Wave Resonance

IB Physics Content Guide

Big Ideas

- Simple harmonic motion is a repeating relationship between an object's position, velocity, and acceleration
- Waves are formed and transferred by particles oscillating in a medium
- All waves have properties can be measured and mathematically related
- Instruments resonate at specific frequencies due to the number of standing waves that fit in the length

1 – Simple Harmonic Motion

I can describe simple harmonic motion using period and frequency			
I can calculate period, frequency, and angular frequency			
I can describe the direction and calculate the magnitude of force for an oscillating spring system			
I can describe the properties of a spring or pendulum system that impact period			

2 – Graphing Simple Harmonic Motion

I can graph displacement, velocity, and acceleration vs time for simple harmonic motion			
I can graph kinetic and potential energy vs time for SHM			
I can graph acceleration and velocity vs displacement for simple harmonic motion			
I can describe the phenomenon of resonance			
I can describe the effect of damping and recognize scenarios where an oscillation is underdamped, overdamped, or critically damped			

3 – Wave Properties

I can describe how waves carry energy through a medium			
I can compare the properties of transverse and longitudinal waves			
I can read a wave's amplitude, wavelength, period, and frequency from a graph			
I can describe the number of complete wavelengths represented in a picture			
I can use the wave speed equation to mathematically relate speed, wavelength, and frequency			

4 – Sound

I can relate the pitch of a sound to the frequency of the sound wave			
I can describe why sound travels at different speeds in different media			
I can calculate how far a distant object is by timing an echo			

5 – Instruments

I can identify and label the node and antinodes on a standing wave diagram			
I can describe the end conditions and nodes/antinodes for open/closed pipes and strings			
I can relate length and wavelength for open/closed pipes and vibrating strings			
I can calculate the length of a pipe/string required to resonate a specific frequency			

Simple Harmonic Motion

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

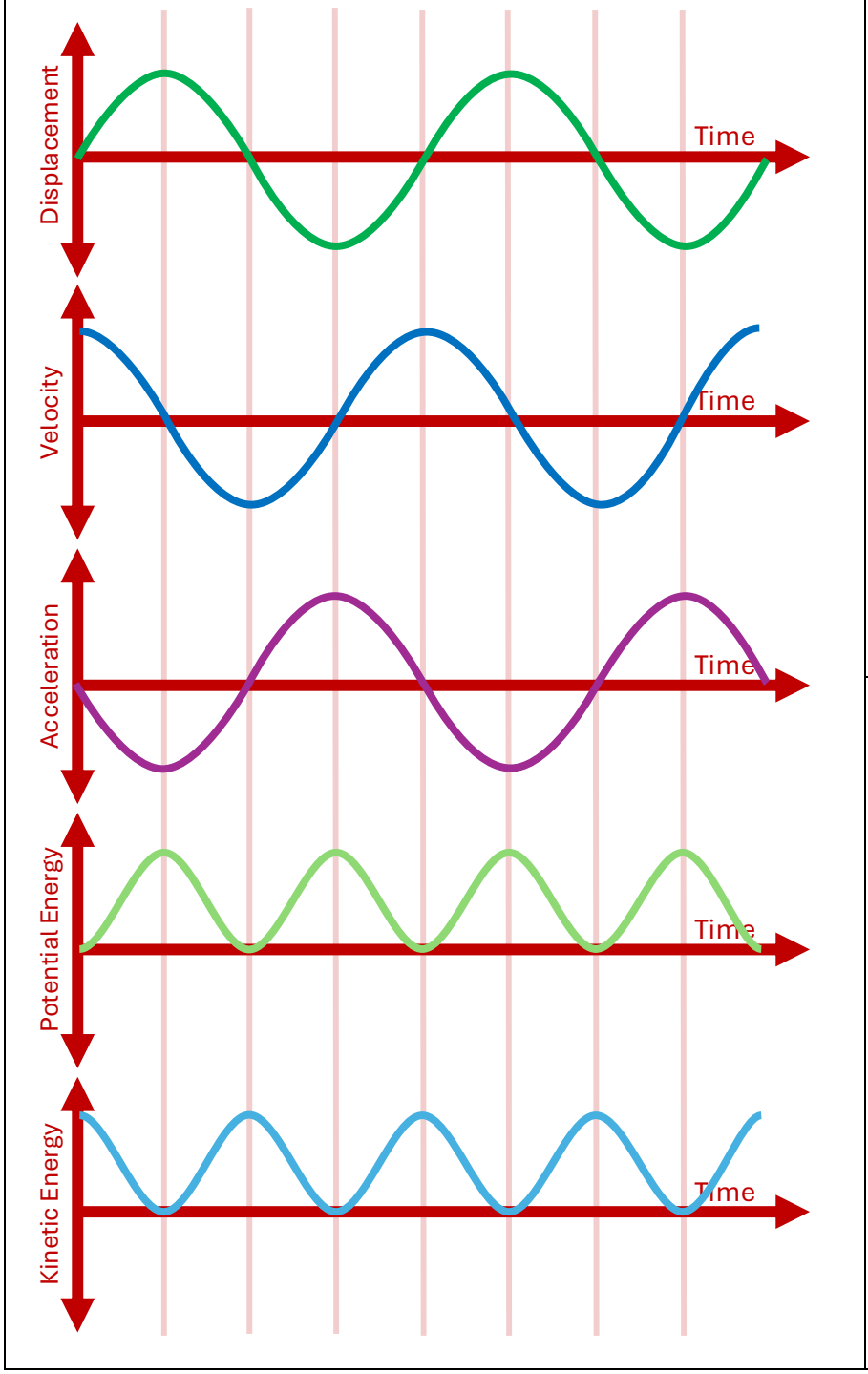
$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

