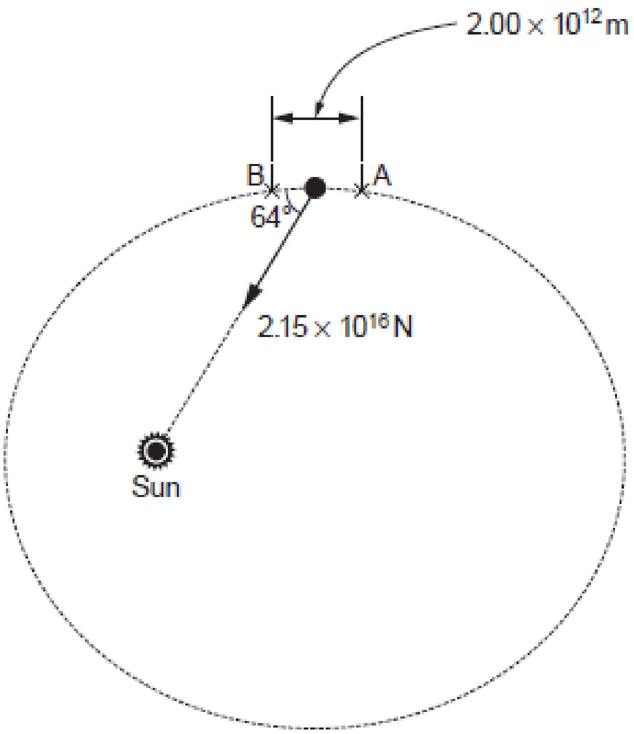
Physics

Question	Maximum Mark	Mark Awarded
#1	6	
#2	8	
#3	9	
#4	11	
#5	11	
#6	11	
#7	13	
#8	16	
#9	15	
#10	15	
#11	16	
#12	16	
Total	147	

#1

2. The diagram shows the dwarf planet, Eris, at one point in its orbit.



(a) Explain why the *moment* (about the centre of the Sun) of the Sun's force on Eris is zero. [1]

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(b) Calculate the *work* done by the Sun's gravitational force on Eris as Eris moves from A to B. The mean values of the force and the angle at which it acts are shown on the diagram. [2]

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(c) Showing your reasoning clearly, determine whether your answer to *(b)* is consistent with these data:

Mass of Eris = 1.66×10^{22} kg

Speed of Eris at A = $3460\,\text{m s}^{-1}$

Speed of Eris at B = $3770\,\text{m s}^{-1}$ [3]

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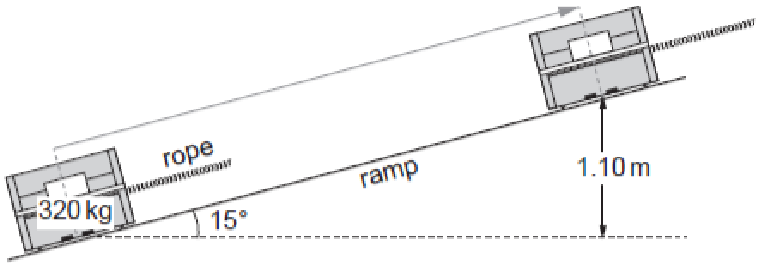
Question taken from Eduqas examination paper 842101, June 2019

#2

A piano of mass 320 kg is raised through a height of 1.10 m using a rope and a ramp angled at 15° to the horizontal. The process takes 35 s, during which the mean tension in the rope is 960 N.



(a) Show that the mean *power* used to pull the piano up the ramp is approximately 120 W. [3]

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(b) Calculate the *efficiency* of the rope and ramp as a means of raising the piano through a height of 1.10 m. [3]

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(c) Evaluate whether or not the kinetic energy given to the piano (at the beginning of the raising operation) is a major reason for inefficiency. [2]

