

# Simple Harmonic Motion

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IB PHYSICS | WAVES - SOUND

# Warm up

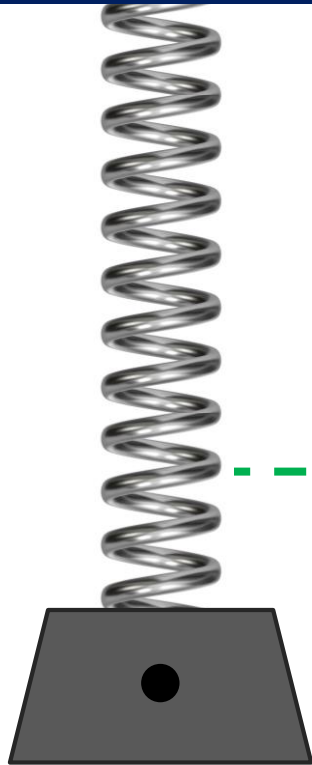
What words would you use to describe the motion of a bobble head doll?



- Oscillating
- Back and Forth
- Repeating
- Etc.

# A Mass on a Spring

## Simple Harmonic Motion



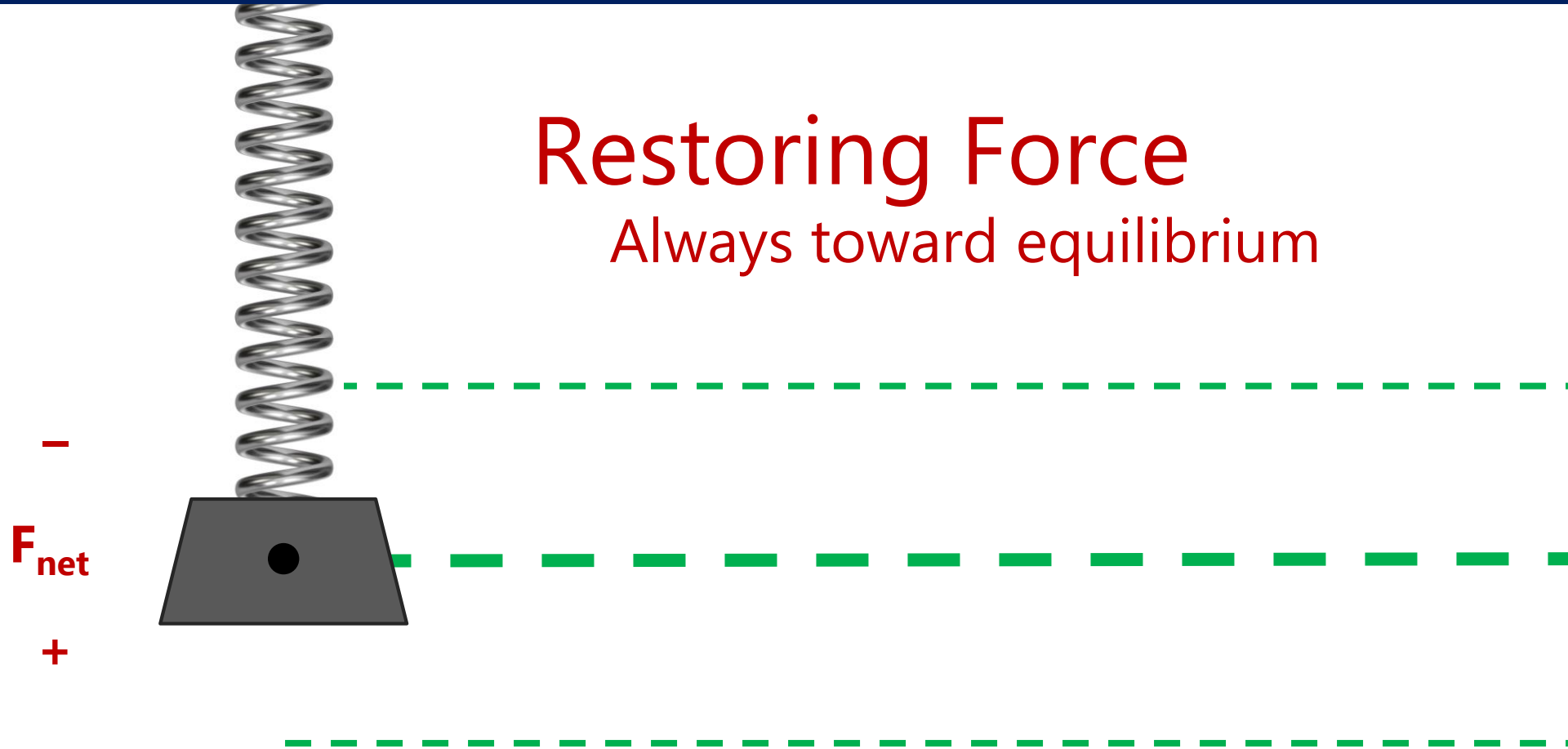
Maximum

Equilibrium Position

Minimum

Let's look at the forces...

