11.1 Oscillation, resonance and phase

Name: _____ Class: _____ Date: _____ **Total: 10 marks**

KEY WORDS damping • resonance

Objective

Oscillation, resonance and phase. Original classroom practice for IB HL; not an official IB paper.

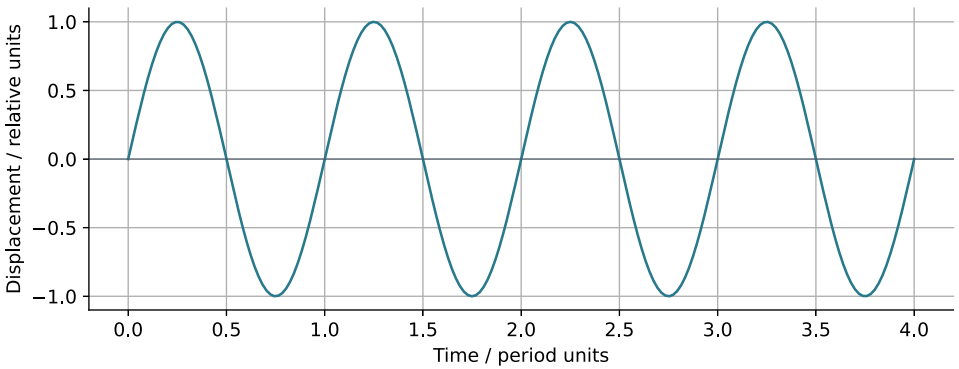
1 Key knowledge and worked examples

■ 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.

■ 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.

In the lab: 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

- Known: 20 cycles take 32 s.
- T=total time/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.

Your turn: 30 cycles take 45 s. Find period.

■ 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.

Not true: Every periodic motion satisfies the condition for simple harmonic motion. SHM needs a restoring force proportional to displacement and directed TOWARD equilibrium. Motion that merely repeats - a bouncing ball, a circular orbit - is periodic without satisfying that condition.

Key:

- Simple harmonic motion has acceleration proportional to displacement and directed toward equilibrium.
- Velocity is greatest near equilibrium for ideal SHM, while acceleration magnitude is greatest at extreme displacement.
- Watch for: not every repeated motion is SHM.

■ Write from a period of 0.40 s

- 40 cycles take 16 s.
- Find the period and the frequency. Not every periodic motion is simple harmonic.

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 In SHM, kinetic energy is greatest where the restoring force has done the most work - at equilibrium, where displacement and acceleration are zero. At maximum displacement the oscillator is instantaneously at rest.

2.2 T=total time/cycles=45/30=1.5 s.

2.3 False. SHM needs a restoring force proportional to displacement and directed TOWARD equilibrium. Motion that merely repeats - a bouncing ball, a circular orbit - is periodic without satisfying that condition.

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

3.1 T=1.60±0.02 s, relative uncertainty 1.25%. A single cycle with the same ±0.4 s timing uncertainty has much larger relative uncertainty. Define the cycle consistently.