Physics

Question	Maximum Mark	Mark Awarded
#1	6	
#2	8	
#3	8	
#4	10	
#5	11	
#6	13	
#7	16	
#8	20	
Total	92	

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#1

Louise and Ryan stand a few metres apart on a stationary boat. Louise throws a heavy ball to Ryan who catches it. Describe and explain the motion of the **boat** from the moment Louise starts to throw the ball until just after the ball is caught by Ryan. *Ignore all resistive forces.*

[6 QER]

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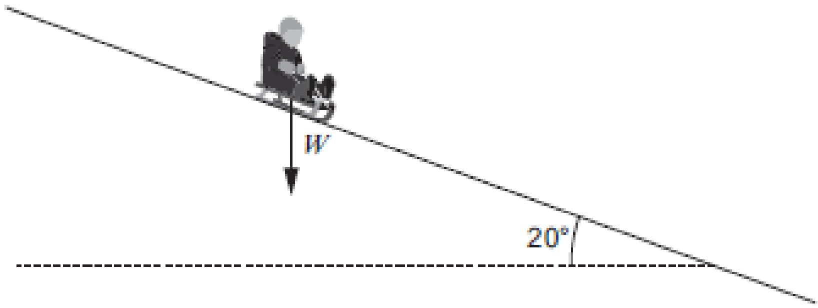
Question taken from Eduqas examination paper 842001, June 2017

#2

1. Matthew is sliding down a snow-covered slope on a sledge. The total mass of Matthew and the sledge is 62 kg.



(a) On the diagram the arrow represents the total weight, W, of Matthew and the sledge. **Add two more arrows** to show the normal contact force on the sledge and the frictional force on the sledge. [1]

(b) (i) Show that the component of W parallel to the slope is approximately 200 N. [2]

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(ii) Calculate the magnitude of the normal contact force. [2]

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(c) The sledge's acceleration just after it has started moving is measured to be $2.5\,\text{m s}^{-2}$. Matthew believes that, starting from rest, it will take him less than 9.0 s to slide 100 m down the slope. Evaluate whether or not he is correct, commenting on whether or not your calculation is conclusive. [3]

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Question taken from Eduqas examination paper 842101, June 2018

#3

3. (a) State Newton's second law of motion in terms of *momentum*. [2]

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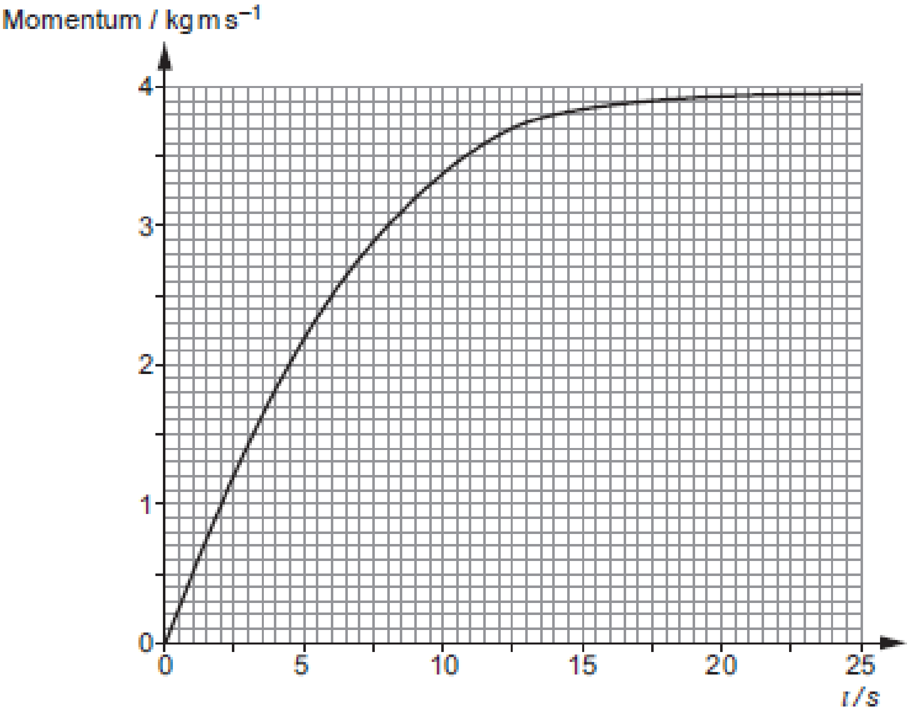
(b) A momentum-time graph is plotted below for an object of mass 0.050 kg dropped (at time t = 0) from the top of a high cliff.