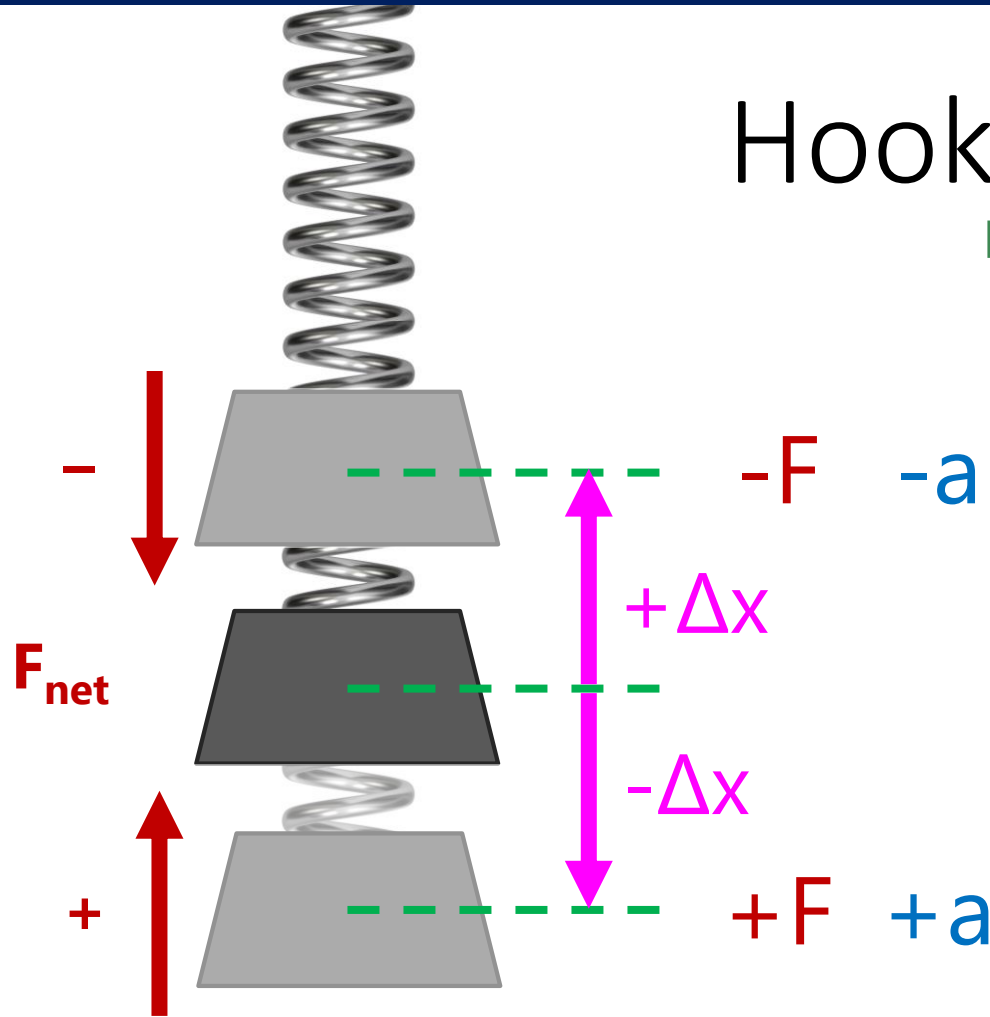
**Restoring Force**  
Always toward equilibrium



