WJEC EDUQAS A-LEVEL PHYSICS · COMPONENT 1

PHYSICS



EXAM QUESTION PACK

1.4 ENERGY CONCEPTS

SCORE	PERCENTAGE
/147	%

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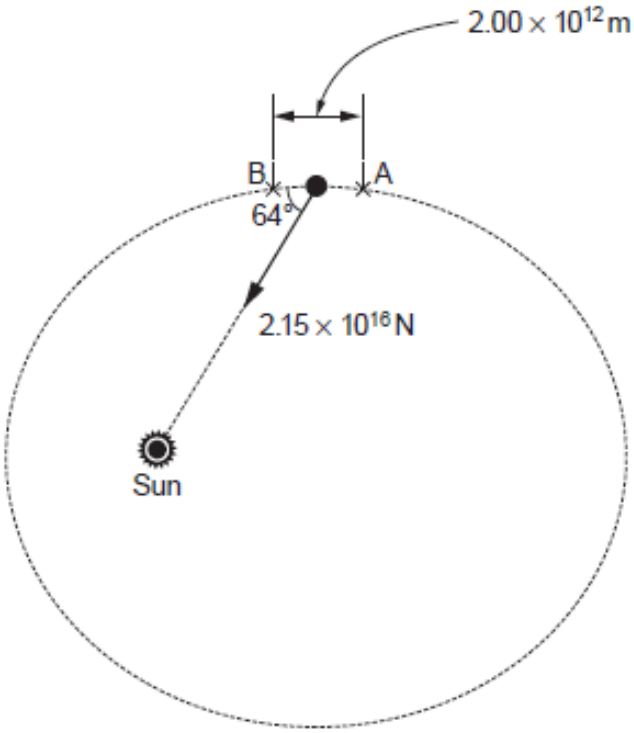
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2. The diagram shows the dwarf planet, Eris, at one point in its orbit.



(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 = $3460\,m\,s^{-1}$

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

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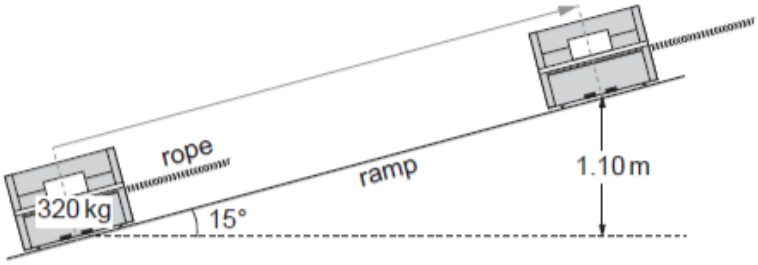
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Question taken from Eduqas examination paper 842101, June 2019

#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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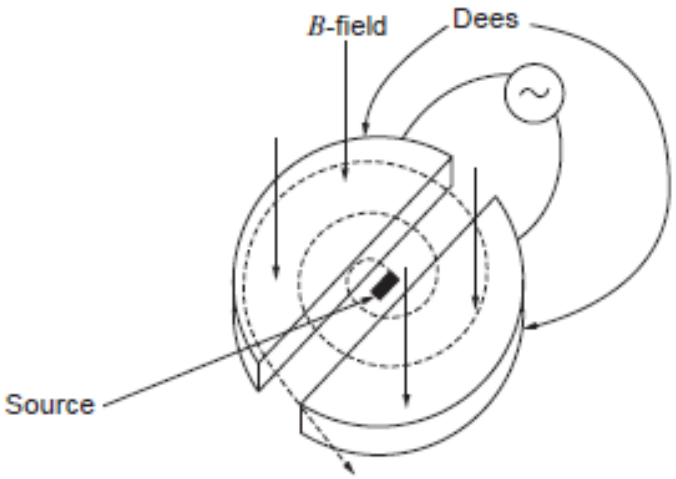
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Question taken from Eduqas examination paper 842101, November 2020

#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]

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

(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.

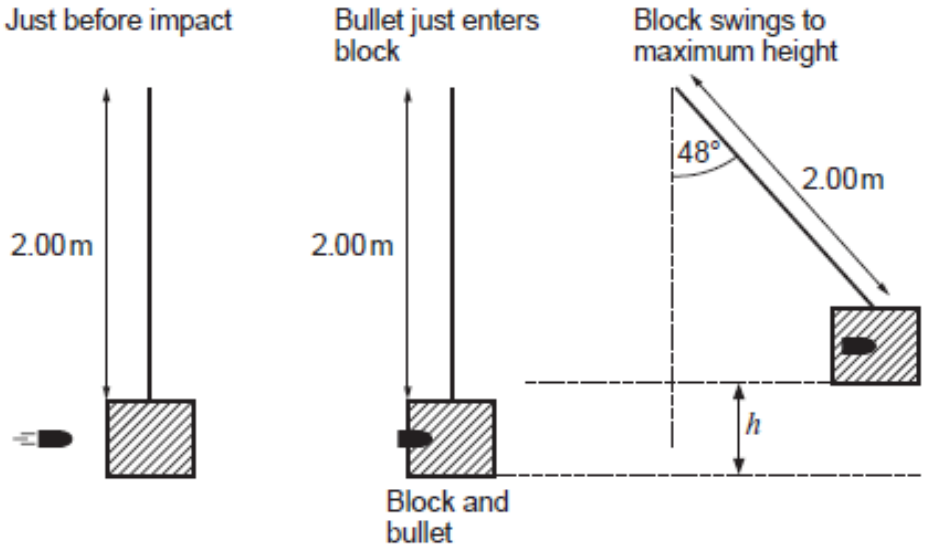
(a) State the principle of conservation of energy. [1]

