

## A Level Mathematics Year 2 Exam Questions by Topic Chapter 22: A model for friction

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These questions are taken from the Specimen Exam materials and the real 2018 papers for the new syllabus AS and A-level mathematics courses and arranged by chapter of the textbooks by Goldie et al (available here: <https://amzn.to/39umfr5> and <https://amzn.to/3hE8kBL> ). There are a mixture of questions from OCR A, OCR B (MEI), Edexcel and AQA. Although the style of questions varies a little across the exam boards the content of the syllabus is almost identical so these are suitable for students preparing for any exam board.

Free problem sets for all other chapters, as well as video solutions, full past papers and other content for GCSE and A-level maths can be found at:

<https://mathsaurus.com/>

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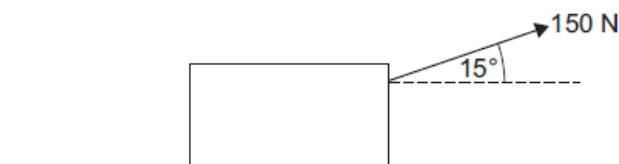
AQA 2018 Paper 2 Question 13:

**13** In this question use  $g = 9.8 \text{ m s}^{-2}$

A boy attempts to move a wooden crate of mass 20 kg along horizontal ground. The coefficient of friction between the crate and the ground is 0.85

**13 (a)** The boy applies a horizontal force of 150 N. Show that the crate remains stationary. [3 marks]

**13 (b)** Instead, the boy uses a handle to pull the crate forward. He exerts a force of 150 N, at an angle of  $15^\circ$  above the horizontal, as shown in the diagram.



Determine whether the crate remains stationary.

Fully justify your answer.

[5 marks]

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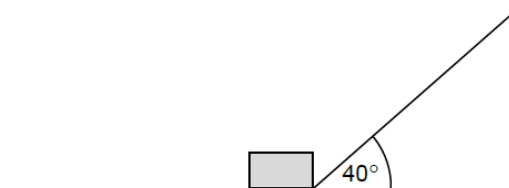
AQA Sample Paper 2 Question 16:

**16** In this question use  $g = 9.8 \text{ m s}^{-2}$ .

The diagram shows a box, of mass  $8.0 \text{ kg}$ , being pulled by a string so that the box moves at a constant speed along a rough horizontal wooden board.

The string is at an angle of  $40^\circ$  to the horizontal.

The tension in the string is  $50 \text{ newtons}$ .



The coefficient of friction between the box and the board is  $\mu$

Model the box as a particle.

**16 (a)** Show that  $\mu = 0.83$

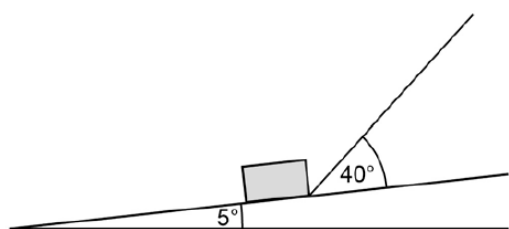
[4 marks]

**16 (b)** One end of the board is lifted up so that the board is now inclined at an angle of  $5^\circ$  to the horizontal.

The box is pulled up the inclined board.

The string remains at an angle of  $40^\circ$  to the board.

The tension in the string is increased so that the box accelerates up the board at  $3 \text{ m s}^{-2}$



**16 (b) (i)** Draw a diagram to show the forces acting on the box as it moves.

[1 mark]

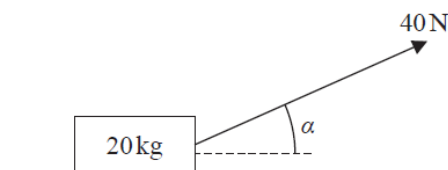
**16 (b) (ii)** Find the tension in the string as the box accelerates up the slope at  $3 \text{ m s}^{-2}$ .

[7 marks]

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Edexcel 2018 Paper 3 Question 7:

7.



**Figure 1**

A wooden crate of mass 20 kg is pulled in a straight line along a rough horizontal floor using a handle attached to the crate.

