PEARSON EDEXCEL IAL PHYSICS · YPH11

PHYSICS



EXAM QUESTION PACK

UNIT 5: OSCILLATIONS

SCORE	PERCENTAGE
/41	%

STEMUP

These questions belong to Pearson Edexcel, not to us.

The examination questions, mark schemes and examiner comments in this pack were written and published by Pearson Edexcel. They are past assessment materials, reproduced here so that students can revise from them.

What we do not own

STEMUP is not affiliated with Pearson Edexcel and does not own, and makes no claim to own, any of the question, mark scheme or examiner report material in this pack. Pearson Edexcel has not endorsed, approved or been involved in the production of it. Pearson Edexcel and the qualification titles used here belong to their respective owners and appear for identification only.

Where to find the originals

Pearson Edexcel publishes its past papers, mark schemes and examiner reports free of charge. Always check the current specification at qualifications.pearson.com before you revise, because content and wording can change between series.

If you hold the rights to any material in this pack and would like it amended or removed, contact admin@stemup.co.uk and we will act on it.

Q1.

In the 17th century, Kepler proposed his 'law of harmonies' for planetary motion. This law suggested that the ratio of the square of the orbital period T to the cube of the mean radius R has the same value for all the planets that orbit the Sun.

Mathematically his 'law of harmonies' can be written

$$T^2 = KR^3$$

where K is a constant.

(a) The table shows data for Earth and Mars.

Planet	T/s	R/m
Earth	3.16×10^7	1.50×10^{11}
Mars	5.93×10^7	2.28×10^{11}

Show that, for Earth and for Mars, K has a value of about $3.0 \times\times 10^{-19}$ s^2 m^{-3}.

(3)

.....

.....

.....

.....

.....

.....

(b) Kepler's law of harmonies was derived later by Newton. Newton applied his law of gravitation to a planet moving in an approximately circular orbit around the Sun.

Determine a value for K by applying Newton's law of gravitation to a planet of mass m moving in a circular orbit about the Sun.

mass of Sun = 1.99×10^{30} kg

(3)

.....

.....

.....

.....

.....

.....

K = ... $s^2\ m^{-3}$

(c) Jupiter is the most massive planet in the solar system and has many moons. Kepler's law of harmonies applies to the orbiting moons. However, the value of K for the moons is not the same as the value that applies to planets orbiting the Sun.

Ganymede is Jupiter's largest moon. Ganymede has an orbital radius of 1.07×10^9 m and an orbital period of 172 hours.

Another moon, Io, has an orbital radius of 4.22×10^8 m.

Calculate the orbital period T_I of Io about Jupiter.

(2)

.....

.....

.....

.....

.....

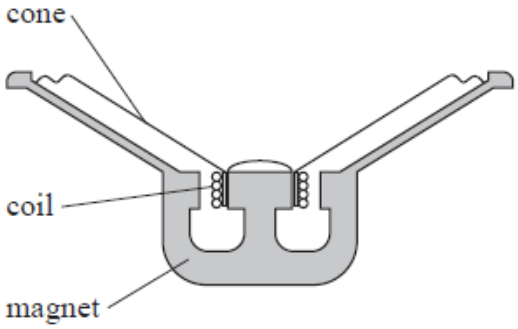
.....

T_I = ...

(Total for question = 8 marks)

Q2.

A music system has a number of loudspeakers. One loudspeaker produces the low frequency sounds. This loudspeaker consists of a coil connected to a cone. The coil is in a region of magnetic field produced by a permanent magnet, as shown.



(a) Explain how an alternating current in the coil causes the cone to oscillate with the frequency of the alternating current.

(3)

.....

.....

.....

.....

.....

.....

.....

(b) A signal of constant frequency is applied to the loudspeaker. The coil moves with simple harmonic motion and the loudspeaker emits a sound of frequency 75 Hz.

When the loudspeaker is producing this sound, the coil moves through a maximum distance of 3.5 mm.

(i) Calculate the maximum velocity of the coil.

(3)

.....

.....

.....

.....

Maximum velocity of the coil = ...

(ii) State the position of the coil when the velocity is a maximum.

(1)

.....

.....

(c) At a particular frequency, the loudspeaker cone starts to oscillate with a very large amplitude.

Explain why this effect is observed.

(2)

.....

.....

.....

.....

.....

(Total for question = 9 marks)

Q3.

A man is about to dive into the sea from a high diving board. The board is horizontal before he walks to the end of the board.

When the man stands on the end of the board, it bends as shown.



(Source: © Fuse / Getty Images)

(a) By pushing on the board, the man displaces the end of the board a small distance downwards. The man and the board then oscillate with approximate simple harmonic motion.

State the conditions for simple harmonic motion.

(2)

.....

.....

.....

.....