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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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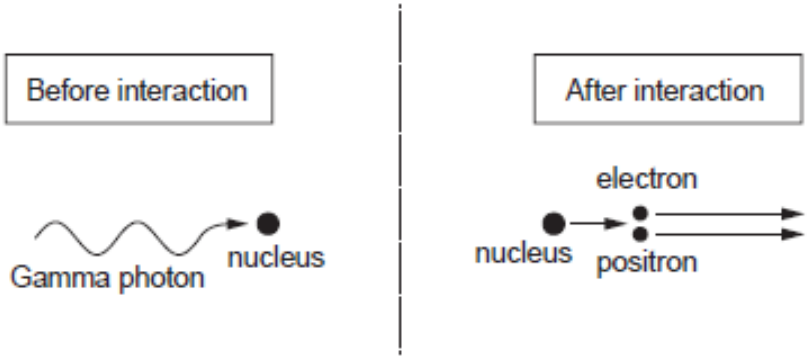
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Question taken from Eduqas examination paper 842001, June 2019

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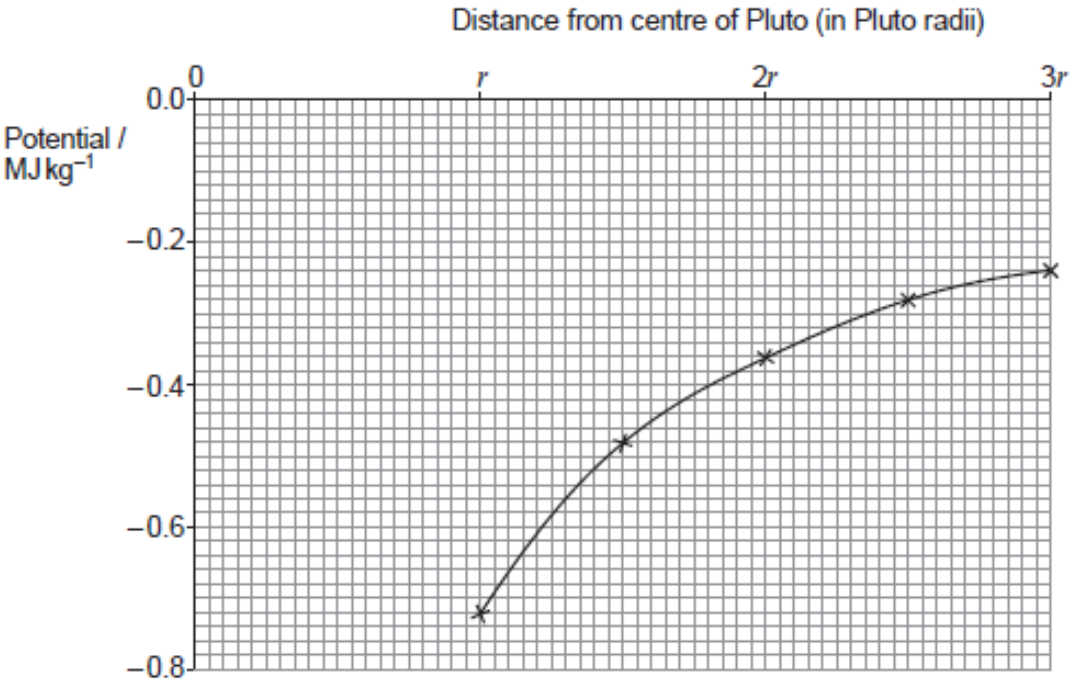
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(c) Use the kinetic energies of 0.005 MeV and conservation of momentum to show that the speeds of the positron and electron are $4.2 \times 10^{7}\,\text{m s}^{-1}$ and that the momentum of the nucleus after the collision is $4.7 \times 10^{-22}\,\text{kg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

(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 $3.3 \times 10^{-25}\,\text{kg}$). [2]

Question taken from Eduqas examination paper 842103, June 2019

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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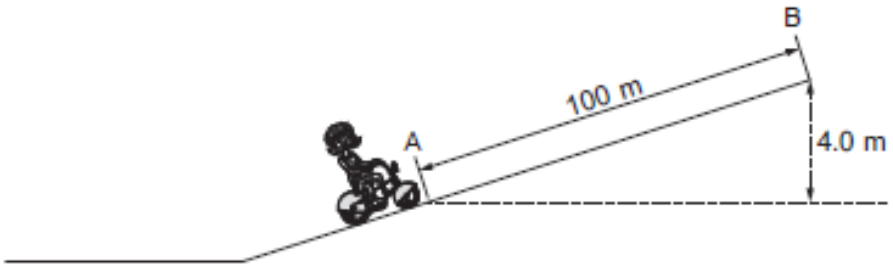
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Question taken from Eduqas examination paper 842102, June 2019