# Force and Displacement

$$\text{Hooke's Law: } F = -k\Delta x$$

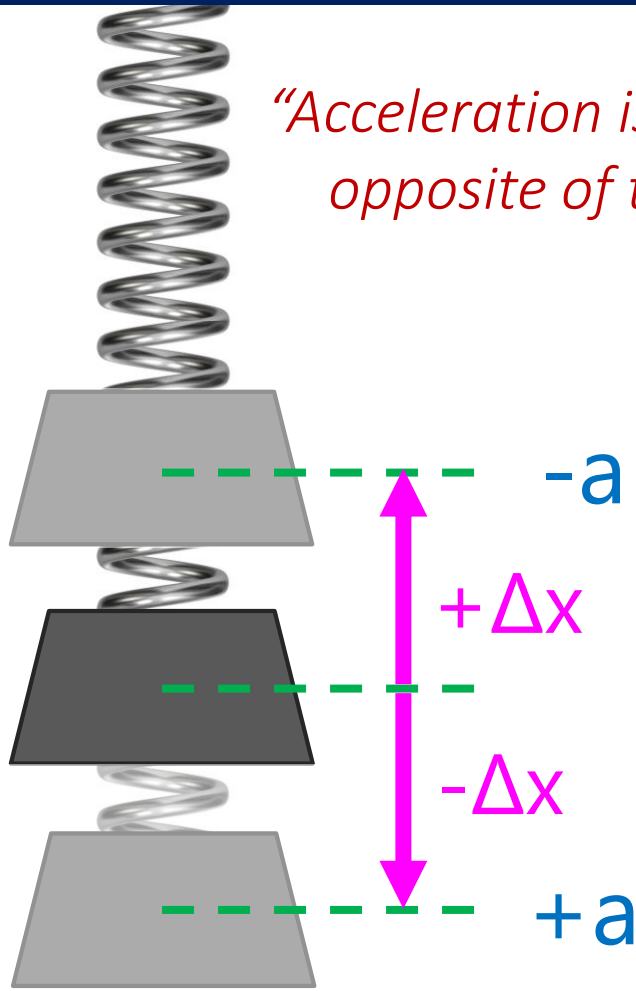
Force is opposite to the displacement



Acceleration is in the same direction as the force

$$F = ma$$

# Why the Negative Sign??



*"Acceleration is proportional to the opposite of the displacement"*

$$a \propto -x$$

Proportional to

# Let's look at this one more time...

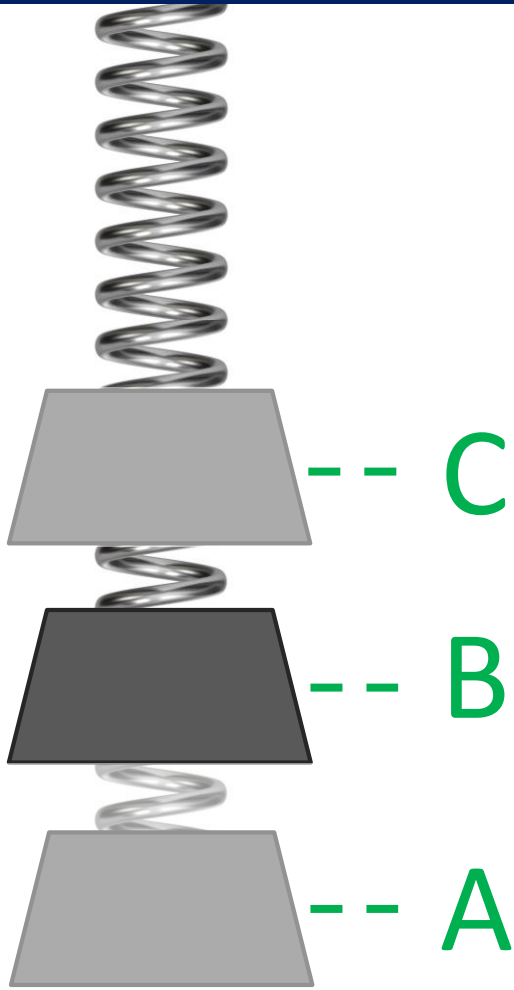


When is the **force** largest?

When is the **acceleration** largest?

When is the **velocity** largest?

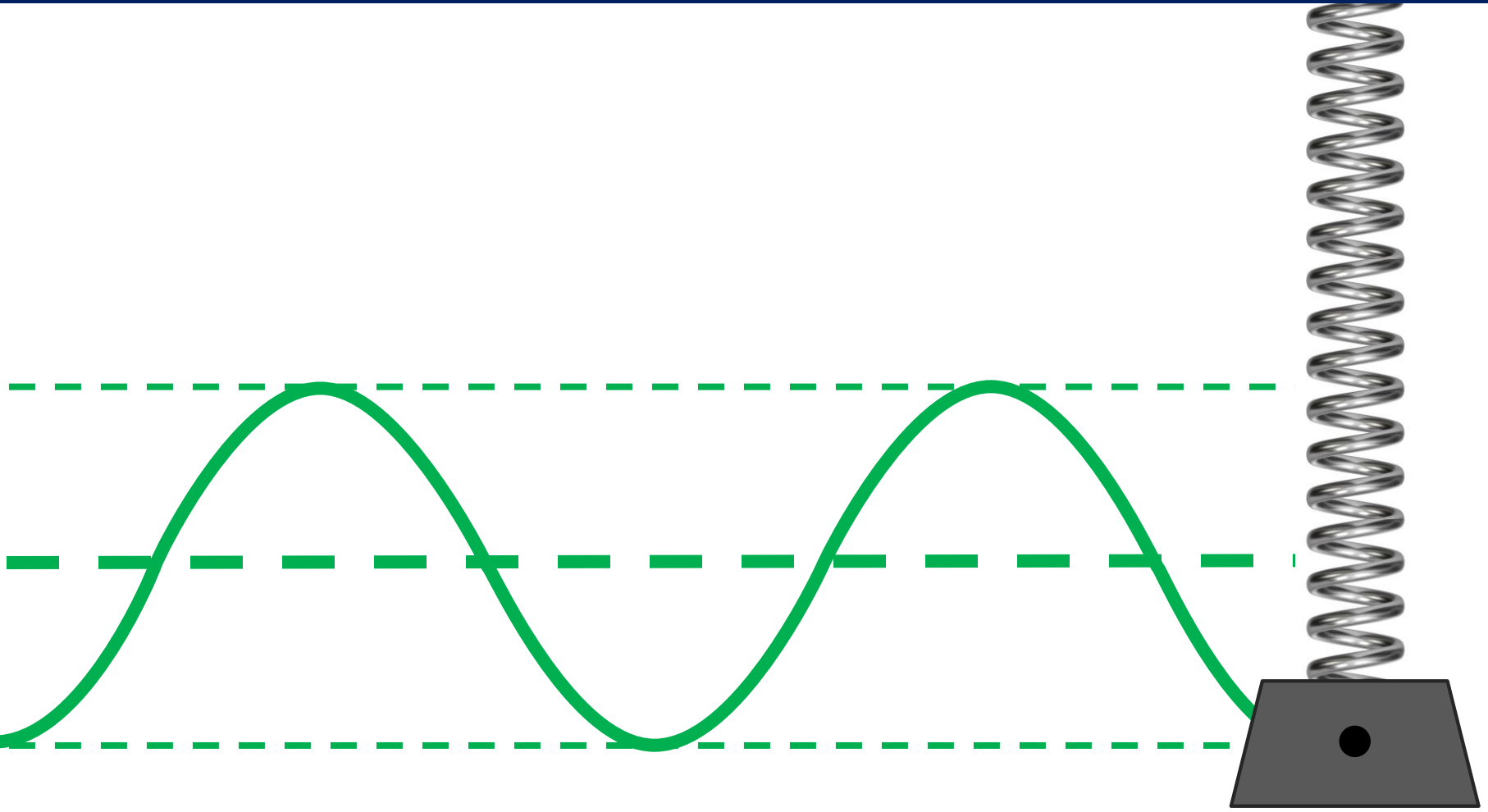
# Where is the Greatest...

