MATHSAURUS

AS Mathematics Exam Questions by Topic
Chapter 20a: Forces and Newton's laws of motion

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/`

OCR B MEI 2018 Paper 1 Question 4:

4 Rory pushes a box of mass 2.8 kg across a rough horizontal floor against a resistance of 19 N. Rory applies a constant horizontal force. The box accelerates from rest to $1.2\,\text{m}\,\text{s}^{-1}$ as it travels 1.8 m.

(i) Calculate the acceleration of the box. **[2]**

(ii) Find the magnitude of the force that Rory applies. **[2]**

OCR B MEI AS Sample Paper 1 Question 3:

3 Fig. 3 shows a particle of weight 8 N on a rough horizontal table. The particle is being pulled by a horizontal force of 10 N. It remains at rest in equilibrium.

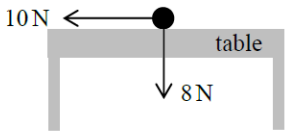


Fig. 3

(i) What information given in the question tells you that the forces shown in Fig. 3 cannot be the only forces acting on the particle? **[1]**

(ii) The only other forces acting on the particle are due to the particle being on the table. State the types of these forces and their magnitudes. **[2]**

OCR B MEI AS Sample Paper 1 Question 12:

12 A small package hangs from a balloon by means of a light inelastic string. The string is always vertical. The mass of the package is 15 kg.

Catherine initially models the situation by assuming that there is no air resistance to the motion of the package. Use Catherine's model to calculate the tension in the string if

(i) the package is held at rest by the tension in the string, **[1]**

(ii) the package is instantaneously at rest and accelerating **upwards** at $2\,\text{m s}^{-2}$, **[2]**

(iii) the package is moving **downwards** at $3\,\text{m s}^{-1}$ and accelerating **upwards** at $2\,\text{m s}^{-2}$. **[1]**

Catherine now carries out an experiment to find the magnitude of the air resistance on the package when it is moving. At a time when the package is accelerating **downwards** at $1.5\,\text{m s}^{-2}$, she finds that the tension in the string is 140 N.

(iv) Calculate the magnitude of the air resistance at that time. Give, with a reason, the direction of motion of the package. **[5]**

AQA AS 2018 Paper 1 Question 12:

12 An object of mass 5 kg is moving in a straight line.

As a result of experiencing a forward force of F newtons and a resistant force of R newtons it accelerates at $0.6\,\text{m s}^{-2}$

Which one of the following equations is correct?

Circle your answer.

[1 mark]

$F - R = 0$ $\quad$ $F - R = 5$ $\quad$ $F - R = 3$ $\quad$ $F - R = 0.6$

AQA Sample Paper 2 Question 10:

10 A single force of magnitude 4 newtons acts on a particle of mass 50 grams.

Find the magnitude of the acceleration of the particle.

Circle your answer.

[1 mark]

$12.5\,\text{m s}^{-2}$ $\quad$ $0.08\,\text{m s}^{-2}$ $\quad$ $0.0125\,\text{m s}^{-2}$ $\quad$ $80\,\text{m s}^{-2}$

OCR B MEI AS 2018 Paper 1 Question 7:

7 A toy boat of mass 1.5 kg is pushed across a pond, starting from rest, for 2.5 seconds. During this time, the boat has an acceleration of $2\,m\,s^{-2}$. Subsequently, when the only horizontal force acting on the boat is a constant resistance to motion, the boat travels 10 m before coming to rest. Calculate the magnitude of the resistance to motion. **[6]**

AQA AS 2018 Paper 1 Question 15:

15 A cyclist, Laura, is travelling in a straight line on a horizontal road at a constant speed of $25\,km\,h^{-1}$

A second cyclist, Jason, is riding closely and directly behind Laura. He is also moving with a constant speed of $25\,km\,h^{-1}$

15 (a) The driving force applied by Jason is likely to be less than the driving force applied by Laura.

Explain why.

[1 mark]

15 (b) Jason has a problem and stops, but Laura continues at the same constant speed.