#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]

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

(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]

(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]

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

(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]

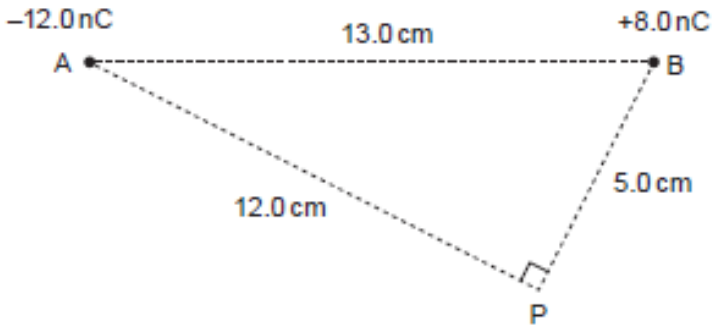
Question taken from Eduqas examination paper 842001, June 2018

#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]

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

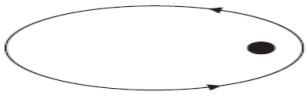
(ii) Calculate the gain in kinetic energy in joules of an electron as it moves from infinity to P. [2]

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

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

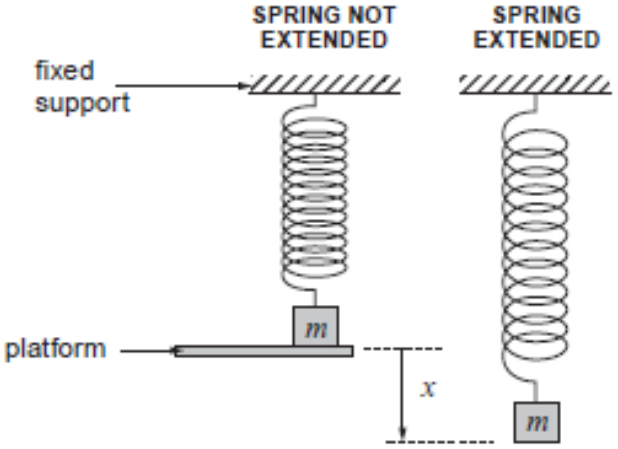
4. *(a)* State the *principle of conservation of energy.* [2]

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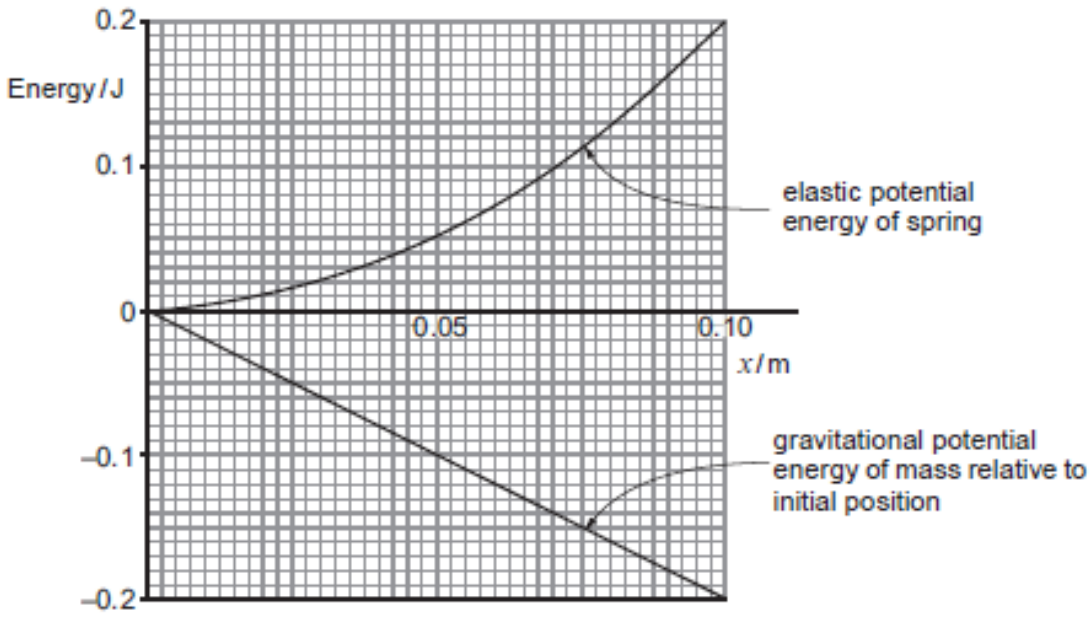
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(b) A mass, m, is attached to a light spring whose top end is held firmly. Initially the mass is supported by a platform with the spring unextended. The platform is suddenly removed so the mass falls.