(b) The man stands at the end of the board. The board is in equilibrium when the end of the

board has a vertical displacement of 18 cm.

mass of man = 75 kg

(i) The board obeys Hooke's law as it deforms.

Show that the stiffness of the diving board is about 4000 N m^{-1}.

(2)

.....

.....

.....

.....

(ii) Calculate the frequency of oscillation of the man on the board. Ignore the mass of the board.

(3)

.....

.....

.....

.....

.....

.....

Frequency of oscillation = ...

(c) If the amplitude of oscillation is large enough, the man will lose contact with the board at a point above the equilibrium position.

Explain why.

(3)

.....

.....

.....

.....

.....

.....

.....

(Total for question = 10 marks)

Q4.

* A teacher is teaching her class about the phenomenon of resonance. To do this, she uses a drinking glass to produce sound in two different ways.



When the glass is gently struck, the glass emits sound for a short time.

When a wet finger is slid around the top of the glass, it is possible to produce a loud continuous sound.

Explain these observations.

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

.....

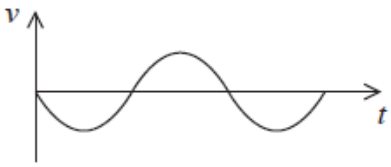
.....

(Total for question = 6 marks)

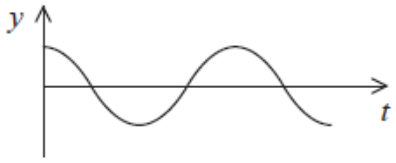
Q5.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

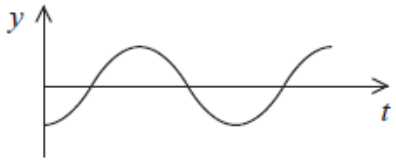
A mass oscillates with simple harmonic motion. The graph shows how the velocity *v* varies with time *t* for the mass.



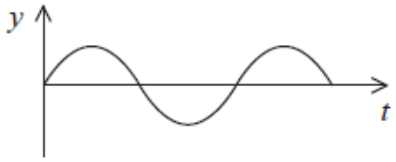
Which graph shows how the displacement *y* from the equilibrium position varies with *t* over the same time interval?



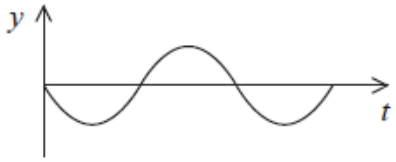
A



B



C



D

☒ **A**

☒ **B**

☒ **C**

☒ **D**

(Total for question = 1 mark)

Q6.

Answer the question with a cross in the box you think is correct ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A mass is hung from a spring and set into vertical oscillation. The mass is then changed so that the frequency of oscillation doubles. The amplitude of the oscillation is unchanged.

Which of the following quantities is also doubled?

☒ **A** the maximum acceleration of the mass

☒ **B** the maximum kinetic energy of the mass

☒ **C** the maximum velocity of the mass

☒ **D** the period of the oscillation

(Total for question = 1 mark)

Q7.

Select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

In the Pantheon in Paris there is a pendulum that takes 8.25 s to swing from one extreme position to the other.

Which of the following expressions gives the length of the pendulum?

☒ **A** $\frac{4\pi^2}{(8.25)^2 \times 9.81}$

☒ **B** $\frac{4\pi^2}{(16.5)^2 \times 9.81}$

☒ **C** $\frac{(8.25)^2 \times 9.81}{4\pi^2}$

☒ **D** $\frac{(16.5)^2 \times 9.81}{4\pi^2}$

(Total for question = 1 mark)

Q8.

Select one answer from A to D and put a cross in the box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.

A mass oscillates with simple harmonic motion about a fixed point O.

Which of the following statements about the motion of the mass is correct?

☒ **A** Its velocity is always towards O.

☒ **B** Its acceleration is always towards O.

☒ **C** Its acceleration is directly proportional to its velocity.

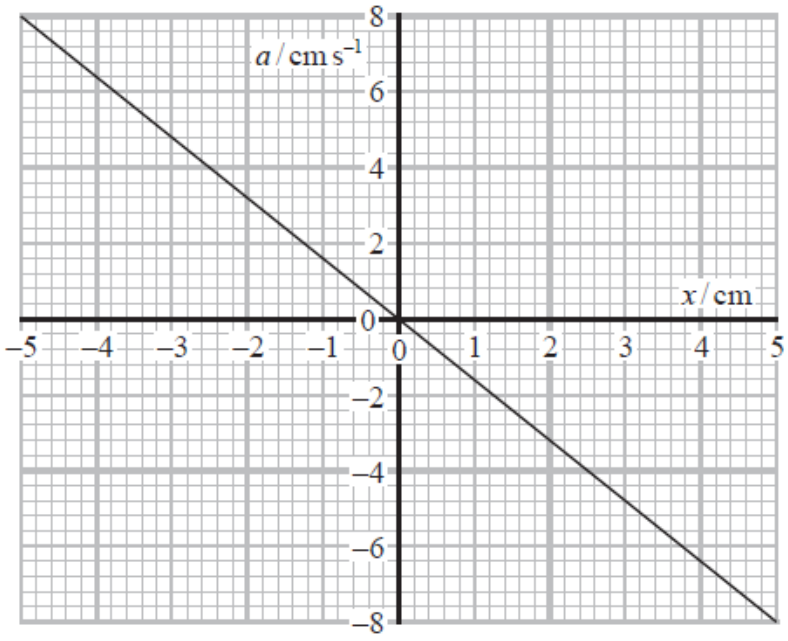
☒ **D** Its acceleration and its velocity are always in opposite directions.

