Name	Date started	Target end date

GCE A LEVEL — DAMPED & FORCED OSCILLATIONS &MIDDOT; RESONANCE QUESTION PACK

Legacy PH4 · New spec Unit 3 Topic 2b · A2 unit, 25% of A-level

REVISE
.wales

PHYSICS — UNIT 3 · DAMPED & FORCED OSCILLATIONS &MIDDOT; RESONANCE

3.2 Vibrations — damping, forced oscillation and resonance

Free vs. damped vs. forced oscillations, light / critical / heavy damping, the resonance condition $f_{drive} = f_0$, and Q-factor / bandwidth considerations from legacy PH4.

NEW 2015 SPEC · UNIT 3 TOPIC 2B

Estimated time for entire question pack: ~1h 4m

Derived from the legacy PH4 paper's pace of 120 marks in 1h 45m.

*You are advised to **not** attempt to complete all of this in one sitting.*

ABOUT THIS QUESTION PACK

This is a **comprehensive practice question pack**, not a single mock paper. It contains every question from the legacy WJEC PH4 papers (2008 modular spec) that maps onto new-spec Unit 3 Topic 2b (3.2).

Questions are ordered chronologically within each section.

INSTRUCTIONS

Use black ink or black ball-point pen. Answer all questions in the spaces provided.

The number of marks is given in brackets at the end of each question or part-question. A calculator is required. The Data Booklet is allowed.

For Examiner's use only

Q	Source	Max	Mark
1	PH4 Jun 12 Q3	11	
2	PH4 Jun 12 Q4	10	
3	PH4 Jun 13 Q3	11	
4	PH4 Jan 12 Q6	14	
	Total	46	

Damped & Forced Oscillations · Resonance — what the new spec asks

WJEC GCE A Level Physics (from 2015) · Unit 3: Oscillations & Nuclei · Topic 3.2.

Free oscillations A

- Oscillation at natural frequency f_0 with constant amplitude when resistive forces are negligible.
- Examples: ideal pendulum / mass-spring in vacuum.

Damped oscillations A

- Light damping: amplitude decays exponentially; T essentially unchanged.
- Critical damping: returns to equilibrium in minimum time without oscillating.
- Heavy damping: very slow return, no oscillation.

Forced oscillations & resonance A

- An external periodic driver causes the system to oscillate at the driver frequency f_d.
- Resonance when $f_d = f_0$ — amplitude peaks.
- Increased damping ⇒ lower & broader resonance peak.

Applications A

- Useful: musical instruments, MRI, tuning circuits.
- Destructive: Tacoma Narrows / car suspension / earthquake building response.

Damped & Forced Oscillations · Resonance in one page

Quick-reference notes — revisit before each section.

Free oscillation

Oscillates at natural frequency f_0.

Amplitude constant; energy constant.

Light damping

Amplitude decays exponentially.

T essentially unchanged from undamped value.

Critical damping

Returns to equilibrium in minimum time without overshooting.

Used in car suspension, instrument needles.

Heavy damping

Slow approach to equilibrium.

System never crosses equilibrium.

Forced oscillation

External periodic force at f_d.

Steady-state amplitude depends on f_d and damping.

Resonance

Amplitude peaks sharply.

More damping ⇒ lower & broader peak.

Energy transferred efficiently from driver to oscillator.

Useful resonance

Strings & air columns in instruments.

MRI imaging; tuning circuits (radio).

Destructive resonance

Tacoma Narrows (wind-driven oscillation).

Buildings in an earthquake.

Wash-machine drum at one specific spin speed.

Sketch tip

Single peak centred on f_0.

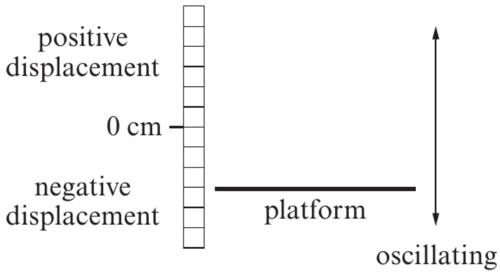
Lower damping ⇒ taller, narrower peak.