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

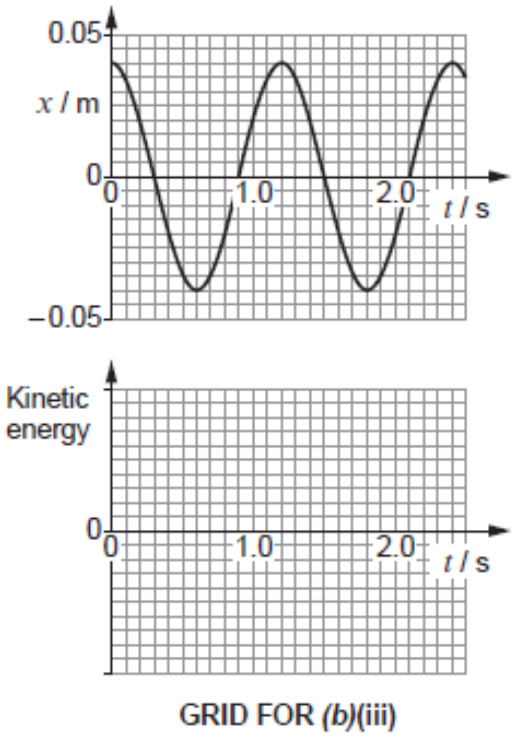
5. *(a)* Define *simple harmonic motion.* [2]

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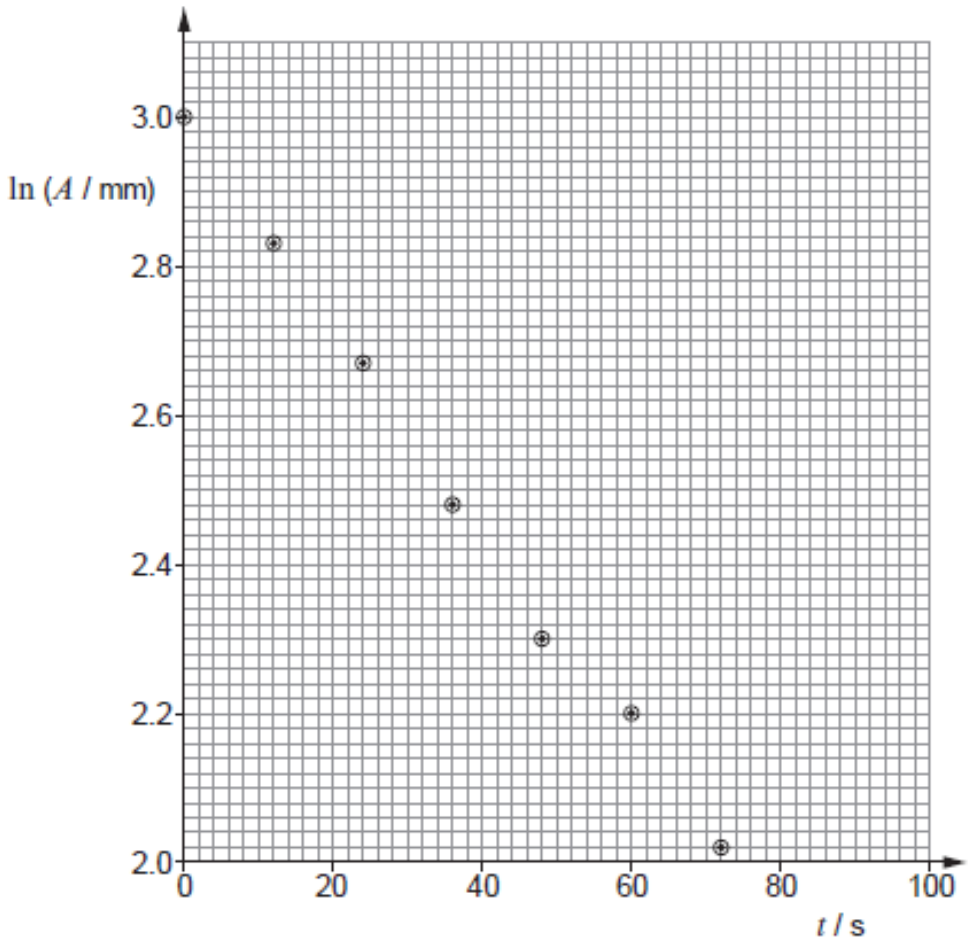
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(iii) Carefully sketch a graph of the sphere's kinetic energy against time **on the axes provided on the opposite page**. A vertical scale is **not** needed. [3]

(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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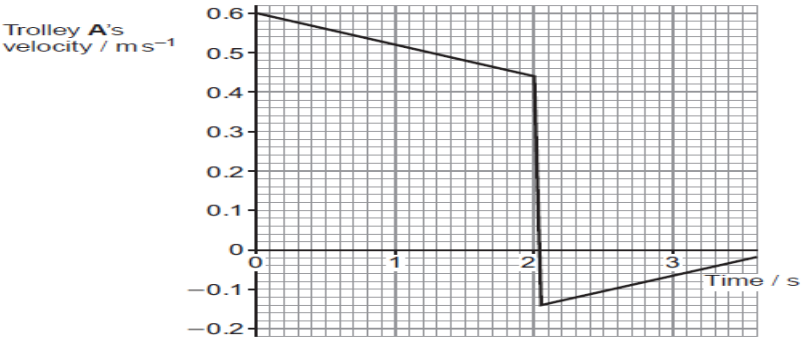
Question taken from Eduqas examination paper 842101, June 2019

