Question 1

(*a*) State Hooke's law.

extension proportional to // (restoring) force prop. to // F = (−)ks **(2)**

(applied)force // displacement // notation **(2)**

The elastic constant of a spring is 12 N m^{-1} and it has a length of 25 mm. An object of mass 20 g is attached to the spring.

What is the new length of the spring?

x = F/k = (0.02 × 9.8)/12 = 0.0163 m **(3)**

new length = 41.3 mm *(–1 for omission of or incorrect units)* **(3)**

The object is then pulled down until the spring's length is increased by a further 5 mm and is then released. The object oscillates with simple harmonic motion.

Sketch a velocity-time graph of the motion of the object.

axes labelled **(3)**
periodic graph **(3)**
correct sinusoidal shape, beginning with v = 0 **(3)**

Calculate the period of oscillation of the object.

ω^2 = k/m (= 600) **(3)**
T = 2π/ω **(3)**
T = 0.256 s *(–1 for omission of or incorrect units)* **(3)**

Question 2

(*a*) **State Hooke's law.**

(restoring) force proportional // $F \alpha -s$ / $F = -ks$ 3
displacement / distance // correct notation for F and s 3

A body of mass 250 g vibrates on a horizontal surface and its motion is described by the equation *a* = – 16 *s*, where *s* is displacement of the body from its equilibrium position. The amplitude of each vibration is 5 cm. Why does the body vibrate with simple harmonic motion?

acceleration proportional to displacement / $a \ \alpha (-)s$ 6

Calculate the frequency of vibration of the body?

$\omega^2 = 16$ / $\omega = 4$ 3

$f = \frac{\omega}{2\pi}$ 3

$f = 0.64 \text{Hz} / \text{s}^{-1}$ **(–1 for omission of or incorrect unit)** 3

What is the magnitude of (i) the maximum force, (ii) the minimum force, which causes the body's motion?

$a_{max} =$ (–)16(0.05) / 0.80 // F_{max} occurs when acceleration / displacement is a maximum 3

$F_{max} =$ (0.250)(0.800) / 0.20 N **(–1 for omission of or incorrect unit)** 2

$F_{min} = 0$ 2

Question 3

A student investigated the variation of the fundamental frequency *f* of a stretched string with its tension *T*. The following is an extract of the student's account of the experiment.

> **"I fixed the length of the string at 40 cm. I set a tuning fork of frequency 256 Hz vibrating and placed it by the string. I adjusted the tension of the string until resonance occurred. I recorded the tension in the string. I repeated the experiment using different tuning forks."**

The following data were recorded.

f/Hz	256	288	320	341	384	480	512
T/N	2.4	3.3	3.9	4.3	5.7	8.5	9.8

How was the tension measured? How did the student know that resonance occurred?

a newton balance/scales // weight of pan+ contents **(–1 if no reference to 'newton' / 'weight')** 3

(paper) rider jumped / (string) vibration at maximum amplitude / loudest sound / beats 3

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Draw a suitable graph to show the relationship between the fundamental frequency of a stretched string and its tension.

six correct values for $\sqrt{T}$ / f^2 **(–1 per each incorrect value)** 2×3
both axes correctly labelled 3
six points correctly plotted **(–1 per each incorrect value)** 3
straight line with a good fit **(–1 for poor distribution)** 3

State this relationship and explain how your graph verifies it.

f is proportional to square root of T // $f \propto \sqrt{T}$ // $f^2 \propto T$ 3
straight line (graph) through the origin 3

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Use your graph to

(i) **estimate the fundamental frequency of the string when its tension is 11 N;**

$\sqrt{T} = 3.32$ 3
$f = (542.24 \pm 10.00)$ Hz **(–1 for omission of or incorrect unit)** 3

(ii) **calculate the mass per unit length of the string.**

$f = \frac{1}{2l}\sqrt{\frac{T}{\mu}}$ 3
formula squared correctly (state/imply) 2
mass per unit length (μ) = 5.86×10^{-5} kg m^{-1} 2
(–1 for omission of or incorrect unit)

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Question 4

Question 1

A student investigated the relationship between the period and the length of a simple pendulum. The student measured the length *l* of the pendulum.

The pendulum was then allowed to swing through a small angle and the time *t* for 30 oscillations was measured.

This procedure was repeated for different values of the length of the pendulum.

The student recorded the following data.

l / cm	40.0	50.0	60.0	70.0	80.0	90.0	100.0
t / s	38.4	42.6	47.4	51.6	54.6	57.9	60.0

Why did the student measure the time for 30 oscillations instead of measuring the time for one?

to reduce (%) error (in the period) / for greater accuracy (in the period) / to get average 3

How did the student ensure that the length of the pendulum remained constant when the pendulum was swinging?

inextensible string / string suspended at fixed point (e.g. split cork or two coins) 6

(state/imply, e.g. correct equation)

Using the recorded data draw a suitable graph to show the relationship between the period and the length of a simple pendulum. What is this relationship?

label axes correctly 3

plot points **(–1 for each omitted or incorrect point)** 2×3

straight line 3

good distribution 3

$T^2 \propto l$ / correct statement / correct equation for T 4

Use your graph to calculate the acceleration due to gravity.