Heavy damping ⇒ broader, flatter response.

Section index

Use this index to jump straight to the section you need.

3. A horizontal platform oscillates vertically with simple harmonic motion around a central position with a period 0.40 s and amplitude 5.0 cm.



(a) Define simple harmonic motion. [2]

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(b) Determine

(i) the maximum velocity of the platform; [2]

....

(ii) the maximum acceleration of the platform. [2]

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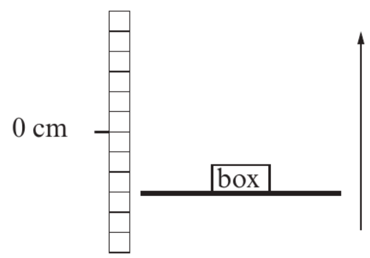
(c) The platform is at its lowest position at time $t = 0$.
The displacement x of the platform at later times is given by the equation:

$$x = A\sin(\omega t + \varepsilon)$$

Rewrite the equation giving correct numerical values for A, ω and ε. [3]

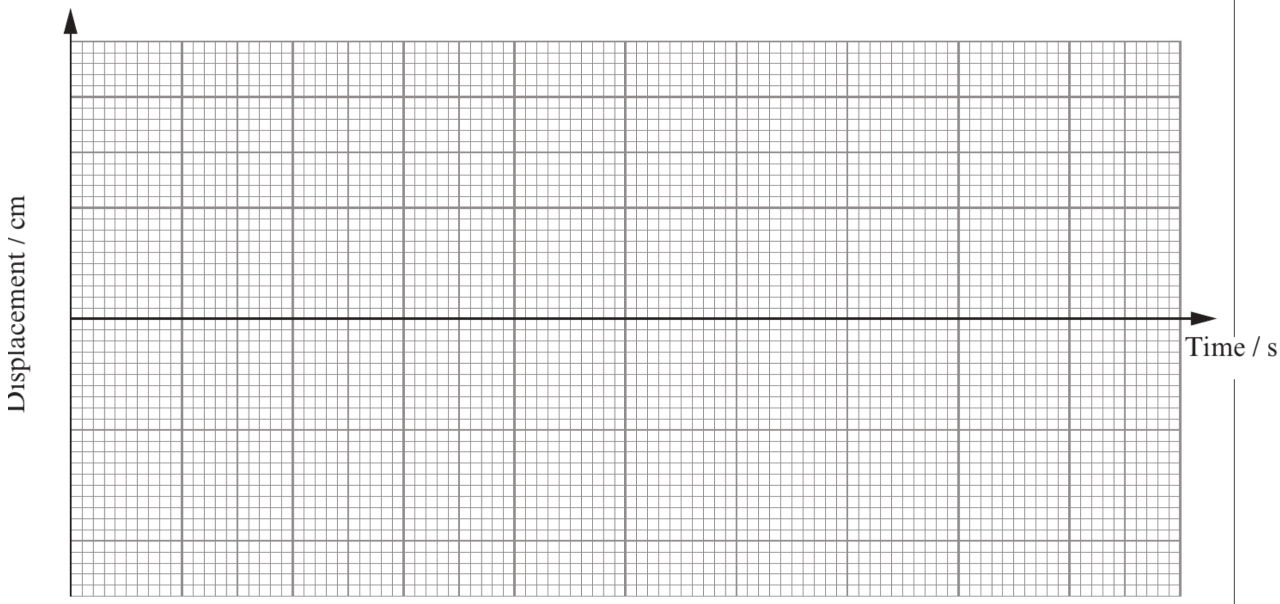
(d)



A small box is carefully placed on the platform when it is at its lowest position. Before the platform reaches its highest position, the box loses contact. Find the displacement at which contact is lost. [2]

4. *(a)* In a laboratory experiment, a load of mass *m* is supported in equilibrium at the lower end of a spring. The load is raised 2.0 cm from its equilibrium position, and is then released from rest so that it oscillates vertically with a period of 0.50 s. The amplitude then decreases to 1.0 cm after 5 oscillations.