(Total for question = 1 mark)

Q9.

A mass is hung from a spring and set into vertical oscillation by displacing the mass 5 cm from its equilibrium position.

The graph shows how the acceleration a of the mass depends upon the displacement x of the mass from its equilibrium position.



Sketch a graph on the axes below to show how x depends upon time t.

.....

.....

.....



(Total for question = 4 marks)

Mark Scheme

Q1.

Question Number	Answer		Mark
(a)	Use of $T^2 = KR^3$	(1)	
	K for Earth = 2.96×10^{-19} ($s^2\ m^{-3}$)	(1)	
	K for Mars = 2.97×10^{-1} ($s^2\ m^{-3}$)	(1)	**3**
	Example of calculation		
	$K = \frac{T^2}{R^3} = \frac{(3.16 \times 10^7 s)^2}{(1.50 \times 10^{11}\ m)^3} = 2.959 \times 10^{-19}\ s^2\ m^{-3}$		
	$K = \frac{T^2}{R^3} = \frac{(5.93 \times 10^7 s)^2}{(2.28 \times 10^{11}\ m)^3} = 2.967 \times 10^{-19}\ s^2\ m^{-3}$		
(b)	**Either**		
	Use of $F = \frac{GMm}{r^2}$ with $F = \frac{mv^2}{r}$	(1)	
	Re-arrangement with $v = \frac{2\pi r}{T}$ to identify K as $\frac{(2\pi)^2}{GM}$	(1)	
	$K = 2.97 \times 10^{-19}$ ($s^2\ m^{-3}$)	(1)	
	Or		
	Use of $F = \frac{GMm}{r^2}$ with $F = m\omega^2 r$	(1)	
	Re-arrangement with $\omega = \frac{2\pi}{T}$ to identify K as $\frac{(2\pi)^2}{GM}$	(1)	
	$K = 2.97 \times 10^{-19}$ ($s^2\ m^{-3}$)	(1)	**3**
	Example of calculation		
	$\frac{GMm}{r^2} = m\omega^2 r$		
	$\frac{GM}{r^2} = \left(\frac{2\pi}{T}\right)^2 r$		
	$T^2 = \frac{(2\pi)^2}{GM} r^3$		
	$K = \left(\frac{4\pi^2}{6.67 \times 10^{-11}\ N\ m^2\ kg^{-2} \times 1.99 \times 10^{30}\ kg}\right) = 2.97 \times 10^{-1}\ s^2 m^{-3}$		

(c)	Use of $T^2 = KR^3$	(1)	
	T = 43 hours	(1)	**2**
	Example of calculation		
	$\left(\frac{T_I}{T_G}\right)^2 = \left(\frac{R_I}{R_G}\right)^3$		
	$T = \sqrt{\left(\frac{4.22 \times 10^8\ m}{1.07 \times 10^9\ m}\right)^3 \times (172\ hour)^2} = 42.6$ hours		
	Total for question		**8**

Q2.

Question Number	Answer		Mark
(a)	**Either** Current carrying coil/conductor in a magnetic field	(1)	
	Coil experiences a force	(1)	
	Force changes direction with current (as current is changing direction)	(1)	
	Or Current in coil causes a magnetic field	(1)	
	Field interacts with permanent magnet's field, so force on coil	(1)	
	Field changes direction with current so force changes direction	(1)	**3**
(b)(i)	Use of $\omega = 2\pi f$	(1)	
	Use of $v = -A\omega \sin \omega t$	(1)	
	$v = 0.82$ m s^{-1}	(1)	**3**
	Example of calculation $\omega = 2\pi$ rad $\times$ 75 s^{-1} = 471 rad s^{-1} $v = 1.75 \times 10^{-3}$m $\times$ 471 s^{-1} $\times$ 1 = 0.8247 m s^{-1}		
(b)(ii)	At the equilibrium/undisplaced/central/middle (position)	(1)	**1**
(c)	**MAX 2** The driver frequency of the coil matches the natural frequency of the cone	(1)	
	There is a maximum transfer of energy (from the coil to the cone)	(1)	
	Resonance occurs	(1)	**2**
	[For full marks the response must be related to the question context]		
	Total for question		**9**

Q3.