#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]

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

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

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

(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]

Question taken from Eduqas examination paper 842101, June 2017

Marking Scheme

#1

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
2	*(a)*			Zero distance from Sun to line of action of force **accept** zero perpendicular distance or [line of action of] force is straight through [centre of] Sun		1		1		
	(b)			Work = $2.15 \times 10^{16} \times 2.0 \times 10^{12} \times \cos 64°$ [1] $= 1.88 \times 10^{28}$ J **unit mark** [1]	1	1		2	2	
	(c)			Work = ΔE_k declared as strategy or implied by conclusion **ecf** from (b) provided comment made [1] Intermediate step: $E_{kA} = 9.94 \times 10^{28}$ [J] or $E_{kB} = 1.18 \times 10^{29}$ [J] or $v_B^2 - v_A^2 = 2.24 \times 10^6$ [m^2 s^{-2}] or correct substitution into $\frac{1}{2}mv_B^2 - \frac{1}{2}mv_A^2$ [1] $E_{kB} - E_{kA} = 1.86 \times 10^{28}$ [J] **clearly arrived at** [1]			3	3	2	
				Question 2 total	**1**	**2**	**3**	**6**	**4**	**0**

#2

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)			Distance up ramp = $\frac{1.10\text{ m}}{\sin 15°}$ [= 4.25 m or by implic] [1] Power in = $\frac{960\text{ N} \times 4.25\text{ m}}{35\text{ s}}$ **ecf on 4.25 m** [1] = 117 [W] **no ecf** [1]		3		3	2	
	(b)			Grav PE gained by piano = $320 \times 9.81 \times 1.10$ [J] [= 3.45 kJ] or by implication [1] Efficiency = $\frac{3453}{960 \times 4.25} \times 100\ \%$ **[ecf on top or bottom]** [1] or Efficiency = $\frac{99\text{ [W]}}{117\text{ [W]}} \times 100\ \%$ **[ecf on top or bottom]** = 85 [%] or 0.85 **no ecf** [1]		3		3	2	
	(c)			KE of piano $\cong \frac{1}{2} \times 320 \times \left(\frac{4.25}{35}\right)^2 = 2.4$] [1] Negligible compared with hauling work [or] GPE gained, so *not* a major cause of inefficiency [1] **Alternative answer** KE got back at the end of the process... [1] ... as piano comes to rest if hauling stopped a little before required height rise [1]			2	2	1	
				Question total	**0**	**6**	**2**	**8**	**5**	**0**

#3

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
9	(a)		Conversion $4.32 \times 10^6 \times 1.6 \times 10^{-19}$ i.e. 6.912×10^{-13} [J] (1) Rearrangement for v i.e. $v = \sqrt{\frac{2E}{m}}$ (1) Answer = 1.44×10^7 m s^{-1} (1)		3		3	2	
	(b)		24 total energy 'kicks' (or 2 per revolution) (1) 4.32 MeV divided by 24 (=180 000) (1) Also need to divide by $2e$, Answer = 90 000 V (1) (2 marks for 180 kV, 1 mark for 360 kV, 2.16 MV →1 mark)		3		3	2	
	(c)		Equating: $m\omega^2 r = Bqv$ (1) or $\omega = \frac{Bq}{m}$ Rearrangement: $f = \frac{Bq}{2\pi m}$ (1) By implication can give 2 marks for this Answer = 3.6 MHz (ecf on part (b) i.e. using $1e$ instead of $2e$ 1.8 MHz) (1)		3		3	2	
			Question 9 total	**0**	**9**	**0**	**9**	**6**	**0**

#4

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
2	(a)		Energy cannot be created or destroyed only changed from one form to another	1			1		
	(b)	(i)	Length from top of pendulum = $2 \cos 48° = 1.34$ [m] (1) Height pendulum rises = 2.00 – 1.34 = 0.66 [m] (1)		2		2	2	
		(ii)	$\frac{1}{2}mv^2 = mgh$ (1) v = 3.60 [m s^{-1}] (1)		2		2	2	
	(c)	(i)	The vector sum of momentum before a collision equals the vector sum of momentum after collision / Accept total for vector sum of (1) provided no external forces act (1)	2			2		
		(ii)	$m_b v_b$ = 1.91 × 3.6 ecf (1) v = 687(.6) or 688 [m s^{-1}] (1)		2		2	2	
	(d)		**Any 2 × (1) from:** - Students over the age of sixteen - Legitimate reason for scientific learning - Needs to be transported through school play ground -Possible dangers in transporting - Risk assessment made			2	2		
			Question 2 total	**3**	**6**	**2**	**11**	**6**	**0**