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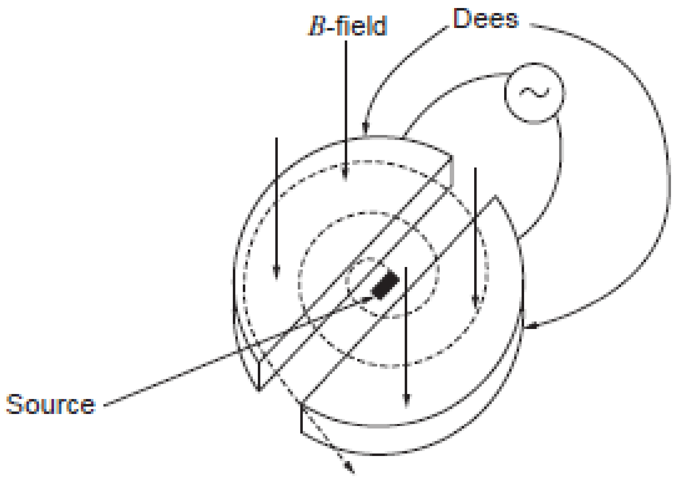
Question taken from Eduqas examination paper 842101, November 2020

#3

9. A cyclotron is shown and it is used to accelerate helium-4 nuclei from rest. After completing 12 cycles of the cyclotron, a helium nucleus has a kinetic energy of 4.32 MeV.



(a) Calculate the final velocity of a helium-4 nucleus (the mass of a helium-4 nucleus is 4u). [3]

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(b) Calculate the pd between the dees. [3]

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(c) The uniform magnetic flux density is 0.47 T. Calculate the frequency of the alternating pd applied to the dees. [3]

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Question taken from Eduqas examination paper 842103, June 2018

#4

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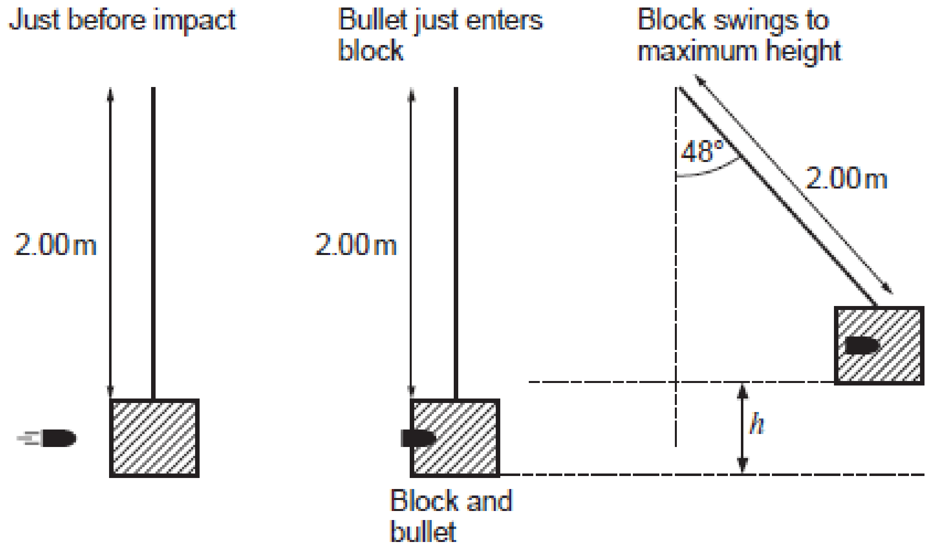
(b) When a bullet of mass 10.0 g is fired horizontally into a pendulum of mass 1.90 kg, the block rises through an angle of 48° as shown. The pendulum string is 2.00 metres long.



(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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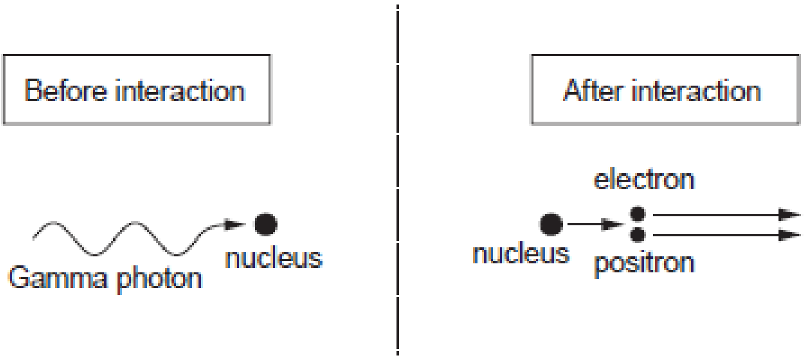
Question taken from Eduqas examination paper 842001, June 2019

#5

5. The following interaction can take place when a gamma photon encounters a stationary nucleus.



The energy of the gamma photon "creates" a positron-electron pair and the nucleus gains some momentum in the direction of the original gamma photon.