Question Number	Answer		Mark
(a)	There is a (resultant) force/acceleration that is:		
	Proportional to the displacement from the equilibrium position	(1)	
	and (always) acting towards the equilibrium position	(1)	2
(b)(i)	Use of $k = -\frac{\Delta F}{\Delta x}$	(1)	
	$k = 4100$ (N m^{-1})	(1)	2
	Example of calculation $k = -\frac{mg}{\Delta x} = \frac{75\text{ kg} \times 9.81\text{ N kg}^{-1}}{0.18\text{ m}} = 4088\text{ N m}^{-1}$		
(b)(ii)	Use of $T = 2\pi\sqrt{\frac{m}{k}}$	(1)	
	Use of $f = \frac{1}{T}$	(1)	
	$f = 1.2$ Hz (allow ecf from (b)(i))	(1)	3
	Example of calculation $T = 2\pi\sqrt{\frac{75\text{ kg}}{4090\text{ N m}^{-1}}} = 0.85\text{ s}$ $f = \frac{1}{0.85\text{ s}} = 1.18\text{ Hz}$		
(c)	The resultant force on the man = ($mg - R$) where R is the (normal) contact force from the board	(1)	
	R decreases as his displacement (from the equilibrium position) increases	(1)	
	Man loses contact with board when $R = 0$ **Or** Man loses contact with board when resultant force on man is equal to his weight	(1)	
	OR		
	Acceleration (for SHM) increases as displacement increases	(1)	
	Maximum (downward) acceleration of man is g	(1)	
	Man loses contact with board when acceleration of the board is equal to g	(1)	3
	Total for question		10

Q4.

Question Number	Answer	Mark
	This question assesses a student's ability to show a coherent and logically structured answer with linkages and fully-sustained reasoning. Marks are awarded for indicative content and for how the answer is structured and shows lines of reasoning. The following table shows how the marks should be awarded for structure and lines of reasoning.	

	Number of marks awarded for structure of answer and sustained line of reasoning
Answer shows a coherent and logical structure with linkages and fully sustained lines of reasoning demonstrated throughout	2
Answer is partially structured with some linkages and lines of reasoning	1
Answer has no linkages between points and is unstructured	0

Total marks awarded is the sum of marks for indicative content and the marks for structure and lines of reasoning

IC points	IC mark	Max linkage mark	Max final mark
6	4	2	6
5	3	2	5
4	3	1	4
3	2	1	3
2	2	0	2
1	1	0	1
0	0	0	0

	Indicative content IC1 Striking the glass sets the glass into (free) oscillation. IC2 Energy is transferred from glass/system and the amplitude (of oscillation) decreases (quickly to zero). **Or** the oscillation is damped and the amplitude (of oscillation) decreases (quickly to zero). IC3 Sliding a wet finger around the top of the glass drives/forces the glass/system into oscillation. IC4 The driving frequency (produced by the wet finger) is equal/close to the natural frequency (of oscillation) of the glass/system IC5 Resonance occurs and there is an efficient/maximum transfer of energy IC6 The amplitude (of oscillation) increases (and transfers energy to the air)	
	Total for question	**6**

Q5.

Question Number	Answer	Mark
	A is the correct answer, as the velocity is the gradient of the graph of displacement against time, and the gradient of this graph starts at zero and then becomes negative for the first half cycle.	**(1)**

Q6.

Question Number	Answer	Mark
	C is the correct answer A is not the correct answer, as $a = (2\pi f)^2 A$ B is not the correct answer, as $E_k = \frac{1}{2}m(2\pi fA)^2$ D is not the correct answer, as $T = \frac{1}{f}$	**(1)**

Q7.

Question Number	Answer	Mark
	D is the correct answer, as $T = 2\pi\sqrt{\frac{L}{g}}$ and $T = 2 \times 8.25$s	**(1)**

Q8.

Question Number	Answer	Mark
	B is the correct answer, as this is part of the definition of s.h.m.	**(1)**

Q9.

Question Number	Answer		Mark
	At least 1 cycle of a sinusoidal graph	(1)	
	Displacement axis shows amplitude as 5 cm	(1)	
	Use of $a = (-)\omega^2 x$ and $\omega = \frac{2\pi}{T}$ to calculate T	(1)	
	Time axis shows period as calculated value of T	(1)	**4**
	<u>Example of calculation</u> $\omega = \sqrt{\frac{8.0 \text{ cm s}^{-2}}{5.0 \text{ cm}}} = 1.26 \text{ s}^{-1}$ $T = \frac{2\pi}{1.26 \text{ s}^{-1}} = 4.97 \text{ s}$		
	Total for question		**4**