$$T = 2\pi\sqrt{\frac{m}{k}}$$

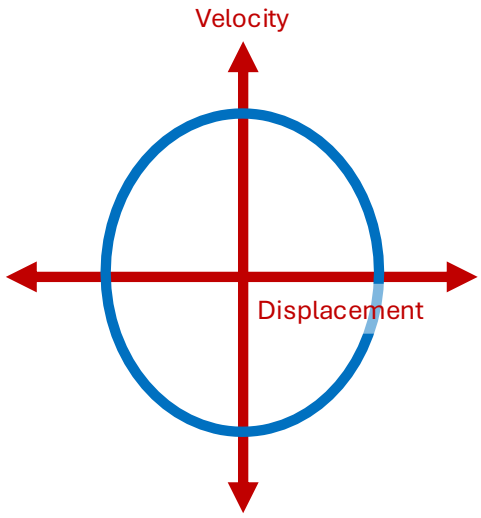
$$T = 2\pi\sqrt{\frac{l}{g}}$$

Variable Symbol	Description	Unit
a	Acceleration	[m/s^2] or [m s^{-2}]
ω	Angular Frequency	[1/s] or [s^{-1}]
x	Position from Equilibrium	[m]
T	Period	[s]
f	Frequency	[Hz]
m	Mass	[kg]
k	Spring Constant	[N/m] or [N m^{-1}]
l	Pendulum Length	[m]
g	Gravitational Field Strength	[N m^{-1}] or [m s^{-2}]

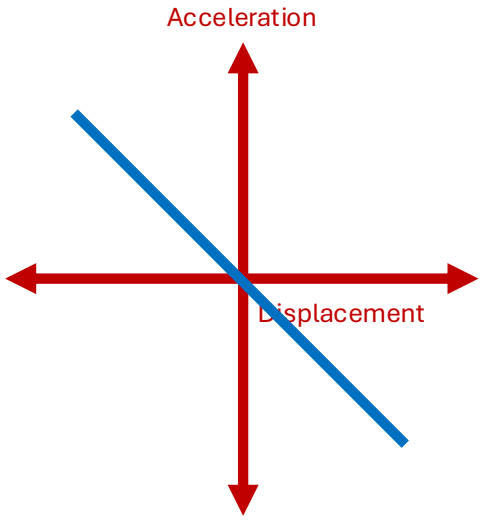
Simple Harmonic Motion Graphs



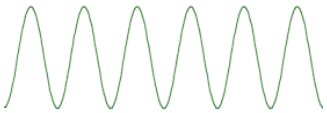
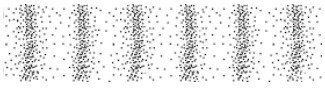
Velocity vs Displacement



Acceleration vs Displacement



Types of Waves

	Picture	Definition	Examples
Transverse		Particles move **perpendicular** to the motion of the wave	• Light • Ripples in a Pond • Earthquakes
Longitudinal		Particles move **parallel** to the motion of the wave	• Sound • Earthquakes

Wave Model

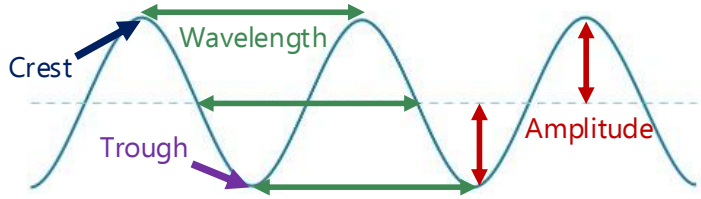
$$v = f\lambda = \frac{\lambda}{T}$$

Variable Symbol	Description	Unit
v	Wave Speed	[m/s] or [m s^{-1}]
f	Frequency	[Hz]
λ	Wavelength	[m]
T	Period	[s]

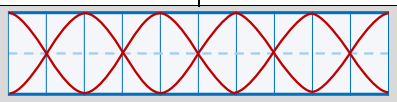
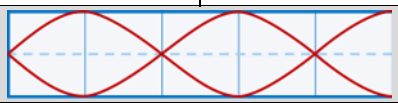
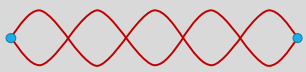
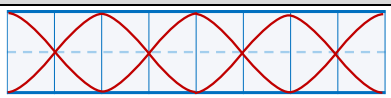
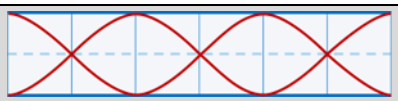
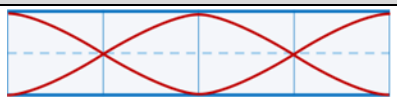
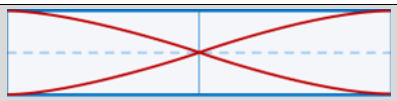
Parts of a Wave

Label the Wave:

- Amplitude
- Wavelength
- Crest
- Trough



Harmonics

	Open Pipe		Closed Pipe		String	
End Conditions	Antinode	Antinode	Node	Antinode	Node	Node
5th Harmonic						
	L = (5/2) × λ		L = (5/4) × λ		L = (5/2) × λ	
4th Harmonic						
	L = (2) × λ				L = (2) × λ	
3rd Harmonic						
	L = (3/2) × λ		L = (3/4) × λ		L = (3/2) × λ	
2nd Harmonic						
	L = (1) × λ				L = (1) × λ	
1st Harmonic (Fundamental)						
	L = (1/2) × λ		L = (1/4) × λ		L = (1/2) × λ	