Laura sees an accident 40 m ahead, so she stops pedalling and applies the brakes.

She experiences a total resistance force of 40 N

Laura and her cycle have a combined mass of 64 kg

15 (b) (i) Determine whether Laura stops before reaching the accident.

Fully justify your answer.

[4 marks]

15 (b) (ii) State one assumption you have made that could affect your answer to part (b)(i).

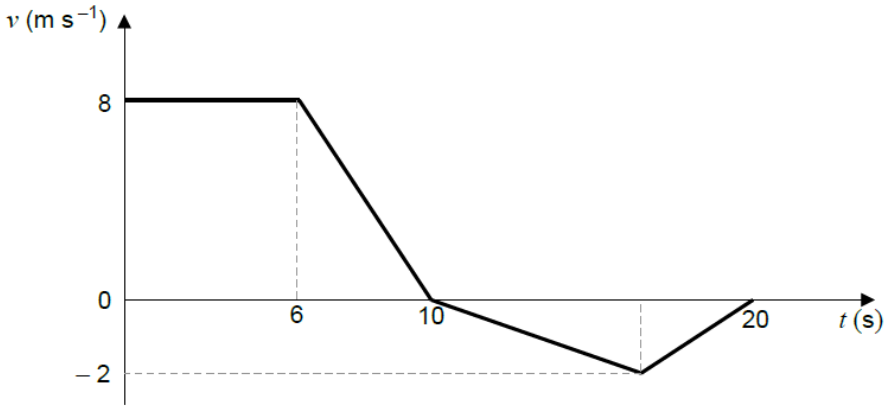
[1 mark]

AQA Sample Paper 2 Question 14:

14 The graph below models the velocity of a small train as it moves on a straight track for 20 seconds.

The front of the train is at the point A when $t = 0$

The mass of the train is 800kg.



14 (a) Find the total distance travelled in the 20 seconds.

[3 marks]

14 (b) Find the distance of the front of the train from the point A at the end of the 20 seconds.

[1 mark]

14 (c) Find the maximum magnitude of the resultant force acting on the train.

[2 marks]

14 (d) Explain why, in reality, the graph may not be an accurate model of the motion of the train.

[1 mark]

OCR B MEI AS 2018 Paper 1 Question 3:

3 A particle is in equilibrium under the action of three forces in newtons given by

$$\mathbf{F}_1 = \begin{pmatrix} 8 \\ 0 \end{pmatrix}, \quad \mathbf{F}_2 = \begin{pmatrix} 2a \\ -3a \end{pmatrix} \quad \text{and} \quad \mathbf{F}_3 = \begin{pmatrix} 0 \\ b \end{pmatrix}.$$

Find the values of the constants a and b. **[3]**

OCR A AS Sample Paper 2 Question 11:

11 In this question the unit vectors **i** and **j** are in the directions east and north respectively.

Distance is measured in metres and time in seconds.

A ship of mass 100 000 kg is being towed by two tug boats. The cables attaching each tug to the ship are horizontal. One tug produces a force of $(350\mathbf{i} + 400\mathbf{j})$ N and the other tug produces a force of $(250\mathbf{i} - 400\mathbf{j})$ N. The total resistance to motion is 200 N. At the instant when the tugs begin to tow the ship, it is moving east at a speed of $1.5\,\text{m s}^{-1}$.

(i) Explain why the ship continues to move directly east. **[2]**

(ii) Find the acceleration of the ship. **[2]**

(iii) Find the time which the ship takes to move 400 m while it is being towed. Find its speed after moving that distance. **[6]**

OCR A AS 2018 Paper 2 Question 9:

9 In this question the horizontal unit vectors **i** and **j** are in the directions east and north respectively.

A model ship of mass 2 kg is moving so that its acceleration vector $\mathbf{a}\,\text{m s}^{-2}$ at time t seconds is given by $\mathbf{a} = 3(2t-5)\mathbf{i} + 4\mathbf{j}$. When $t = T$, the magnitude of the horizontal force acting on the ship is 10 N.

Find the possible values of T. **[4]**