(i) Sketch a displacement–time graph for these 5 oscillations. [3]



(ii) Suggest a cause for the observed damping. [1]

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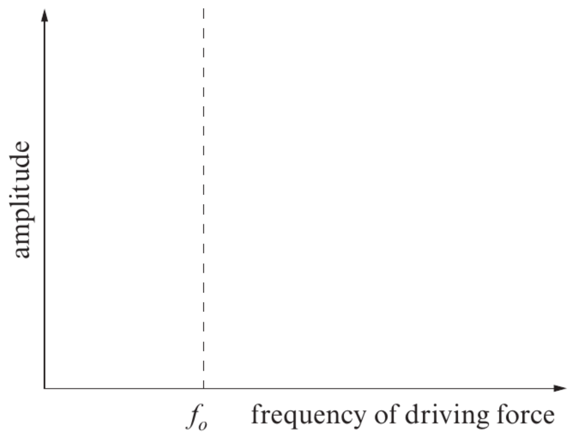
(b) A driving force of frequency f is now applied to the top end of the spring. The frequency of the driver can be varied from zero to a frequency well beyond the natural frequency f_o of the spring system.

(i) Sketch the variation of the amplitude of the motion of the load with the frequency of the driving force on the axes below. Label the curve as A. [1]



(ii) If the damping on the system is increased slightly, sketch the variation of the amplitude with frequency on the same axes. Label this curve as B. [1]

(iii) Explain what is meant by *resonance*. [1]

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(iv) Give a practical example of resonance. Identify the driving force of the system and the responding oscillator. [3]

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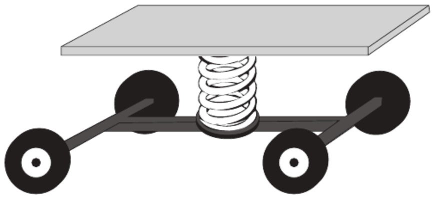
3. A car suspension is modelled as a 2000 kg platform supported on a spring resting on a wheel base. When supporting the platform the spring is compressed 15.0 cm from its natural length.



(a) Calculate the spring constant. [2]

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(b) Two passengers, of masses 75 kg and 85 kg, sit on the platform.

(i) Calculate the additional compression of the spring. [2]

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(ii) Determine the period of the natural oscillation of the system. [2]

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(iii) The car travels over a series of speed humps. This results in a driving force of frequency 1.24 Hz. Explain what happens to the oscillation of the platform in the suspension system. [2]

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Examiner only

(c) Explain the purpose of damping in a car suspension system. [3]

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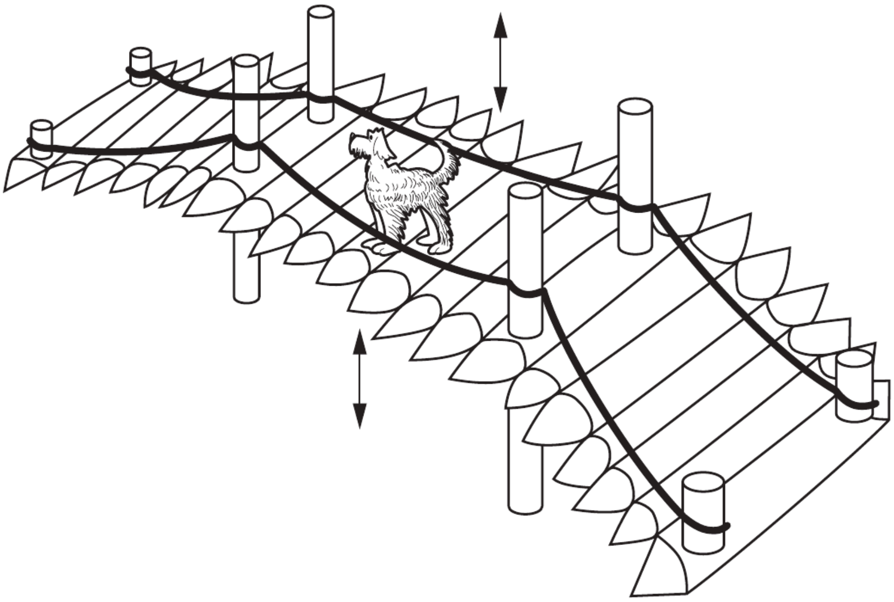
6. A poorly-designed bridge oscillates up and down at its natural period of 0.81 s.