(a) Show that this interaction can only take place if the energy of the gamma photon is greater than 1.02 MeV. [3]

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(b) The actual energy of the incident gamma photon is 1.03 MeV. **Assuming that the kinetic energy of the nucleus after the interaction is negligible**, explain briefly why the kinetic energies of the positron and electron are approximately 0.005 MeV **each**. [2]

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(c) Use the kinetic energies of 0.005 MeV and conservation of momentum to show that the speeds of the positron and electron are $4.2 \times 10^7\,\text{m s}^{-1}$ and that the momentum of the nucleus after the collision is $4.7 \times 10^{-22}\,\text{kg m s}^{-1}$. [4]

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(d) The momentum of the nucleus ($4.7 \times 10^{-22}\,\text{kg m s}^{-1}$) is essential otherwise conservation of momentum would be impossible. Deduce whether or not the assumption in part *(b)* is valid (the mass of the nucleus is 3.3×10^{-25} kg). [2]

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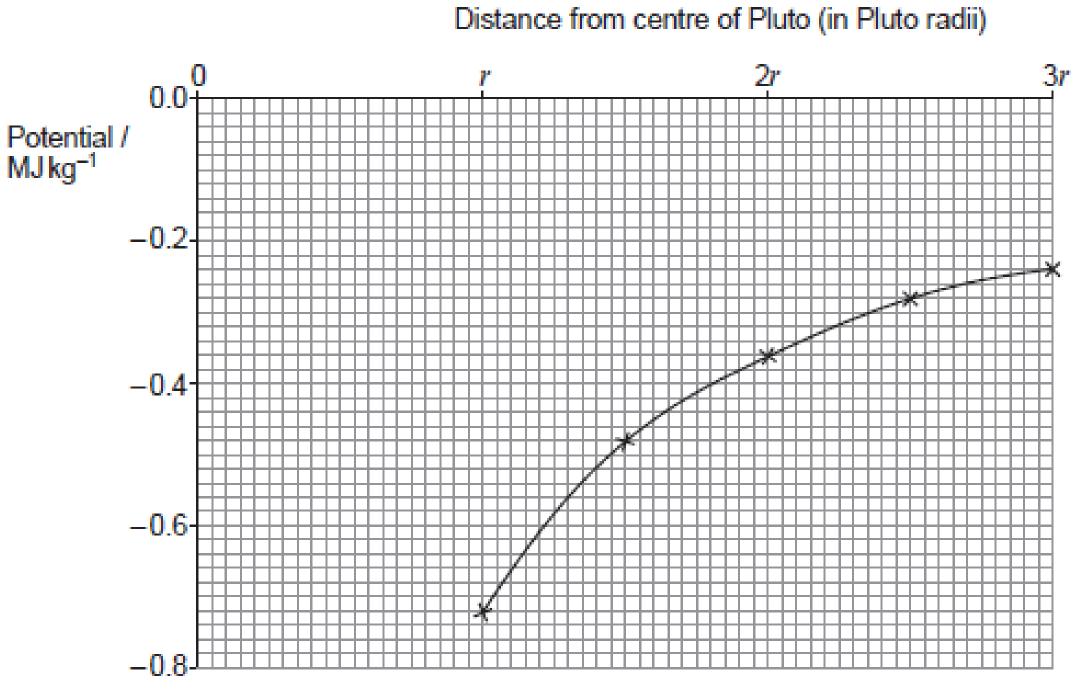
Question taken from Eduqas examination paper 842103, June 2019

#6

6. The variation in gravitational potential near Pluto is shown by the graph.



(a) Assuming that the potential at the surface is correct, confirm that the potential at $3r$ is plotted correctly. [2]

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(b) (i) Calculate the gravitational potential energy of a spacecraft of mass 600 kg at rest on the surface. [2]

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(ii) 'Escape velocity' is defined as the minimum velocity required for a body to escape from the gravitational influence of a massive body. Calculate the 'escape velocity' of the spacecraft. [3]