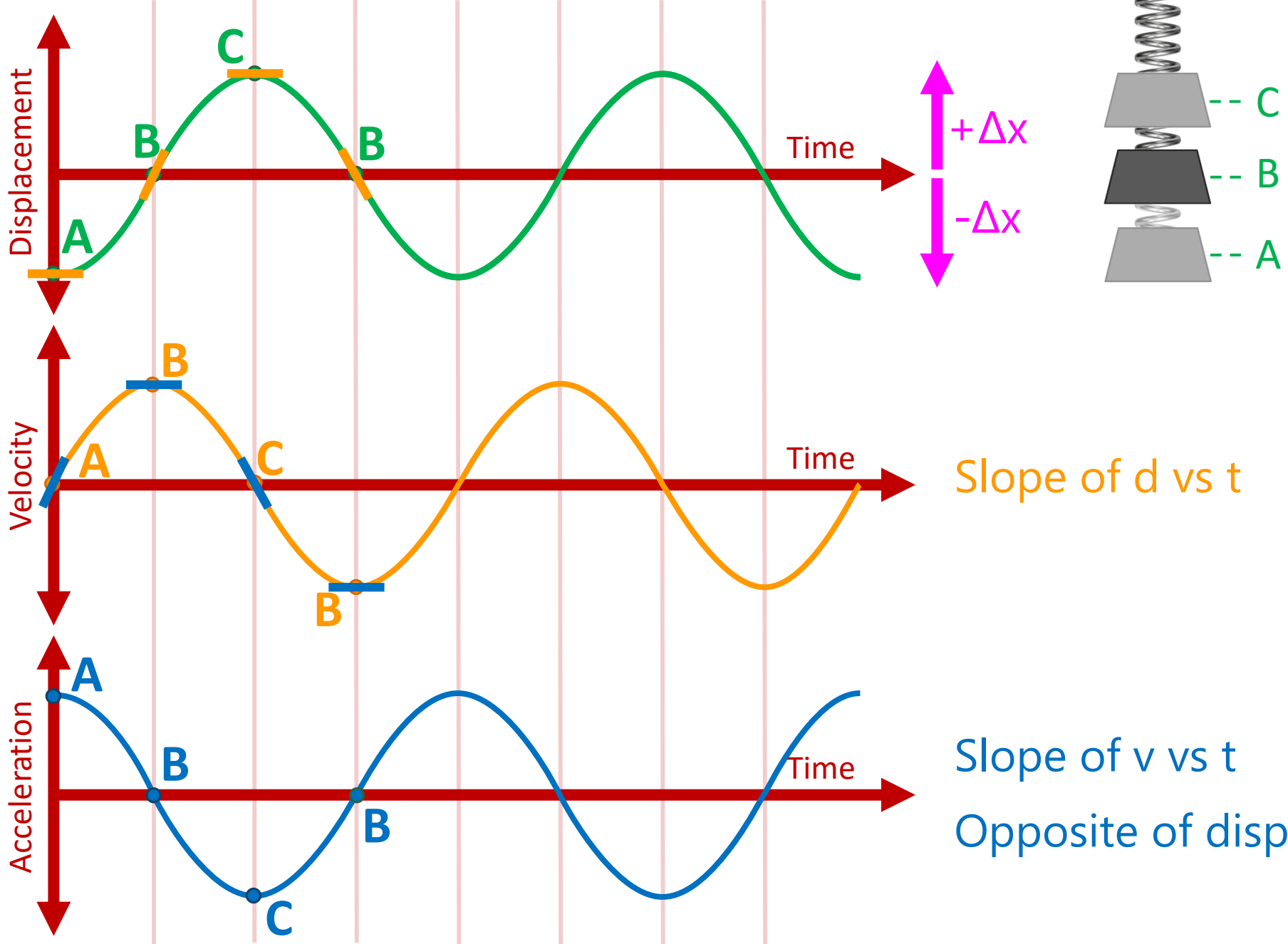


	Displacement	Velocity	Acceleration
C	X		X
B		X	
A	X		X



# Graphing Displacement vs Time

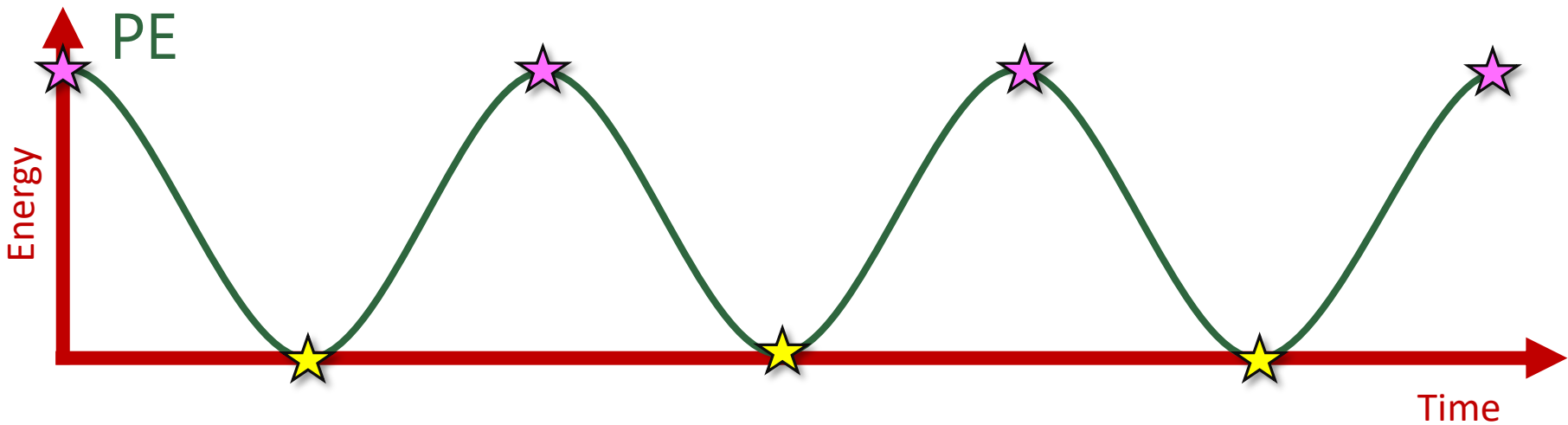