The handle is inclined at an angle  $\alpha$  to the floor, as shown in Figure 1, where  $\tan \alpha = \frac{3}{4}$

The tension in the handle is 40 N.

The coefficient of friction between the crate and the floor is 0.14

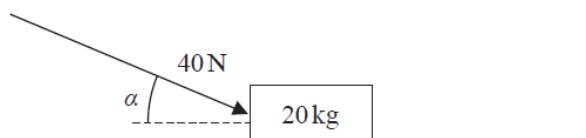
The crate is modelled as a particle and the handle is modelled as a light rod.

Using the model,

(a) find the acceleration of the crate.

(6)

The crate is now pushed along the same floor using the handle. The handle is again inclined at the same angle  $\alpha$  to the floor, and the thrust in the handle is 40 N as shown in Figure 2 below.



**Figure 2**

(b) Explain briefly why the acceleration of the crate would now be less than the acceleration of the crate found in part (a).

(2)

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OCR B MEI Sample Paper 1 Question 9:

9 In a class experiment a small box is hit across a floor. After it has been hit, the box slides without rotation. The box passes a point A. The distance the box travels after passing A before coming to rest is  $S$  metres and the time this takes is  $T$  seconds. The only resistance to the box's motion is friction due to the floor. The mass of the box is  $m$  kg and the frictional force is a constant  $FN$ .

(i) (A) Find the equation of motion for the box while it is sliding.

(B) Show that  $S = kT^2$  where  $k = \frac{F}{2m}$ . [4]

(ii) Given that  $k = 1.4$ , find the value of the coefficient of friction between the box and the floor. [4]

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Edexcel Sample Paper 3 Question 7:

7. A rough plane is inclined to the horizontal at an angle  $\alpha$ , where  $\tan \alpha = \frac{3}{4}$ .

A particle of mass  $m$  is placed on the plane and then projected up a line of greatest slope of the plane.

The coefficient of friction between the particle and the plane is  $\mu$ .

The particle moves up the plane with a constant deceleration of  $\frac{4}{5}g$ .

- (a) Find the value of  $\mu$ . (6)

The particle comes to rest at the point  $A$  on the plane.

- (b) Determine whether the particle will remain at  $A$ , carefully justifying your answer. (2)

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OCR A Sample Paper 3 Question 10:

- 10 A body of mass 20 kg is on a rough plane inclined at angle  $\alpha$  to the horizontal. The body is held at rest on the plane by the action of a force of magnitude  $P$  N acting up the plane in a direction parallel to a line of greatest slope of the plane. The coefficient of friction between the body and the plane is  $\mu$ .

- (i) When  $P = 100$ , the body is on the point of sliding down the plane. Show that  $g \sin \alpha = g \mu \cos \alpha + 5$ . [4]

- (ii) When  $P$  is increased to 150, the body is on the point of sliding up the plane. Using this and your answer to part (i), find an expression for  $\alpha$  in terms of  $g$ . [3]

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OCR B MEI 2018 Paper 1 Question 11:

- 11 Fig. 11 shows two blocks at rest, connected by a light inextensible string which passes over a smooth pulley. Block A of mass 4.7 kg rests on a smooth plane inclined at  $60^\circ$  to the horizontal. Block B of mass 4 kg rests on a rough plane inclined at  $25^\circ$  to the horizontal. On either side of the pulley, the string is parallel to a line of greatest slope of the plane. Block B is on the point of sliding up the plane.

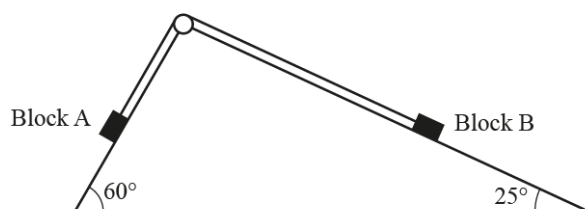


Fig. 11

- (i) Show that the tension in the string is 39.9 N correct to 3 significant figures. [2]
- (ii) Find the coefficient of friction between the rough plane and Block B. [5]