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(c) The radius of Pluto is 1.18×10^6 m and the gravitational field strength at the surface is $0.62\,\text{N kg}^{-1}$. Using this information and by **drawing a suitable tangent** show that the gravitational field strength at $2r$ agrees with the theoretical value given by:

$$g \propto \frac{1}{r^2}$$ [4]

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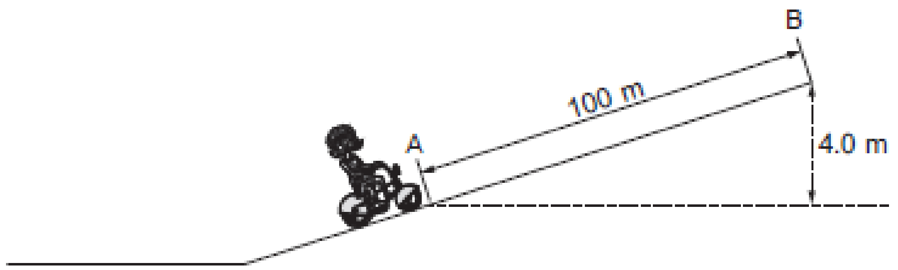
Question taken from Eduqas examination paper 842102, June 2019

#7

3. Helen is riding an electric bike (a bike that is assisted by an electric motor) up a hill at a speed of 4.5 m s^{-1}. At point A she starts the electric motor and accelerates uniformly reaching a speed of 9.2 m s^{-1} at B. Whilst accelerating she also gains a height of 4.0 m as shown in the diagram below.



(a) Show that the time taken for Helen's journey between A and B is approximately 15 s. [2]

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(b) Helen and the bike have a combined mass of 95 kg. Determine the gain in total energy between A and B. [3]

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(c) (i) If the bike's electric motor operates at 36 V and 7.0 A calculate the electrical energy used by the motor between A and B. [2]

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(ii) Helen, by pedalling, also provides 5 500 J of work between A and B. Determine the efficiency of the electric motor. *Ignore all resistive forces on Helen and the bike.* [2]

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(iii) In practice resistive forces will act. Identify these forces and where they act. [2]

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(d) Helen believes that by riding an electrically powered bike to the shops rather than using her car she is benefiting the environment. Explain whether or not Helen is correct. [2]

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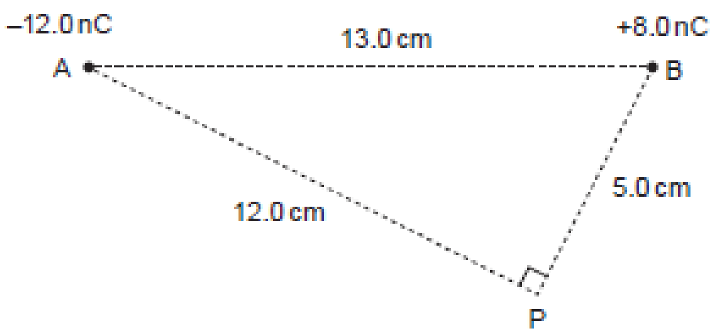
Question taken from Eduqas examination paper 842001, June 2018

#8

7. *(a)* Complete the following table: [3]

Quantity	Definition	Vector or Scalar
Electric field strength, E	....	....
Electric potential, V	....	....

(b) Point charges of –12.0 nC and +8.0 nC are placed at A and B, 13.0 cm apart as shown. P is a point in space which is 12.0 cm from A and 5.0 cm from B.



(i) Draw on the diagram two arrows to show the directions of the field strength at P due to each charge. [1]

(ii) Hence draw on the diagram one arrow to represent the direction of the resultant field strength at P. Label this arrow R. [1]

(iii) Calculate the **magnitude and direction** of the electric field strength at P. [4]

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(c) (i) Show that the potential at P is + 540 V. [2]

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(ii) Calculate the gain in kinetic energy in joules of an electron as it moves from infinity to P. [2]

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(d) Without calculation, explain how the de Broglie wavelength of the electron changes as it moves towards P. [3]

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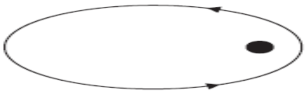
Question taken from Eduqas examination paper 842102, June 2018

#9

(a) The diagram shows the elliptical orbit of a planet around a star. Use the diagram (by adding to it) to explain Kepler's second law of planetary motion. [2]



(b) Starting with Newton's law of gravitation, show that for a circular orbit, the period of orbit, T, of a planet around a star is related to its distance, r, from the centre of the star by the relationship $T^2 \propto r^3$. [Assume the mass of the planet is much less than the mass of the star.] [3]

(c) Mars has two small moons, Phobos and Deimos. The diagram shows their orbital paths around Mars.