(i) Show clearly that the resultant force on the object at t = 10 s is approximately 0.15 N. [3]

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(ii) Deduce the magnitude of the force of air resistance on the object at t = 10 s. [2]

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(iii) State the magnitude of the force of air resistance on the body when it has reached its terminal velocity. [1]

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Question taken from Eduqas examination paper 842101, June 2018

#4

3. (a) State the principle of conservation of momentum. [2]

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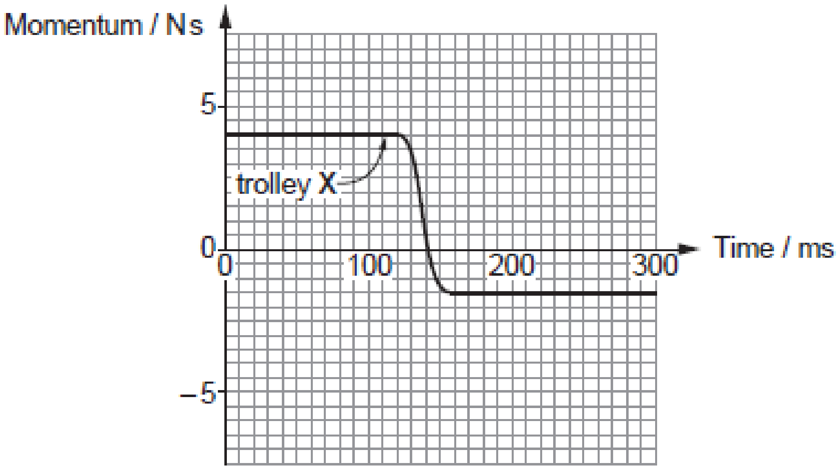
(b) A trolley, **X**, travels towards a stationary trolley, **Y**. See diagram.

The trolleys collide head-on. A momentum-time graph is given for trolley **X**.



(i) Trolley **Y** has a mass of 2.4 kg. Determine its velocity after the collision. [3]

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(ii) **Using the same graph grid (opposite)** carefully sketch a graph of **Y**'s momentum between 0 and 300 ms. [3]

(iii) Use the momentum-time graph for **X** to estimate the mean *force* on **X** during the collision. [2]

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Question taken from Eduqas examination paper 842101, June 2019

#5

2. A wooden block on a string (ballistic pendulum) is a device that can be found at well equipped shooting ranges. It is used to find the speed of a bullet. To calculate the speed it is necessary to use both the principles of conservation of energy and momentum.

(a) State the principle of conservation of energy. [1]