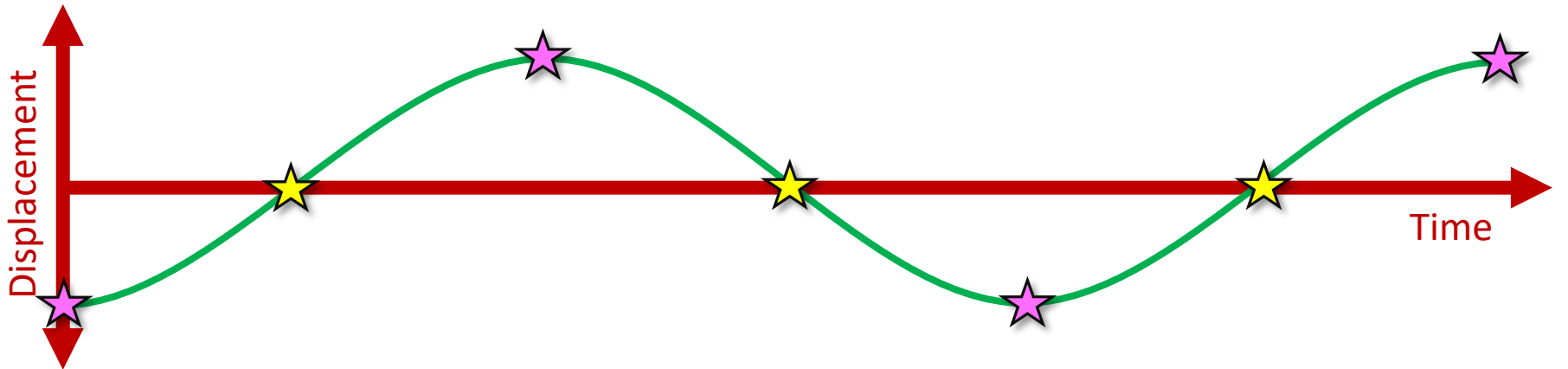




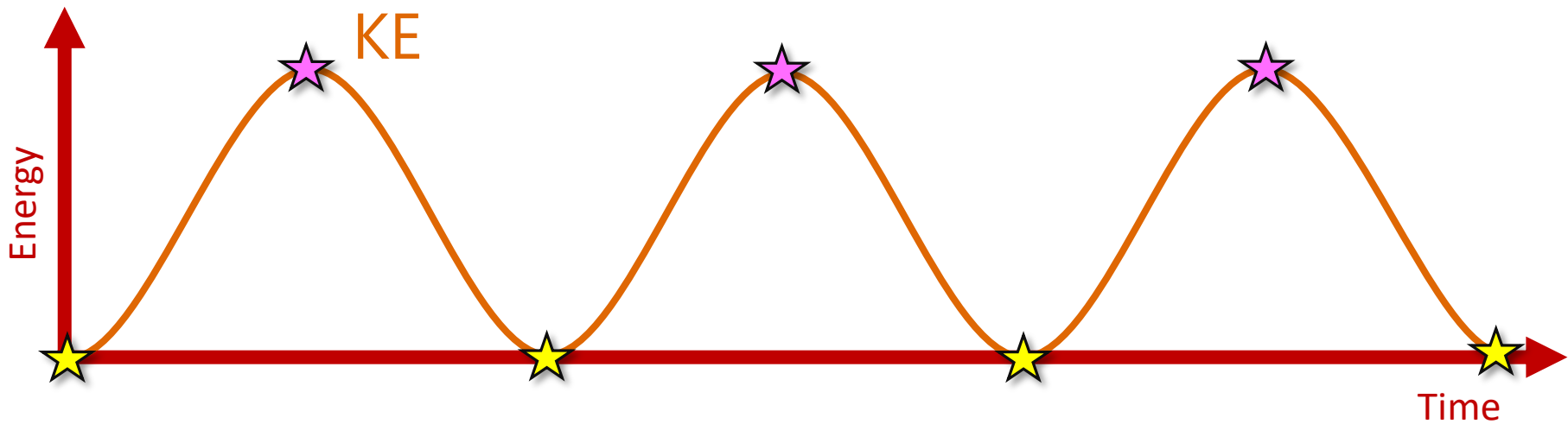
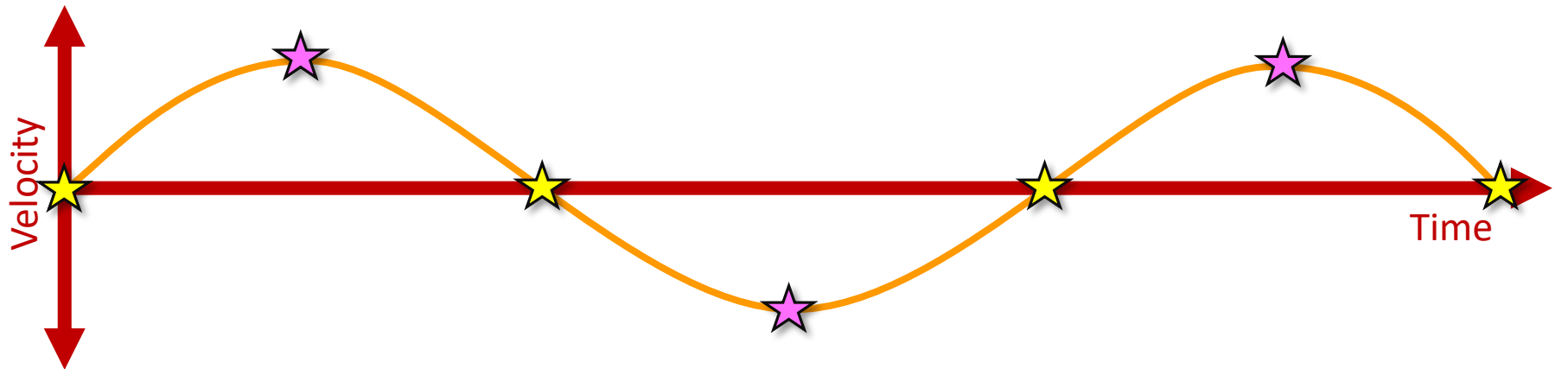
Slope of  $d$  vs  $t$

