Physics

Question	Maximum Mark	Mark Awarded
#1	6	
#2	15	
#3	16	
#4	13	
#5	19	
Total	69	

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Question Bank

4. Describe an experiment that uses a pendulum to determine the acceleration due to gravity with graphical analysis. [6 QER]

#2

3. Simple harmonic motion (SHM) may be represented by:

$$a = -\omega^2 x$$

(a) State what quantities are represented by: [1]

a ....

ω ....

x ....

(b) If the amplitude of the oscillation of an object moving with SHM is 0.012 m and the period is 0.40 s:

(i) determine the maximum acceleration; [3]

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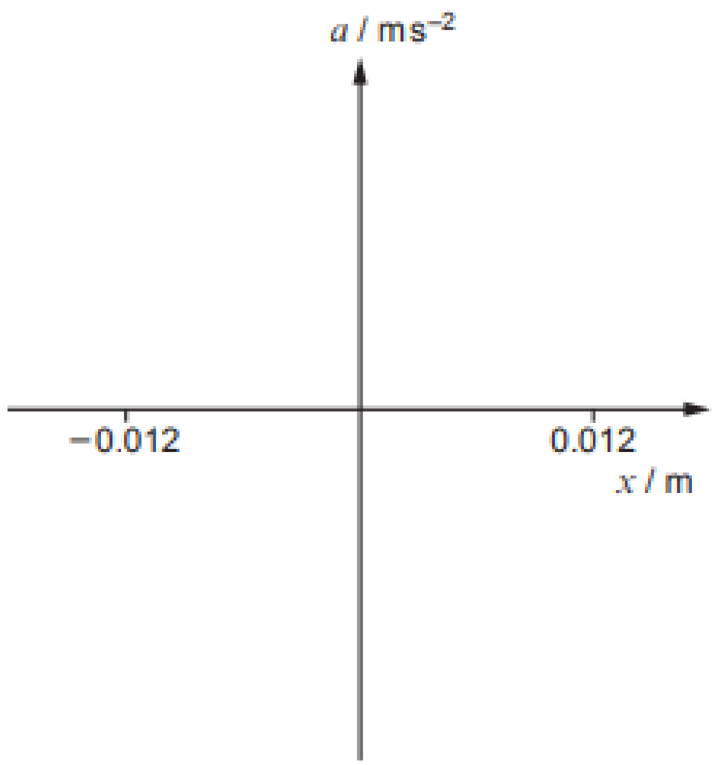
(ii) sketch a graph showing the variation of a with x. Insert values on the a-axis. Values are given on the x-axis. [3]



(c) The oscillating object in part (b) is at its centre position when t = 0 and moving in the positive x direction. Insert the missing values in the expression for x in metres. [3]

$$x = \boxed{}\cos(\boxed{}\,t + \boxed{})$$

(d) An oscillating system may be driven by an external force. Describe and explain:

(i) an application of forced oscillations that is useful; [2]

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(ii) an example of forced oscillations that should be avoided. [3]

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#3

7. *(a)* A pendulum oscillating with simple harmonic motion consists of a small 0.05 kg mass oscillating at the end of a string of length 4.0 m. The displacement x in metres at time t can be written as:

$$x = 0.25 \cos \omega t$$

(i) Show that the angular velocity, ω, is approximately 1.57 rad s^{-1}. [2]

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(ii) Calculate the maximum speed of the mass. [2]

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(iii) Show that the kinetic energy (E_k) of the mass, in joules, may be written as: [2]