(i) Phobos has an orbital period of 7.7 hours and the radius of its orbit is 9400 km. Show that the mass of Mars is approximately 6.4×10^{23} kg. [3]

(ii) It is proposed to send a space-probe to study Phobos and Deimos. The first part of the mission will be to place the probe in orbit around Phobos.

I. Show that the gravitational potential due to Mars at the Phobos orbit is approximately $-4.5\,\text{MJ kg}^{-1}$. [2]

II. The second part of the mission involves manoeuvring the space-probe into a higher orbit to enable it to study Deimos. However, on the journey to Mars the probe used more fuel than was expected. Scientists are now unsure as to whether or not the probe has enough fuel to enable it to reach the orbit of Deimos. The following information is available:

Energy available per kg of space-probe: $4.4\,\text{MJ kg}^{-1}$
Efficiency of fuel-burn process: 60 %
Distance of Deimos from centre of Mars: 23 500 km

Assuming the mass of the fuel is very small compared to the mass of the probe itself, and ignoring the gravitational effects of both moons, determine whether or not the scientists should attempt the manoeuvre. [4]

(iii) Explain why it is not possible to use the equation $\Delta E_p = mg\Delta h$ when determining the change in the gravitational potential energy of the probe as it moves between these orbits. [1]

Question taken from Eduqas examination paper 842102, November 2020

#10

4. *(a)* State the *principle of conservation of energy.* [2]

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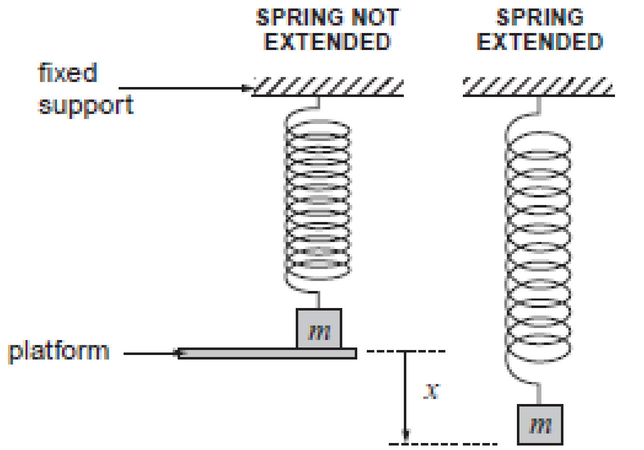
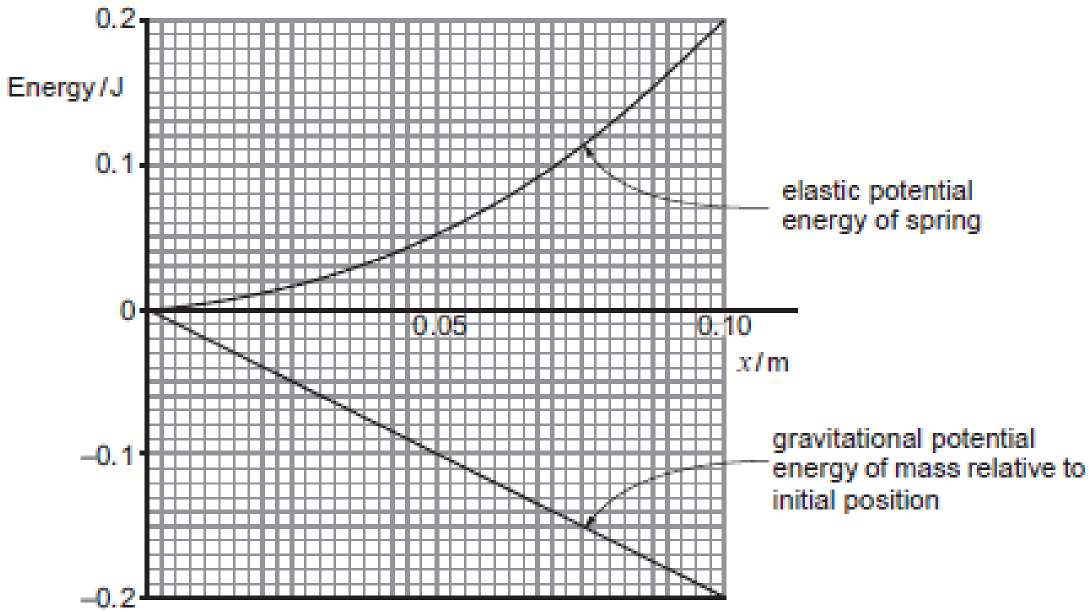
(b) A mass, m, is attached to a light spring whose top end is held firmly. Initially the mass is supported by a platform with the spring unextended. The platform is suddenly removed so the mass falls.