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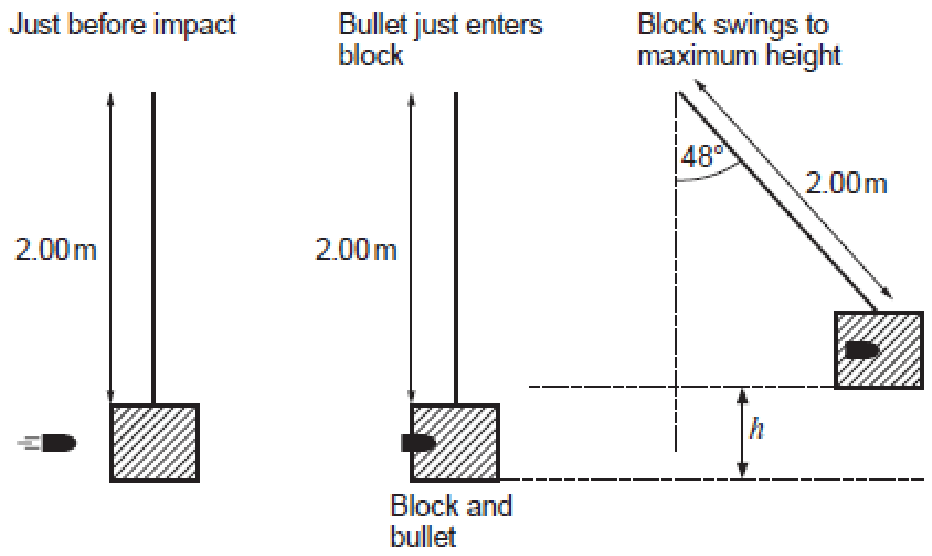
(b) When a bullet of mass 10.0 g is fired horizontally into a pendulum of mass 1.90 kg, the block rises through an angle of 48° as shown. The pendulum string is 2.00 metres long.



(i) Show that the height, h, the block rises is approximately 0.70 m. [2]

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(ii) Using the principle of conservation of energy, determine the velocity of the block and the bullet just after the bullet has embedded itself in the block. [2]

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(c) (i) State the principle of conservation of momentum. [2]

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(ii) Determine the speed of the bullet just before it enters the block. [2]

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(d) Discuss whether you feel it would be appropriate for a Physics teacher to carry out this experiment in school with a group of sixth form students. [2]

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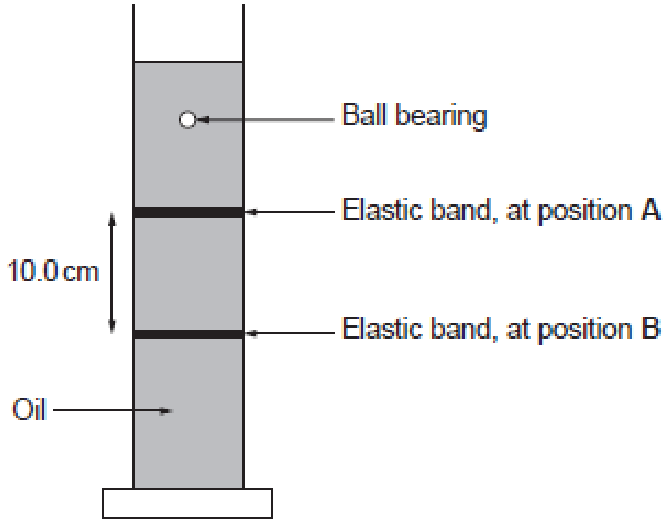
Question taken from Eduqas examination paper 842001, June 2019

#6

6. Emma investigates the viscosity of oil by measuring the terminal velocities of a number of different sized ball bearings as they move through it. She uses the following apparatus.



(a) (i) Once released, a ball bearing attains terminal velocity before it reaches the elastic band at position A. Explain what is meant by terminal velocity. [1]

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(ii) At terminal velocity the two main forces acting on the ball bearing are its weight and the drag of the oil. According to Newton's third law, for each of these forces there is a corresponding equal and opposite force. Identify each of these forces and the body upon which it acts. [2]

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(b) Emma measures the time it takes the ball bearings to fall from the elastic band at position A to the elastic band at position B. She carries out each measurement twice, and obtains the following results. The distance between the two elastic bands is 10.0 cm. The uncertainty in this distance can be considered negligible when calculating the uncertainty in the terminal velocity.