$$E_k = 3.8 \times 10^{-3} \sin^2 1.57t$$

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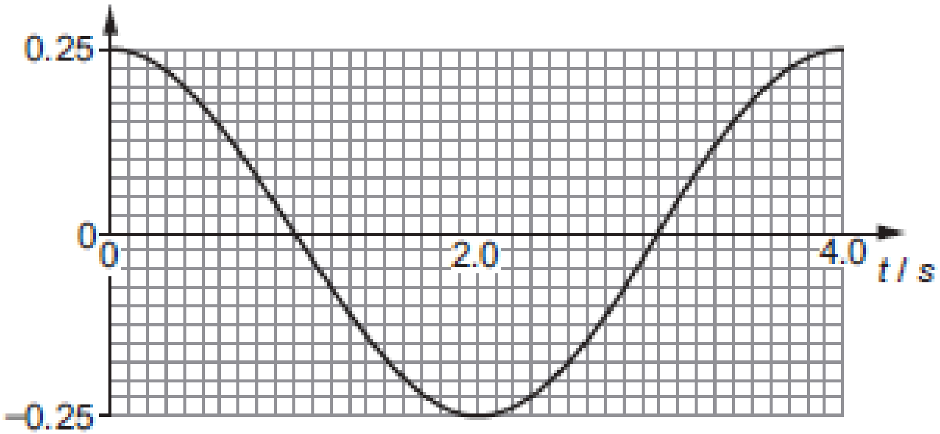
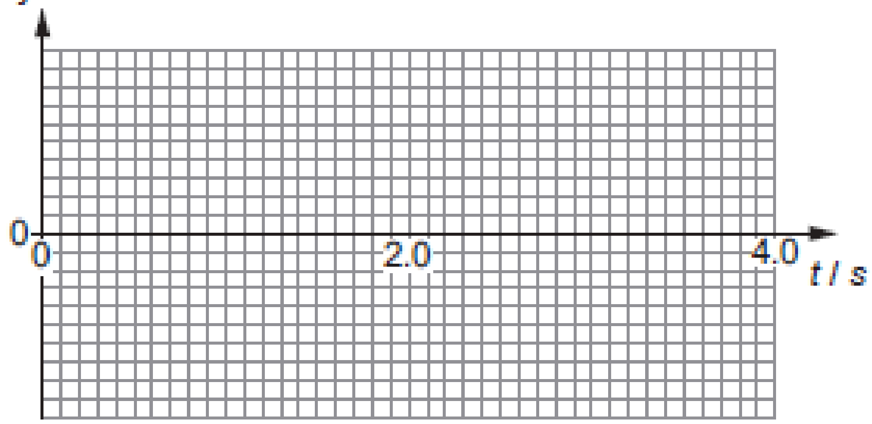
(iv) The displacement-time curve for the pendulum is shown for a time interval of one period i.e. 4.0 s. Draw curves for velocity, v, and E_k on the axes below for the same interval of time. Indicate values on your axes for v and E_k. [4]

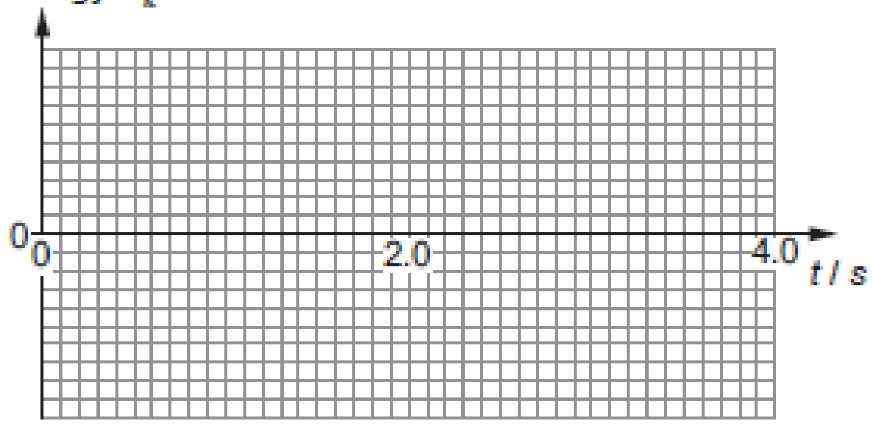
Displacement x / m



Velocity v / m s^{-1}



Kinetic energy E_k / J



(v) Determine the maximum height reached by the pendulum mass above the level of its lowest point. [2]

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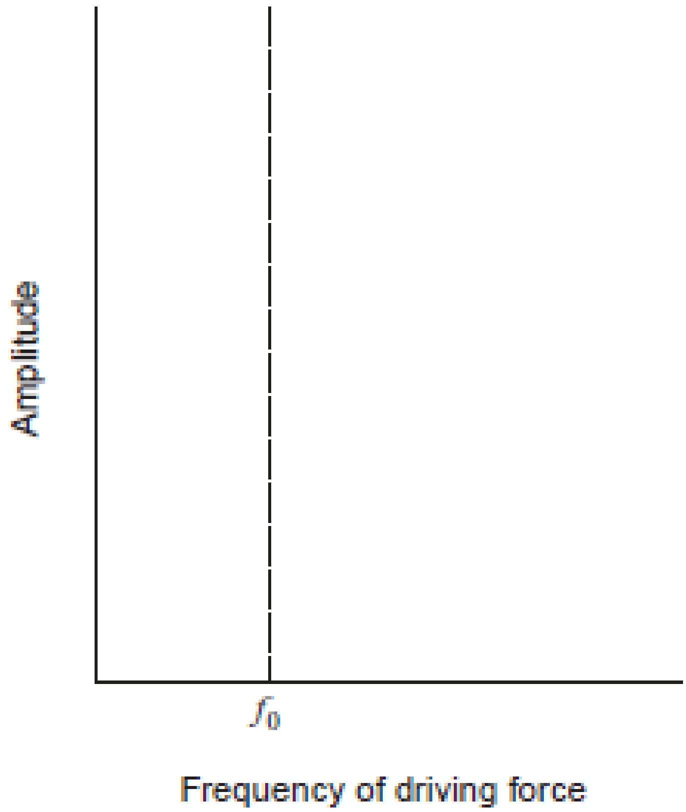
(b) A system that can oscillate may be driven by an external sinusoidal force.