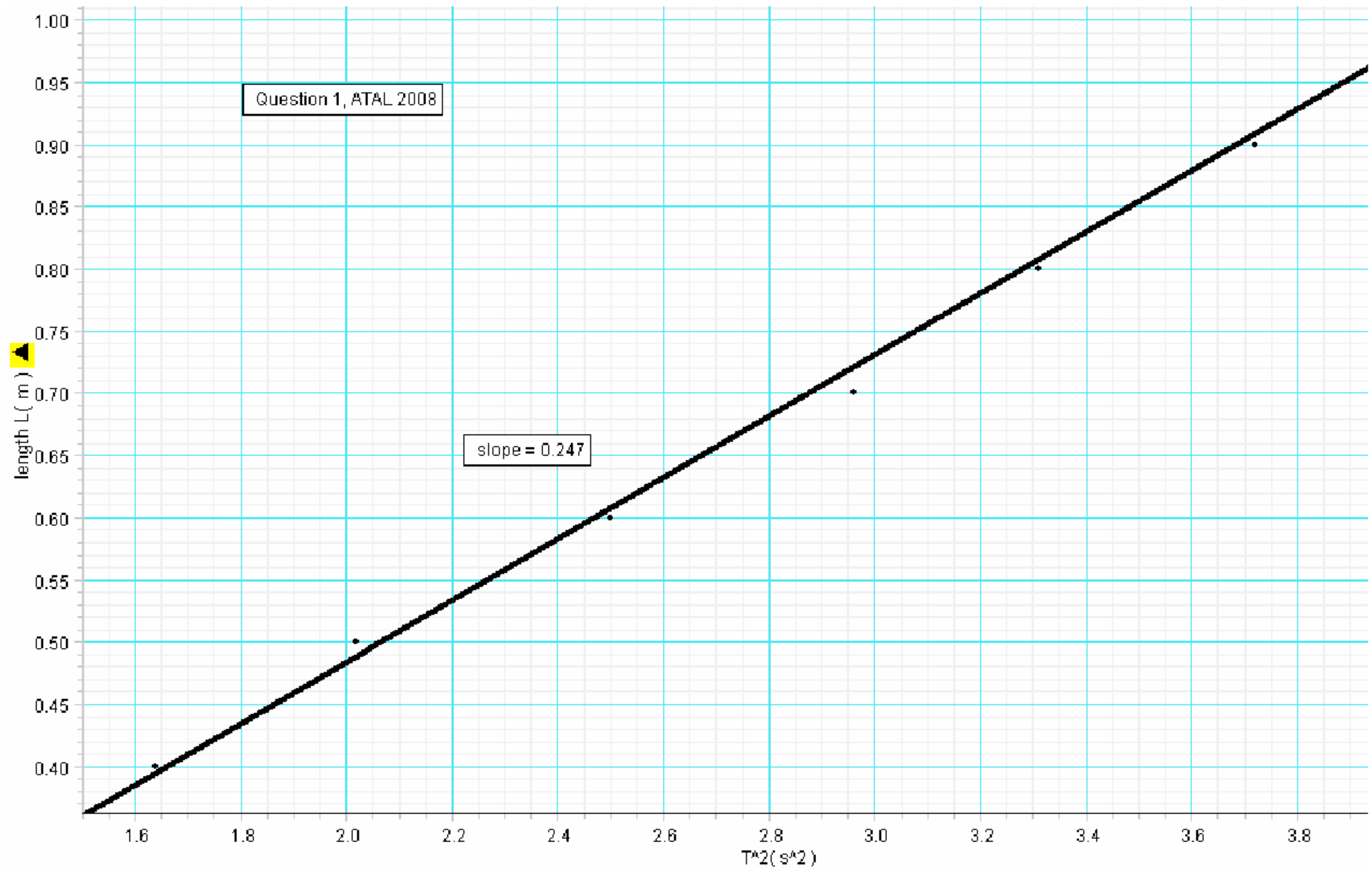
correct method for obtaining slope 3

slope = 0.2462 / 0.25 (m s^{-2}) [range: 0.24 – 0.25 m s^{-2}] 3

correct pendulum formula (any format) 3

g = 9.7196 / 9.72 m s^{-2} [range: 9.4 – 9.9 m s^{-2}] 3

(–1 for omission of or incorrect units)



Question 1, ATAL 2008
slope = 0.247
length L(m)
T^2(s^2)
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65
0.60
0.55
0.50
0.45
0.40
1.6
1.8
2.0
2.2
2.4
2.6
2.8
3.0
3.2
3.4
3.6
3.8