#5

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
5	(a)		E = [2×] $9.11 \times 10^{-31} \times c^2$ or $m = \frac{9.11 \times 10^{-31}}{1.66 \times 10^{-27}}$ [= 0.000549 u] [1] Conversion to eV i.e. dividing by 1.6×10^{-19} or × 931 [1] 1.025 MeV seen or $2 \times 9.11 \times 10^{-31} \times \frac{(3 \times 10^8)^2}{1.6 \times 10^{-19}}$ or $2 \times 0.000549 \times 931$ [1]		3		3	3	
	(b)		Excess energy or 0.01 MeV [1] Equal amounts shared by electrons & positron due to equal (light) masses [1]		2		2		
	(c)		$0.5 \times 9.11 \times 10^{-31} \times v^2 = 0.005 \times 10^6 \times 1.6 \times 10^{-19}$ seen or equivalent: $(0.5 \times 9.11 \times 10^{-31} \times (4.2 \times 10^7)^2$ giving 0.005 MeV or 4.19×10^7 seen [1] Momentum of gamma ray [= $\frac{E}{c}$] = 5.49×10^{-22} [N s] [1] Momentum of electron or positron = $9.11 \times 10^{-31} \times 4.2 \times 10^7$ = 3.8×10^{-23} or 7.6×10^{-23} [1] $5.49 \times 10^{-22} - 2 \times 4.2 \times 10^7 \times 9.11 \times 10^{-31}$ seen [1]		4		4	3	
	(d)		KE calculated (3.35×10^{-19} J or 2.1 eV) [1] Correct conclusion – negligible [1] **No ecf**			2	2	1	
			Question 5 total	**0**	**9**	**2**	**11**	**7**	**0**

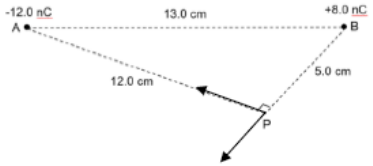
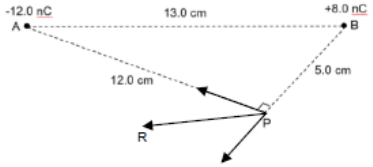
#6

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
6	(a)		$V \propto \frac{1}{r}$ or equivalent or $\frac{-0.72 \times 10^6}{3}$ seen (accept 0.73) [1] V shown as -0.24×10^6 [J kg^{-1}] [1] Accept answers based on determination of			2	2	1	
	(b)	(i)	Substitution: $E_P = 600 \times [-] 0.72 \times 10^6$ [1] E_P = [–] 4.3×10^8 [J] [1]	1	1		2	1	
		(ii)	Concept: $E_k = -E_P$ or equivalent [1] Substitution: 4.3×10^8 ecf = ½ × 600 × v^2 or $v = \sqrt{2 \times 0.72 \times 10^6}$ [1] v = 1.2 k[m s^{-1}] [1]		3		3	2	
	(c)		Equation used to show that g at $2r$ should be ¼ of surface value or determined i.e. g at $2r$ = 0.15(5) N kg^{-1} or $gr^2 = k$ or equation used to calculate mass of Pluto [1] Good tangent [1] Gradient calculated e.g. $\frac{0.56 \times 10^6}{3 \times 1.18 \times 10^6}$ = 0.15[8] (approx.) [1] Appropriate comment or analysis to show that $g \propto \frac{1}{r^2}$ [1]			4	4	3	
			Question 6 total	**1**	**4**	**6**	**11**	**7**	**0**

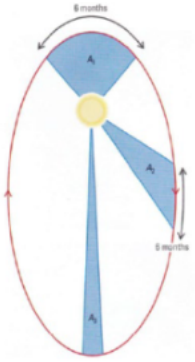
#7

Question			Marking details		Marks available				
				AO1	AO2	AO3	Total	Maths	Prac
3	*(a)*		Use of $s = \frac{1}{2}(u+v)t$ (1) t = 14.6 [s] (1)	1	1		2	2	
	(b)		Gain in KE = 4 020 – 962 = 3 058 [J] (1) Gain in PE = 95 × 9.8 × 4 = 3 728 [J] (1) Total = 3 058 + 3 728 = 6 786 [J] ecf (1)		3		3	3	
	(c)	(i)	Use of $E = VIt$ (1) 3 679 or 3 680 [J] ecf (1)	1	1		2	2	
		(ii)	Useful energy of motor = *(b)* – 6 500 = 1 286 [J] (1) Efficiency $= \frac{1286}{3679} \times 100 = 35$ [%] (1) ecf from (c)(i)		2		2	2	
		(iii)	Friction within motor / between front tyre and road (not just 'friction') (1) Air resistance on bike and Helen (1) Do not accept just heat / sound loss	2			2		
	(d)		Yes compared to petrol vehicles no [direct] emissions (1) ..and power station emissions [of CO_2, PM2s etc] much less than petrol vehicles			2	2		
			Question 3 total	**4**	**7**	**2**	**13**	**9**	**0**

