metres from the point of collision. Find the magnitude of the retardation of C .

(3)

(Total 6 marks)

- Q3.** 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)

- Q4.** A child travels down a slide at a **constant speed**. Model the slide as a rough plane inclined at an angle of 40° to the horizontal. Model the child as a particle of mass 20 kg and assume that there is no air resistance as the child moves.

- (a) (i) Draw a diagram to show the forces acting on the child. (1)
- (ii) Show that the magnitude of the normal reaction force acting on the child is approximately 150 N.

(2)

- (iii) Find the magnitude of the friction force acting on the child and show that the coefficient of friction between the child and the slide is 0.84, correct to two significant figures.

(4)

- (b) In reality, air resistance acts on the child as she slides at a constant speed. How would this affect the value of the coefficient of friction that you calculated in part (a)(iii)?

(1)

(Total 8 marks)

Q5. A particle, of mass 2 kg, is set into motion up a rough slope inclined at 40° to the horizontal. The coefficient of friction between the particle and the slope is 0.3. Assume that there is no air resistance acting on the particle.

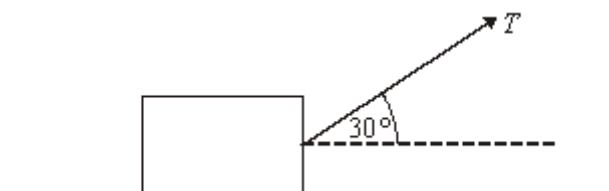
- (a) Find the magnitude of the friction force that acts on the particle.
- (b) Find the acceleration of the particle as it moves up the slope.

(3)

(3)

(Total 6 marks)

Q6. A heavy crate, of mass 200 kg, is pulled along a rough horizontal surface at a constant speed by a rope. The rope is at an angle of 30° to the horizontal. The tension in the rope is T newtons. The coefficient of friction between the crate and the surface is 0.6. Model the crate as a particle.



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- (a) Draw a diagram to show the forces acting on the crate. (1)
- (b) Show that the magnitude of the normal reaction force on the crate is $(1960 - 0.5 T)$ newtons. (3)
- (c) Find T . (5)

(Total 9 marks)