Ball bearing		Time to fall			Terminal velocity	
Diameter, d / cm	(Diameter)^2, d^2 / cm^2	Reading 1 / s	Reading 2 / s	Mean / s	Velocity, v / cm s^{-1}	Uncertainty, Δv / cm s^{-1}
0.24	0.058	14.0	14.6	14.3		± 0.01
0.32	0.10	8.0	8.6	8.3		± 0.05
0.40	0.16	5.3	5.9		1.8	±
0.48	0.23	3.6	4.1		2.6	±
0.64	0.41	2.2	1.9	2.1	4.8	± 0.3

Complete the table. *Space has been left for any calculations if needed.* [4]

(c) (i) Emma's friend, Fiona, thinks that the terminal velocity, v, is directly proportional to the square of the diameter, d, of the ball bearing,

$$v \propto d^2.$$

Plot a suitable graph to check whether Fiona is correct. [4]

(ii) Evaluate whether or not Fiona is correct. [2]

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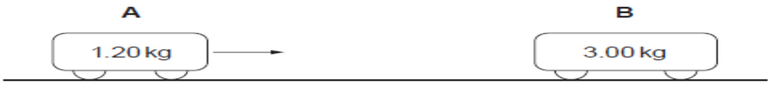
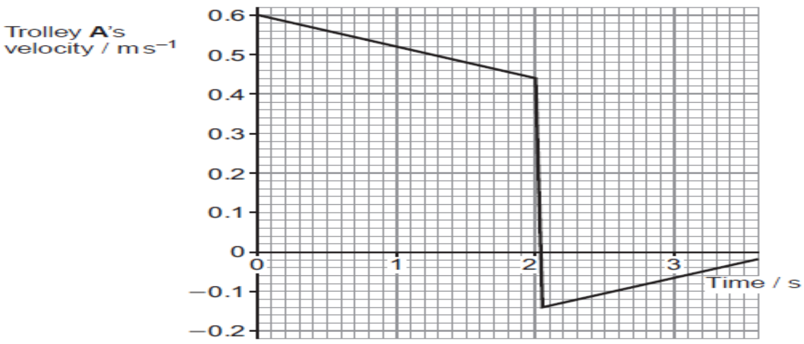
Question taken from Eduqas examination paper 842001, June 2019

#7

(a) A trolley, **A**, is initially moving on a flat surface towards a stationary trolley, **B**, as in the diagram.



A datalogger is used to produce a velocity-time graph for **A**, starting before the collision and continuing after the collision.



(i) Calculate the resistive force on trolley **A** before the collision. [3]

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(ii) Calculate the work done by this resistive force between time $t = 0$ and time $t = 2.0$ s. [3]

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(iii) Determine the velocity of trolley **B** immediately after the collision. *[Ignore the effects of resistive forces during the collision.]* [4]

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(iv) Jasmine suggests that this is an elastic collision. Determine whether or not she is right, showing your working clearly. [3]

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(b) It is suggested that cars should be made of thicker metal. Discuss whether this is a good suggestion. You may discuss environmental as well as safety issues. [3]

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Question taken from Eduqas examination paper 842101, June 2017

#8

ROCKET PHYSICS

(including extracts from REAL WORLD PHYSICS PROBLEMS)

Picture of Saturn V Launch for Apollo 15 Mission. Source: NASA

Rocket physics, in the most basic sense, involves the application of Newton's laws to a system with variable mass. A rocket has variable mass because its mass decreases over time, as a result of its fuel (propellant) burning off. 1

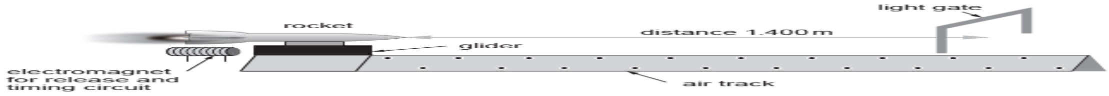
A rocket obtains thrust by the principle of action and reaction (Newton's 3rd law). As the rocket propellant ignites, it experiences a very large acceleration and exits the back of the rocket (as exhaust) at a very high velocity. This backwards acceleration of the exhaust exerts a "push" force on the rocket in the opposite direction, causing the rocket to accelerate forward. This is the essential principle behind the physics of rockets, and how rockets work. 2