Slope of  $v$  vs  $t$   
Opposite of disp

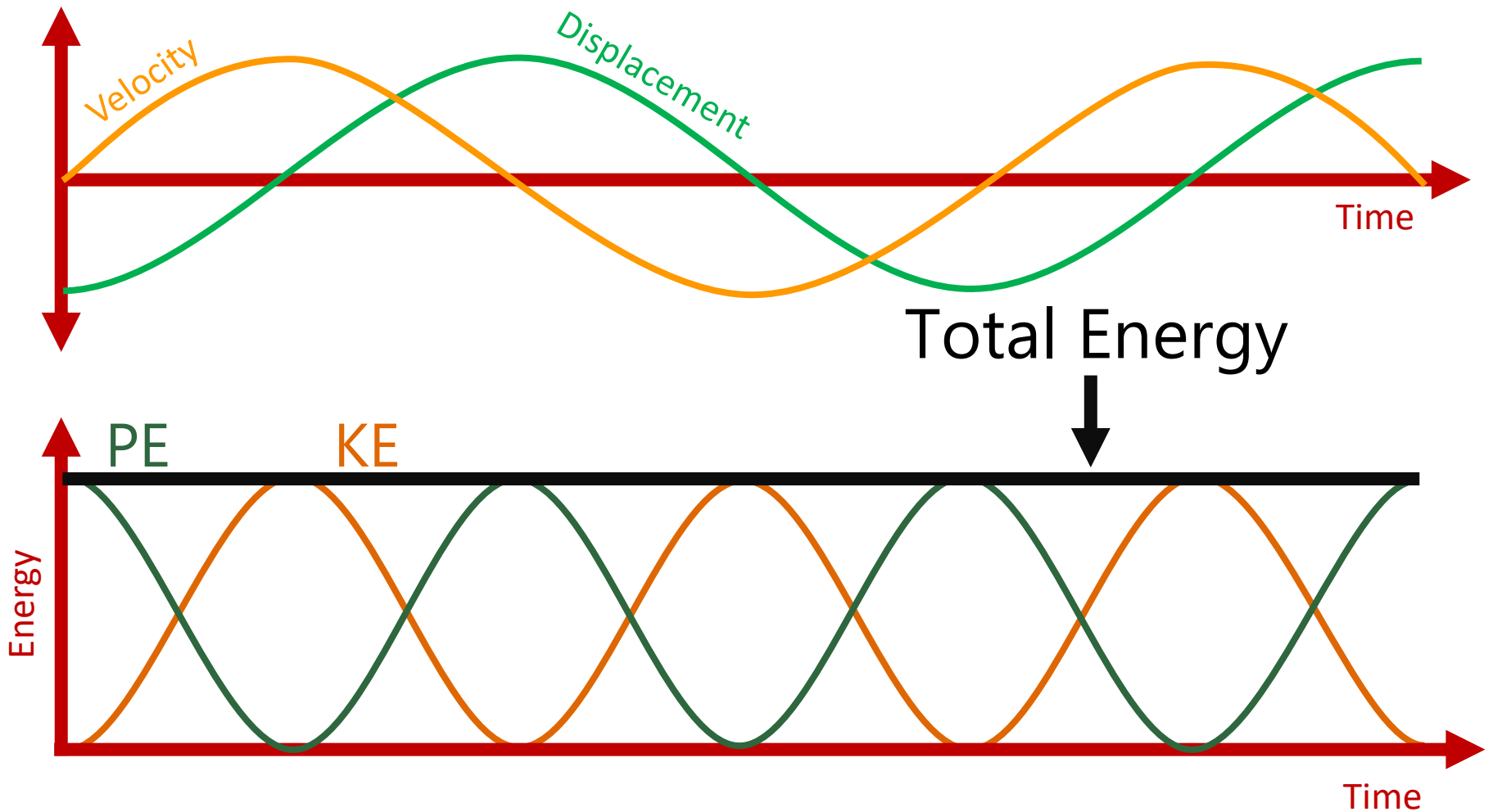
# Energy for SHM



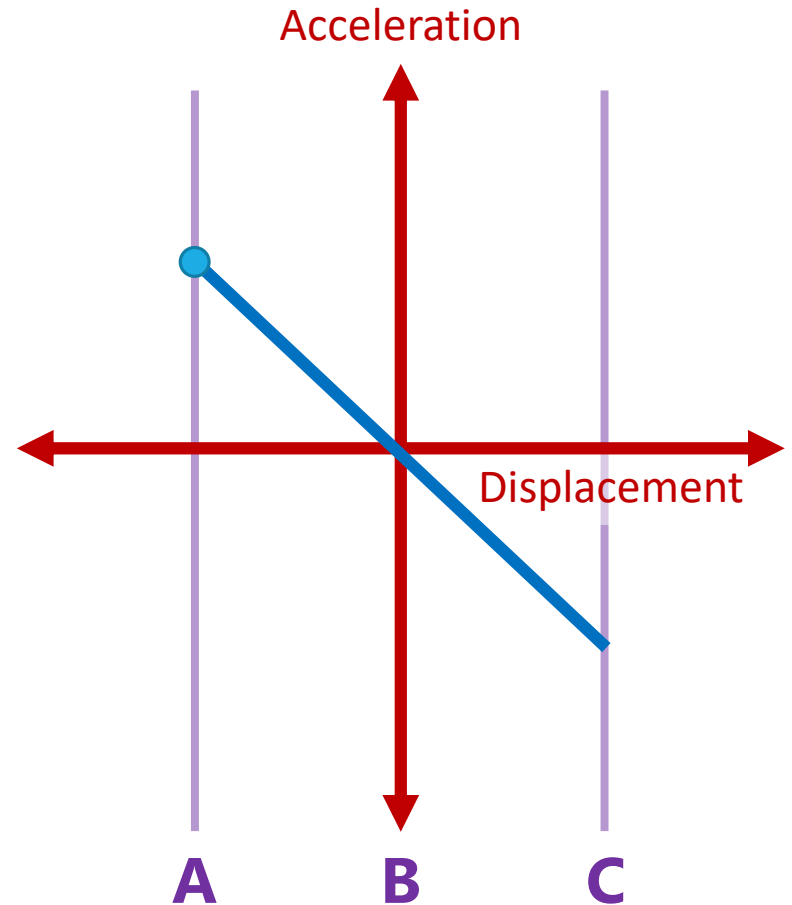
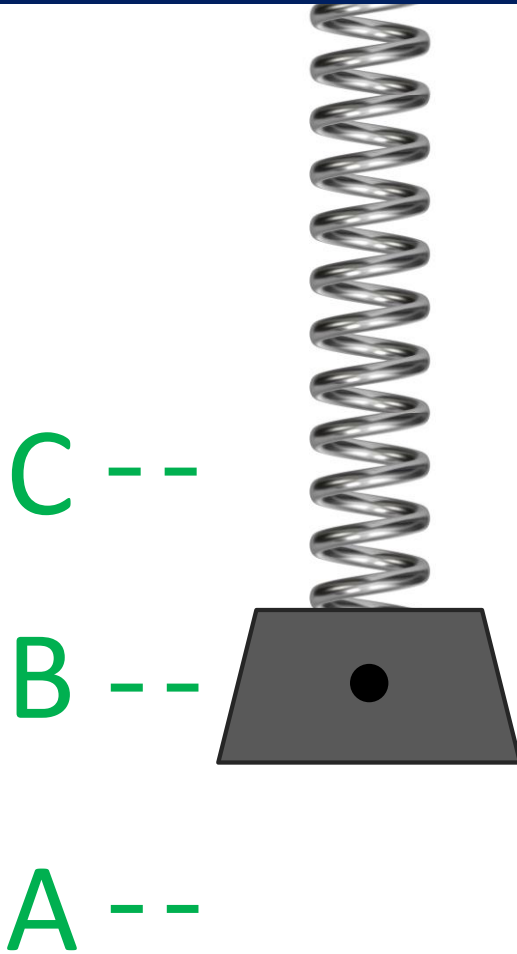