#8

Question			Marking details	AO1	AO2	AO3	Total	Maths	Prac
				Marks available					
7	(a)		Electric field strength, E, is the force per unit charge [on a small positive test charge placed at the point]. (1) Electric potential, V, [at a point] is the work done per unit charge [in bringing the charge] from infinity [to that point]. (1) E- vector **and** V- scalar (both needed) (1)	3			3		
	(b)	(i)	 Both arrows seen. Ignore length of arrows. [Must be along dotted lines]	1			1		
		(ii)	 R correctly drawn and labelled [ecf]. Ignore length of arrow.		1		1		
		(iii)	E at P due to A (–12.0 nC) = 7 500 N C^{-1} (1) E at P due to B (+8.0 nC) = 28 800 N C^{-1} (1) (Deduct 1 mark for powers of 10 error) Resultant field strength at P = $(7\,500^2 + 28\,800^2)^{1/2}$ = 29 760 N C^{-1} (1) (**ecf** on both values of E) [or using horizontal and vertical components] Correct trigonometric relationship applied e.g. between R and A: $\theta = \cos^{-1}\left(\frac{7500}{29760}\right)$ = 75.4° (or 14.6° between R and B) [accept 2 sf and different ways of expressing directions] (1)		4		4	4	
	(c)	(i)	V_P due to A (–12.0 nC) =[–] 900 V V_P due to B (+ 8.0 nC) = [+] 1 440 V **Both potentials regardless of signs** (1) Correct sign convention [and addition clearly shown] (= + 540 V) (1) **Alternative** $\therefore V_P = \frac{1}{4\pi\varepsilon}\left\{\frac{-12\times10^{-9}}{12\times10^{-2}} + \frac{8\times10^{-9}}{5\times10^{-2}}\right\}$ values(1) and signs (1)		2		2	2	
		(ii)	Correct substitution into $W = q\Delta V$ i.e -1.6 × 10^{-19} (+540 – 0) (1) **Or** W = - 8.64 × 10^{-17} J seen (accept 540 eV converted into J) Hence gain in E_k = (+) 8.64 × 10^{-17} J (1) (+) can be awarded by implication	1	1		2	1	
	(d)		de Broglie $\lambda = \frac{h}{p}$ (1) Electron accelerates (or velocity or E_k increases) towards point P, **so** momentum increases (need to explain why momentum increases here) (1) So λ decreases (1) Ecf from (c) on marks 2 and 3: If $\Delta E_k < 0$ then opposite answer required.	1	1 1		3		
			Question 7 total	**6**	**10**	**0**	**16**	**7**	**0**

#9

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
	(a)			Areas and time periods shown correctly or described [1] $A_1 = A_2 (= A_3)$ indicated [1]  6 months	2			2		
	(b)			$\frac{mv^2}{r} = \frac{GMm}{r^2}$ [1] $v = \frac{2\pi r}{T}$ [1] Substitution and clear algebra step shown [1] **Or** $mr\omega^2 = \frac{GMm}{r^2}$ [1] $\omega = \frac{2\pi}{T}$ [1] Substitution and clear algebra step shown [1]	1	1 1		3	2	
	(c)	(i)		$\omega = \frac{2\pi}{(7.7 \times 3\,600)}$ or $2.26(7) \times 10^{-4}$ rads^{-1} seen [1] $M = \frac{(2.27 \times 10^{-4})^2 \times (9.4 \times 10^6)^3}{6.67 \times 10^{-11}}$ substitution and re-arrangement [1] $M = 6.39[8] \times 10^{23}$ k[g] [1]		3		3	3	
		(ii)	I	Substitution into $V_g = -\frac{GM}{R}$ i.e. $V_g = -\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{9.4 \times 10^6}$ [1] $V_g = -4.5(4) \times 10^6$ [J kg^{-1}] [1]	1	1		2	2	
			II	V_g at orbit of Deimos = $-\frac{6.67 \times 10^{-11} \times 6.4 \times 10^{23}}{2.35 \times 10^7}$ $= -1.8(2) \times 10^6$ J kg^{-1}[1] $\Delta V = -1.82 + 4.54 = 2.72$ M[J kg^{-1}] [1] Energy available per kg of fuel = $0.6 \times 4.4 = 2.64$ M[J kg^{-1}] [1] Scientists should not attempt manoeuvre [1] [**ecf** based on calculations]			4	4	3	
		(iii)		One of: • g is not constant [over the distance between orbits] • g decreases as height increases • work done per metre decreases as height increases • field is not uniform		1		1		
				Question total	**4**	**7**	**4**	**15**	**10**	**0**

#10

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
4	*(a)*			Total energy [of a closed system] stays constant [or equivalent] (1) but energy can be stored [or calculated] in different ways [accept can be converted from one form to another or equivalent] (1).	2			2		
	(b)	(i)	I	Substitution of data from one point on the curved graph or by implication (1) Re-arrangement at any stage of $E = \frac{1}{2}kx^2$ (1) k = 40 N m^{-1} **unit** Accept equivalent unit such as J m^{-2} (1)	1	1 1		3	2	
			II	Substitution of data from one point on straight line or by implication (1) 0.20 kg (1)	1	1		2	1	
			III	Total energy (including at x = 0.050 m) is zero or by implication (1) KE = 0.050 J (1) 'Correct' answer from $\frac{1}{2}mv^2 = \frac{1}{2}kx^2 \rightarrow$ 0 marks		2		2	1	
		(ii)		Graph passes through (0, 0), (0.05, 0.05), (0.1, 0) [1] rises and falls smoothly [1]		2		2	2	
	(c)			Attach **different** masses, m, drop, and measure x_{max} each time (1) Any one relevant experimental detail (e.g. measure x_{max} with metre rule or repeat readings or take precautions against parallax). (1) Plot x_{max} against m [or m against x_{max}] or for each pair of readings calculate $\frac{x_{max}}{m}$ [or $\frac{m}{x_{max}}$] (1) Straight line through origin or constancy of calculated quotient will verify relationship. (1)			4	4	2	4
				Question 4 total	**4**	**7**	**4**	**15**	**8**	**4**