(a) Calculate the natural frequency of oscillation. [2]

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(b) Show that the angular velocity of the oscillations is approximately 7.8 rad s^{-1}. [2]

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(c) When people walk across this bridge, oscillations of large amplitude occur. Explain the cause of the large-amplitude oscillations and the possible consequences. [3]

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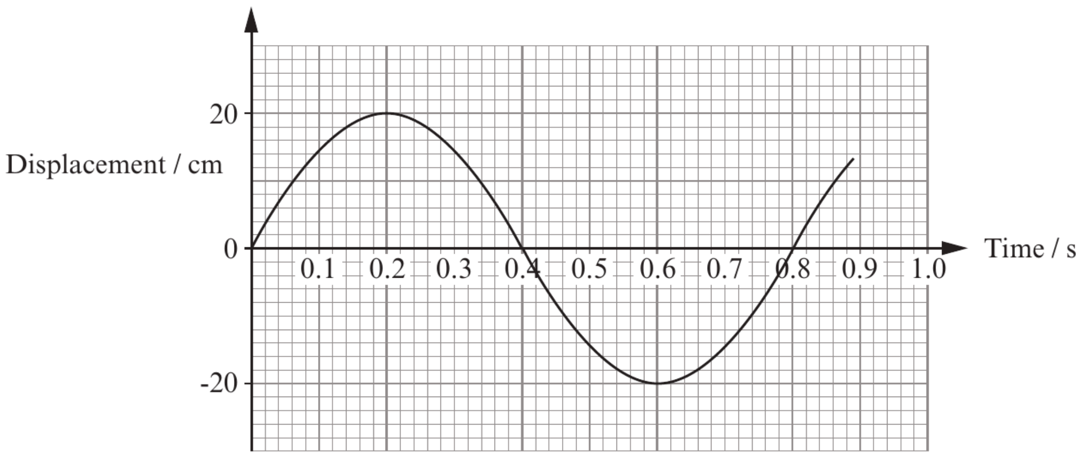
(d) A dog standing in the middle of the bridge moves up and down with simple harmonic motion with an amplitude of 10.4 cm (and period 0.81 s). At time t = 0 s, the dog is at the centre of its motion moving upwards. Calculate the displacement of the dog at time t = 1.40 s. [2]

(e) The amplitude of oscillation is increased and is now so great that the dog temporarily loses contact with the bridge. The displacement of the bridge where the dog is standing varies as shown.



(i) Calculate the dog's displacement when it loses contact with the bridge. [Hint: The downward acceleration of the dog cannot be greater than g.] [3]

(ii) **Without further calculation** indicate, on the graph above, the point at which the dog loses contact with the bridge and the **approximate point** at which it makes contact with the bridge again. [2]

END OF QUESTION PACK

4 questions · 46 marks · ~1h 4m

Source: WJEC PH4 (2008 modular spec)

Curated for WJEC Physics 2015 spec A2 Unit 3 — Topic 2b (3.2)