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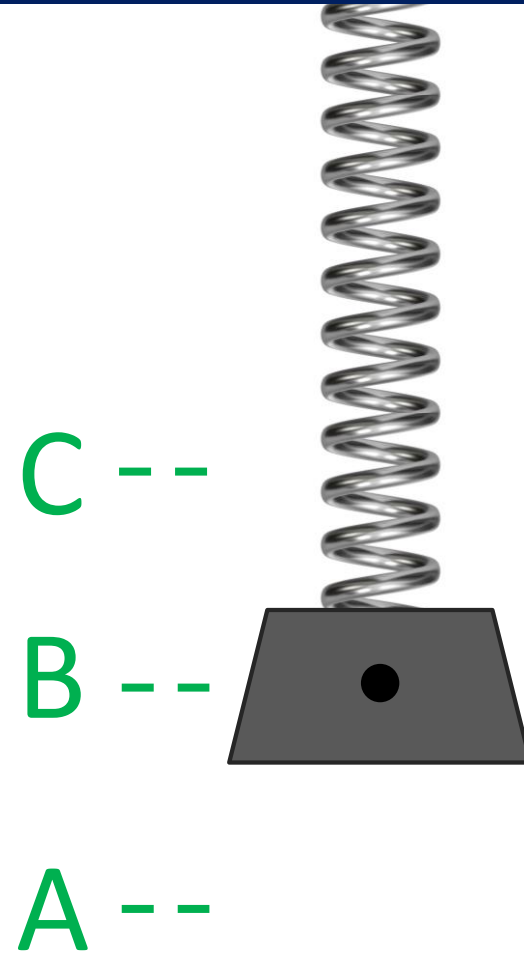
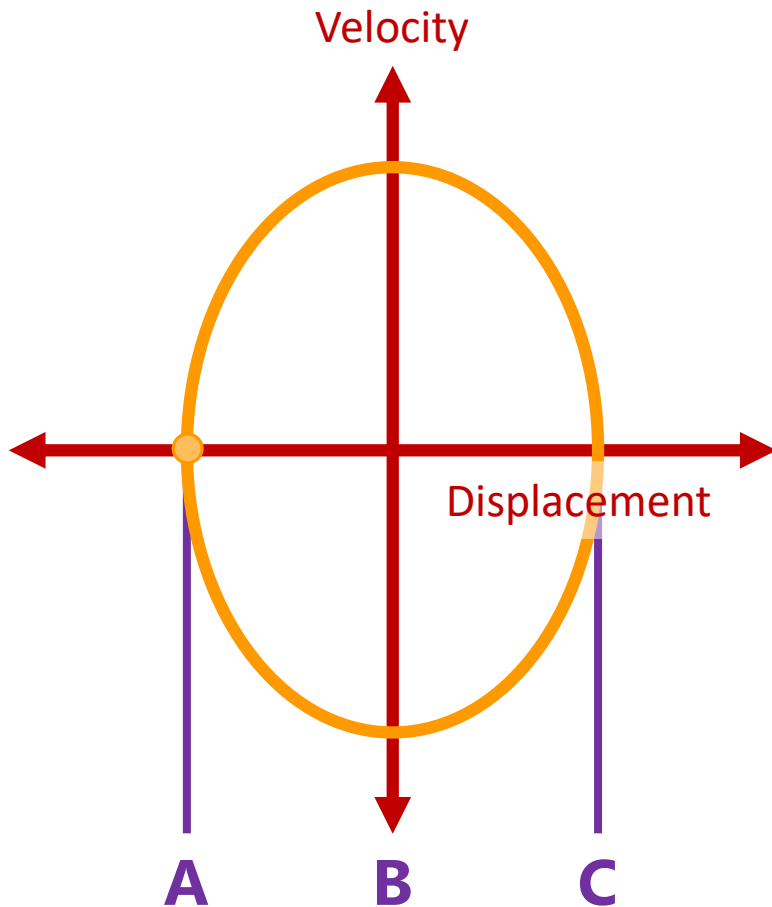
# Energy for SHM