Rockets tend to burn fuel at a steady rate and with a constant exhaust speed which produces a constant thrust. However, rocket science is a little more complicated than normal A level physics motion because this does not lead to a constant acceleration. This is due to the decreasing mass of a rocket as it burns its fuel (as stated previously). The usual equation of motion for a rocket is: 3

$$ma = u\frac{\Delta m}{\Delta t} \qquad \textbf{Equation 1}$$

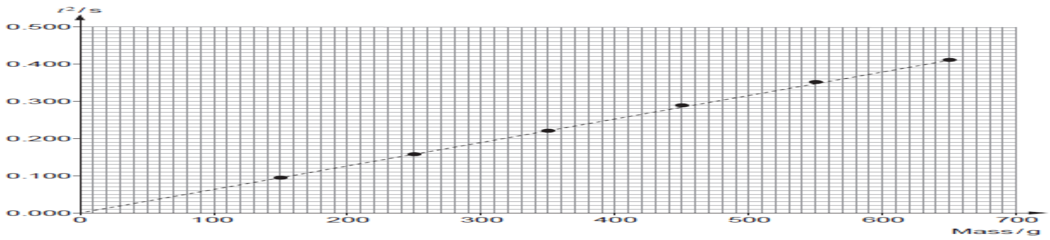
where m is the instantaneous mass of the rocket, a its acceleration, u the velocity of the exhaust gases relative to the rocket and $\frac{\Delta m}{\Delta t}$ the rate at which the mass of the rocket is decreasing. This is a simple application of Newton's 2nd and 3rd laws of motion. 4

If the mass of the rocket is much greater than that of the rocket fuel, we can assume that the acceleration is constant. We can also burn the fuel slowly and then the acceleration will be nice and small so that we can carry out an experiment on an air track to check **Equation 1**. 5



In the set-up opposite, the rocket is attached to a glider and released from rest using the electromagnet. The timer is started automatically and the time is then recorded for the rocket to travel the 1.400 m to the light gate. This process is repeated for a series of glider masses. 6

Mass of glider and rocket / g	Time / s	Corrected time, t / s	t^2 / s
150	0.328	0.308	0.095
250	0.418	0.398	0.158
350	0.490	0.470	0.221
450	0.558	0.538	0.289
550	0.614	0.594	0.353
650	0.663	0.643	0.413



The graph shows a constant acceleration, in excellent agreement with theory. Moreover, the rate of mass loss for the rocket was measured as 1.10×10^{-2} kg s^{-1}. The exhaust gas speed was 402 m s^{-1} as measured using the Doppler shift of light emitted by the exhaust gases. These measurements provide a theoretical value of around 4.4 N for the rocket thrust and this is in excellent agreement with the graph too. 7

Answer the following questions in your own words. Direct quotes from the original article will not be awarded marks.

(a) Explain how Equation 1 is an application of Newton's 2nd and 3rd laws of motion (see paragraphs 2 and 4). [3]

(b) The author states in paragraph 5 that the acceleration is "constant" and "nice and small". Explain why this is true (see paragraphs 3 and 5). [3]

(c) (i) The author has made a mistake in the table and the graph with one of the units. Identify the mistake. [1]

(ii) Explain how the corrected time, t, was obtained from the time in the table and suggest why this correction was necessary. [2]

(d) Use equations of uniformly accelerated motion to explain why a graph of t^2 against mass was plotted **and** why the gradient of this graph is expected to be $\frac{2.80}{F}$ (where F is the resultant force in newtons acting on the glider and rocket). [3]

(e) Show that a rate of mass loss of 1.10×10^{-2} kg s^{-1} and an exhaust gas speed of 402 m s^{-1} produce a thrust of approximately 4.4 N (see paragraph 7). [1]

(f) The gradient of the graph is 0.635 in the correct SI unit. Use this to determine whether the force of 4.4 N to which the author refers is consistent with the graph (see paragraph 7 and the graph). [2]

(g) (i) State what is meant by Doppler shift (see paragraph 7). [2]

(ii) Describe how the exhaust gas speed might be measured "using the Doppler shift of light emitted by the exhaust gases" (see paragraph 7). [3]

Question taken from Eduqas examination paper 842101, November 2020