

11.1 Oscillation, resonance and phase

Name: _____ Class: _____ Date: _____

Total: 10 marks

KEY WORDS damping • resonance

Objective

Oscillation, resonance and phase. Supported HL concept preparation; original classroom practice, not an official IB paper or assessed learner work.

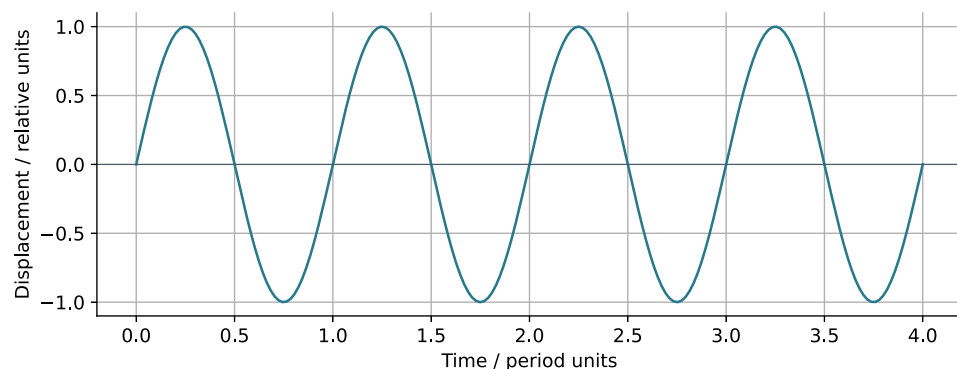
1 Key knowledge and worked examples

■ What would explain this observation?

- A swing gains a large amplitude when pushes arrive with the right timing. The forcing frequency and **damping** help determine the response.
- Start with a prediction. State the quantities or features you would compare, then decide what evidence could distinguish two explanations.

■ Build the model

- Simple harmonic motion has acceleration proportional to displacement and directed toward equilibrium. Period is time per cycle; frequency is its reciprocal. Damping transfers energy away from the oscillating system.
- **resonance** : A large response to periodic forcing near a natural frequency; damping: Energy transfer out of an oscillating system.



■ Choose evidence that can test it

- Velocity is greatest near equilibrium for ideal SHM, while acceleration magnitude is greatest at extreme displacement. Resonance can occur near the natural frequency under periodic driving, with amplitude limited by damping.
- Measure time for several complete oscillations and divide. Define a cycle consistently and use a small displacement when the model requires it. Keep pendulum paths clear and record damping effects rather than assuming perfect motion.

■ Work from known quantities

- State the known values and their units. Choose the relation because its assumptions fit this case, then rearrange before substitution.
- Known: 20 cycles take 32 s. $T = \text{total time} / \text{cycles} = 32 / 20 = 1.6$ s. Frequency $= 1/T = 1/1.6 = 0.625$ Hz. A shorter total timing interval would make reaction-time error a larger fraction of the measurement.

Example:

30 cycles take 45 s. Find period. Use the same sequence: known quantities $\rightarrow$ model $\rightarrow$ relation $\rightarrow$ substitution $\rightarrow$ unit and interpretation.

■ Check the conclusion and its limits

- Not every repeated motion is SHM. A force proportional to displacement but directed away from equilibrium does not produce SHM.
- Return to the original observation. Explain what the result supports, which conditions it assumes, and one way to test a competing explanation.

Warn:

Every periodic motion satisfies the condition for simple harmonic motion. This claim is false: Not every repeated motion is SHM. A force proportional to displacement but directed away from equilibrium does not produce SHM.

Key:

Oscillation, resonance and phase: Velocity is greatest near equilibrium for ideal SHM, while acceleration magnitude is greatest at extreme displacement. Resonance can occur near the natural frequency under periodic driving, with amplitude limited by damping.

2 Practice

2.1 For ideal SHM, where is speed greatest? Choose one answer.

- A At equilibrium
 - B At maximum displacement
 - C At every point equally
- [1]

2.2 30 cycles take 45 s. Find period. Show the relation, substitution and units. [2]

2.3 Decide whether this claim is true and justify: Every periodic motion satisfies the condition for simple harmonic motion. [2]

2.4 A large response to periodic forcing near a natural frequency: write the technical term. [1]

3 Exam-style questions

3.1 Twenty cycles take 32.0 ± 0.4 s. Find period and maximum absolute uncertainty, treating cycle count as exact. Why time several cycles? [4]

Solutions

2.1 A Velocity is greatest near equilibrium for ideal SHM, while acceleration magnitude is greatest at extreme displacement. Resonance can occur near the natural frequency under periodic driving, with amplitude limited by damping.

2.2 $T = \text{total time} / \text{cycles} = 45 / 30 = 1.5 \text{ s}$.

2.3 False. Not every repeated motion is SHM. A force proportional to displacement but directed away from equilibrium does not produce SHM.

2.4 resonance. resonance means A large response to periodic forcing near a natural frequency.

3.1 $T = 1.60 \pm 0.02 \text{ s}$, relative uncertainty 1.25%. A single cycle with the same $\pm 0.4 \text{ s}$ timing uncertainty has much larger relative uncertainty. Define the cycle consistently.