The graphs show how the elastic potential energy of the spring and the gravitational potential energy of the mass vary with the distance, x, of the mass below the platform (see diagrams).



(i) Assuming that resistive forces are negligible, use data from the graphs to calculate:

I. the spring constant, k; [3]

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II. the mass, m; [2]

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III. the kinetic energy of m when x = 0.050 m. [2]

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(ii) Sketch a graph of the kinetic energy of the mass, m, against x **on the same grid as the other graphs.** [2]

(c) In the arrangement described in *(b)*, the furthest distance, x_{max}, that m falls is 0.10 m. However, a larger mass would fall further. In theory, x_{max} is directly proportional to the mass, m. Describe briefly how you would verify this relationship by experiment. [4]

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Question taken from Eduqas examination paper 842101, June 2018

#11

5. (a) Define *simple harmonic motion*. [2]

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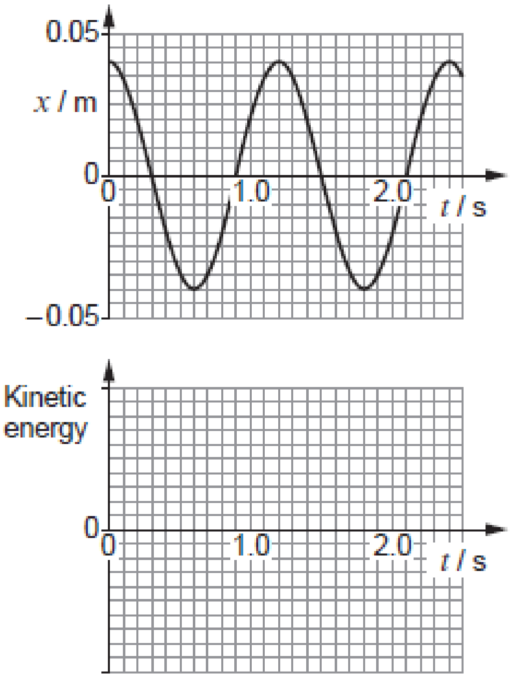
(b) A metal sphere of mass 0.175 kg hangs from a spring whose top end is clamped. The sphere is set oscillating up and down, and a displacement-time graph is plotted.



GRID FOR (*b*)(iii)

(i) Calculate the stiffness constant, k, of the spring. [3]

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(ii) Calculate the maximum kinetic energy of the sphere. [3]