(i) Sketch the amplitude of a lightly damped system as the frequency of the driver is increased. The natural frequency f_0 of the system is indicated. Label the curve **X**. [1]



(ii) Name the effect seen near the frequency, f_0. [1]

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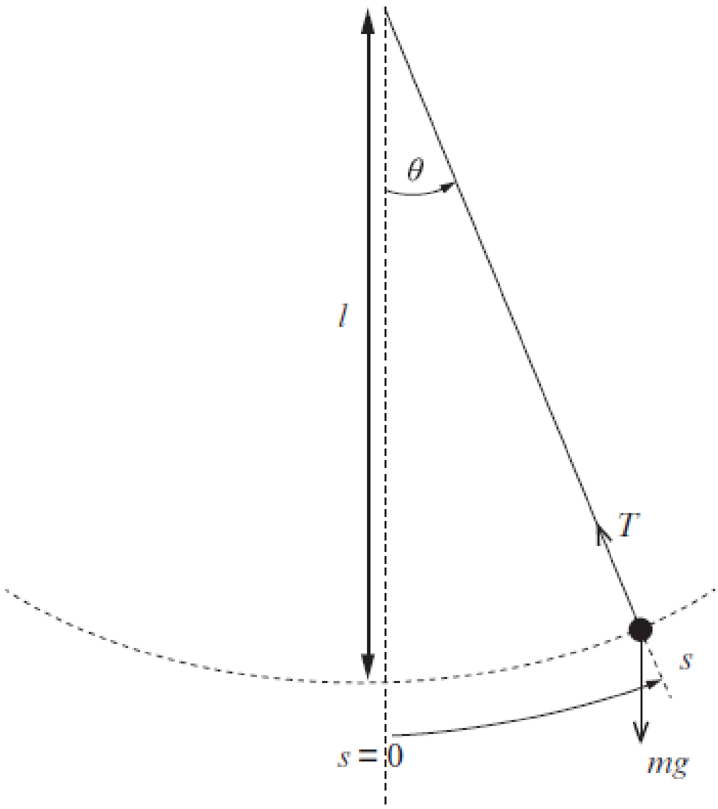
(iii) Sketch a second curve on the axes above for an identical oscillating system that is damped to a greater extent. Label the curve as Y. [2]

#4

(a) The pendulum in the figure below has a small bob of mass, m, suspended at the bottom of a light string of length, l. The string is shown at an angle, θ, to the vertical and the mass, m, is at a distance, s, along the arc. The forces acting on the mass are shown.



(i) Name the **two** forces acting on the mass. [1]

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(ii) By considering these forces show that:

resultant force component on the mass along the arc = $-mg\ \sin\theta$

You may add to the diagram if you wish. [3]

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(iii) If the oscillation is small so that $\sin\theta \simeq \theta$ show in clear steps that the acceleration along the arc may be written as: [2]

$$\text{acceleration} = -\frac{gs}{l}$$

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(iv) Discuss whether the equation in part *(a)*(iii) satisfies the definition of simple harmonic motion. [2]

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(b) A small mass oscillates at the lower end of a pendulum of length 1.20 m.

(i) Determine its:

I. period; [2]

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II. frequency. [1]

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(ii) If the maximum displacement angle of the mass is 0.067 rad, justify the use of simple harmonic motion in part *(b)*(i). [2]

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#5

6. *(a)* A load of 0.150 kg is attached to the lower end of a light vertical spring of stiffness (spring constant) $7.50\,\text{N m}^{-1}$. The system is initially in equilibrium. A student raises the load vertically through a distance of 0.095 m and releases it so that it oscillates.

Determine:

(i) the extension of the spring when the system is in equilibrium; [2]

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(ii) the period of oscillation. [2]

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(b) The student notices the amplitude of oscillation decreasing and records the following amplitudes.

Oscillation number (n)	Amplitude (A) /m
0	0.095
10	0.062
20	0.043
30	0.029
40	0.019
50	0.014
60	0.009

She comments that "the rate of decrease of amplitude is larger at the start of the experiment than at its end". Justify the statement using the data from the table. [2]

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(c) She expects that the measured amplitude of oscillation can be described by the equation:

$$A = A_0 e^{-\frac{n}{N}}$$

where A_0 is the initial amplitude, n is the oscillation number and N is a constant for the experiment that describes the decay of the amplitude.