#11

Question				Marking details	Marks available					
					AO1	AO2	AO3	Total	Maths	Prac
5	*(a)*			[Motion such that] acceleration proportional to displacement from a fixed point [1] but in opposite direction or directed towards that point [1] **or** $a = -\omega^2 x$ with a = acceleration and x = displacement [1] ω [or ω^2] constant [1]	2			2		
	(b)	(i)		T = 1.2[0] s (from graph) or by implication [1] Correct re-arrangement $k = \frac{4\pi^2 m}{T^2}$ at any stage **or by impl.** [1] k = 4.80 N m^{-1} **unit mark** [1]		3		3	2	
		(ii)		Correct use of $v_{max} = A\omega$ [= 0.209 m s^{-1}] **or by implic** [1] Correct use of $E_k = \frac{1}{2}mv^2$ **ecf** on slips in v_{max} [1] $E_{k\,max}$ = 3.8 × 10^{-3} J [1]	1 1	1		3	2	
		(iii)		 Zeros at t = 0, 0.6 s, 1.2 s, 1.8 s, 2.4 s [1] KE never negative with equal peaks [1] Smooth (sinusoidal) curve [1]	 1 1	1		3	2	
	(c)			Reasonable straight line of best fit drawn [1] Straight line expected as equation equivalent to $\ln A = \ln A_0 - \lambda t$ [1] Some comment about scatter of points – either supporting or casting doubt on straight line [1] λ = –gradient **or by impl.** [1] Gradient calculated correctly e.g. 0.014 [s^{-1}] No *second* penalty for mishandling minus sign [1]			5	5	3	5
				Question 5 total	**6**	**5**	**5**	**16**	**9**	**5**

#12

Question			Marking details	Marks available					
				AO1	AO2	AO3	Total	Maths	Prac
	(a)	(i)	Acceleration = $\frac{0.16}{2.0}$ [=0.08] [m s^{-2}] or by implication (1) Force = $1.2 \times [\frac{0.16}{2.0}]$ [N] (**ecf** on acc for this mark only) (1) Force = 0.096 [N] (1) [Deduct only 1 if wrong answer clearly due to arithmetical slip.] **Alternative:** **Don't award individual marks unless overall method clear** s =1.04 [m] (1) v^2-u^2 = 0.166 [m^{2}s^{-2}] **or** ΔE_k = 0.0988 [J] (1) Force = 0.096 [N] (1)	1	1 1		3	3	
		(ii)	Distance = (½)(0.60 + 0.44) × 2.0 [= 1.04 m] **or** equiv **or** by imp (1) Work = 0.096 × [calculated distance] [J] **ecf on (a)(i)** (1) Work = 0.10 [J] (1) **Alternative solution:** Final KE = (½) 1.2 × 0.44^2 [= 0.11616 J] **or** by imp (1) Initial KE = (½) 1.2 × 0.60^2 [= 0.216 J] **or** by imp (1) Work = 0.10 [J] (1)	1	1 1		3	3	
		(iii)	Momentum of system before collision = 1.2 × 0.44 [= 0.528 N s] [or by implic] (1) Momentum of A after collision = –1.2 × 0.14 [= – 0.168 N s] (1) 1.2 × 0.44 = –1.2 × 0.14 + 3.0 v **or** equivalent **or** by implic (1) v = 0.23 [m s^{-1} to the right] (1) Penalty for failure to take account of A's velocity being to the left after collision (gives v = 0.12 [m s^{-1}]) is 2 marks if all else correct. 1 mark penalty for taking A's initial velocity as 0.60 [m s^{-1}]	1 1	 1 1		4	4	
		(iv)	Initial KE = (½) 1.2 × 0.44^2 [= 0.116 J] **or** by imp (1) Final KE = (½) 1.2 × 0.14^2 + (½) 3.0 × 0.232^2 [= 0.092 J] **ecf** (1) [KE lost] so inelastic **ecf** (1) **ecf** on A's initial velocity = 0.60 [m s^{-1}]			3	3	2	
	(b)		**3 valid points made - 3rd mark can be a follow-up of one of the points** Examples of 'follow-ups' are preceded by dashes (-) below. Better traction or equivalent May reduce damage to cars in collisions - Metal less likely to deform [under given stress, though stress likely to be greater!] More damage to objects hit by cars May increase damage to passengers during collisions - Thicker metal likely to [decrease collision time and] increase accelerations during collisions Would increase fuel consumption - More energy used to accelerate **or** more energy dissipated in tyres. More metal used [per car] [uses up resources faster] Makes manufacture more difficult Makes cars harder to repair if damaged			3	3		
			Question total	**4**	**6**	**6**	**16**	**12**	**0**

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