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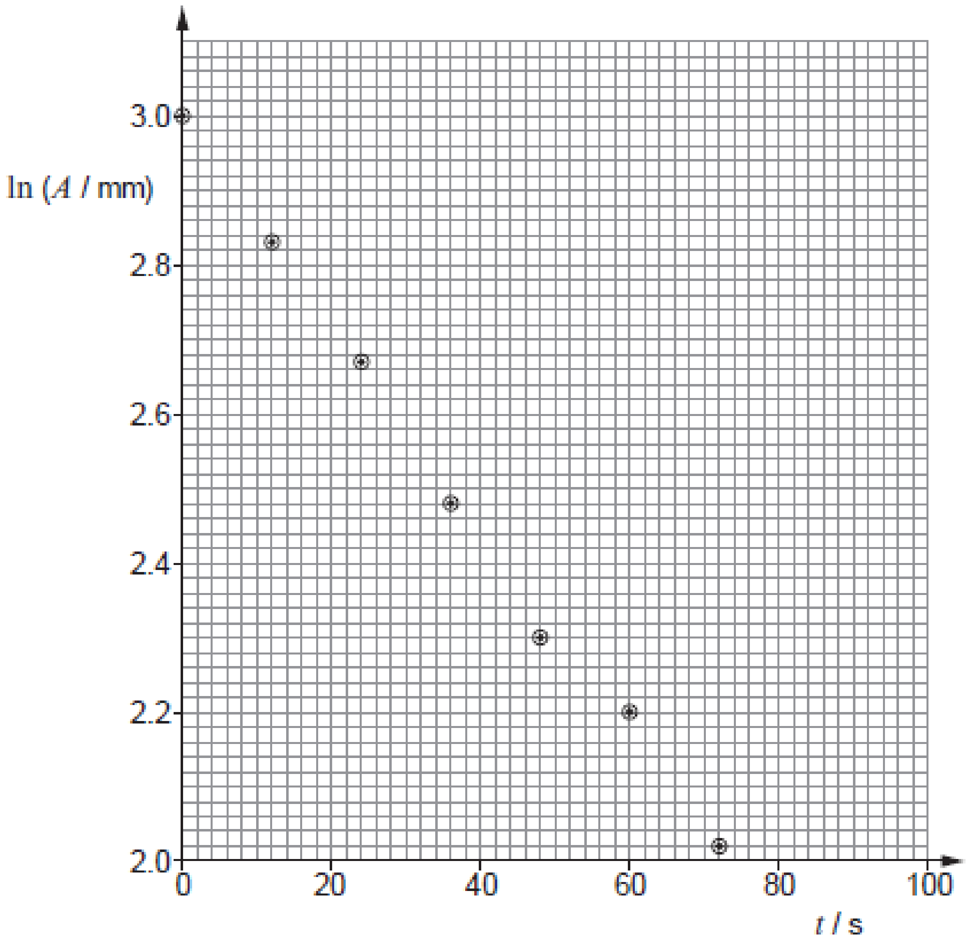
(iii) Carefully sketch a graph of the sphere's kinetic energy against time **on the axes provided on the opposite page**. A vertical scale is not needed. [3]

(c) Over several oscillations it is clear that the amplitude of the sphere's motion is decreasing. Evgeniya suspects that the amplitude is decreasing exponentially, according to the equation:

$$A = A_0 e^{-\lambda t}$$

To check this idea she uses readings of the amplitude, A, taken at regular intervals to plot $\ln(A / \text{mm})$ against time, t.



Evgeniya claims that the points she has plotted support the exponential decrease of amplitude. Justify her claim and determine a value for λ. [5]

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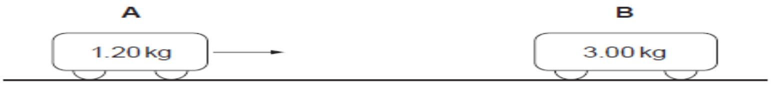
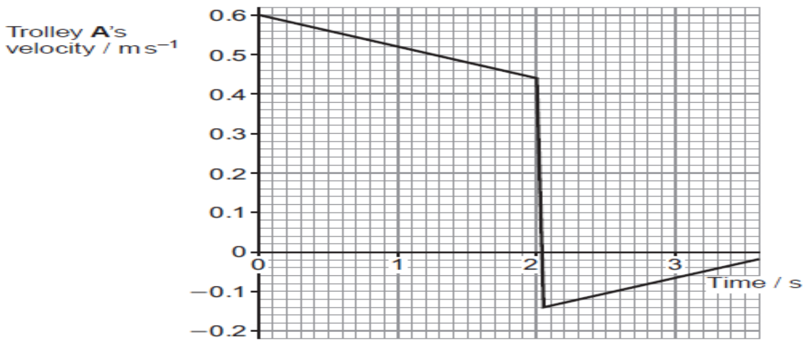
Question taken from Eduqas examination paper 842101, June 2019

#12

(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