(i) Justify that A_0 is the amplitude when $n = 0$. [1]

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(ii) By considering the amplitude when $n = 30$ use the equation to determine a value for N. [2]

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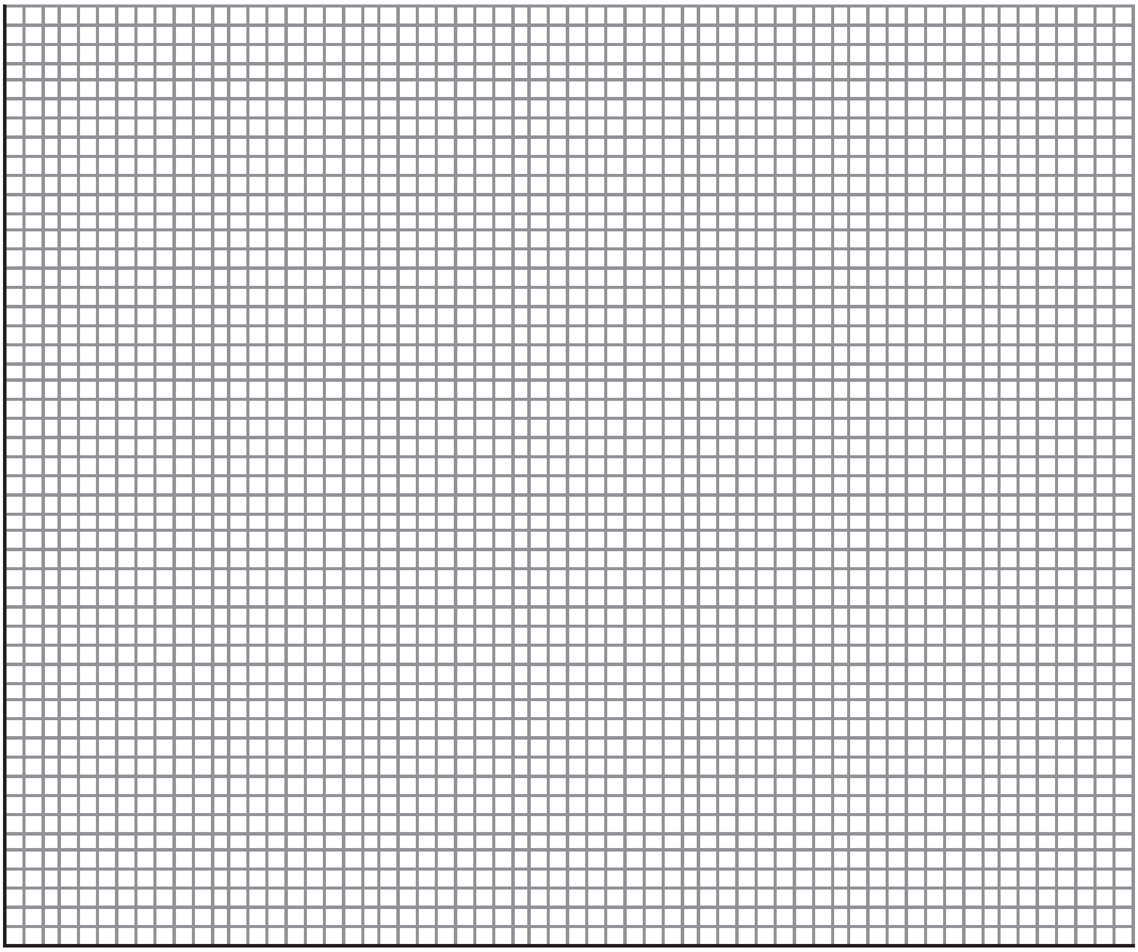
(d) The student decides to check the validity of the equation.

(i) Complete the third column in the table. The first four rows have already been completed. [1]

Oscillation number *(n)*	Amplitude *(A)* / m	$\ln\left(\frac{A_0}{A}\right)$
0	0.095	0
10	0.062	0.43
20	0.043	0.79
30	0.029	1.19
40	0.019	
50	0.014	
60	0.009	

(ii) Plot $\ln\left(\frac{A_0}{A}\right)$ (y-axis) as a function of the oscillation number (x-axis) and draw a line of best fit. [3]



(iii) Explain whether or not your graph is in agreement with the equation $A = A_0 e^{-\frac{n}{N}}$. [2]

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(iv) Use the graph to determine a value for N. [3]

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(v) Explain which of the two values obtained for N is expected to be the more accurate, the value in part *(c)*(ii) or *(d)*(iv). [1]

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