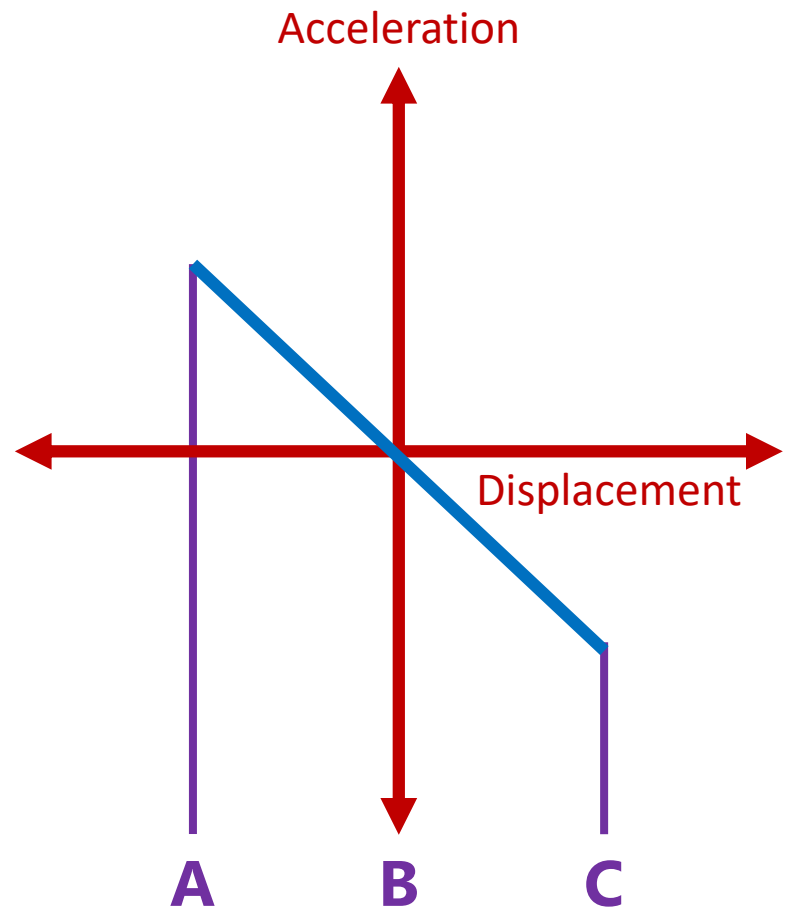
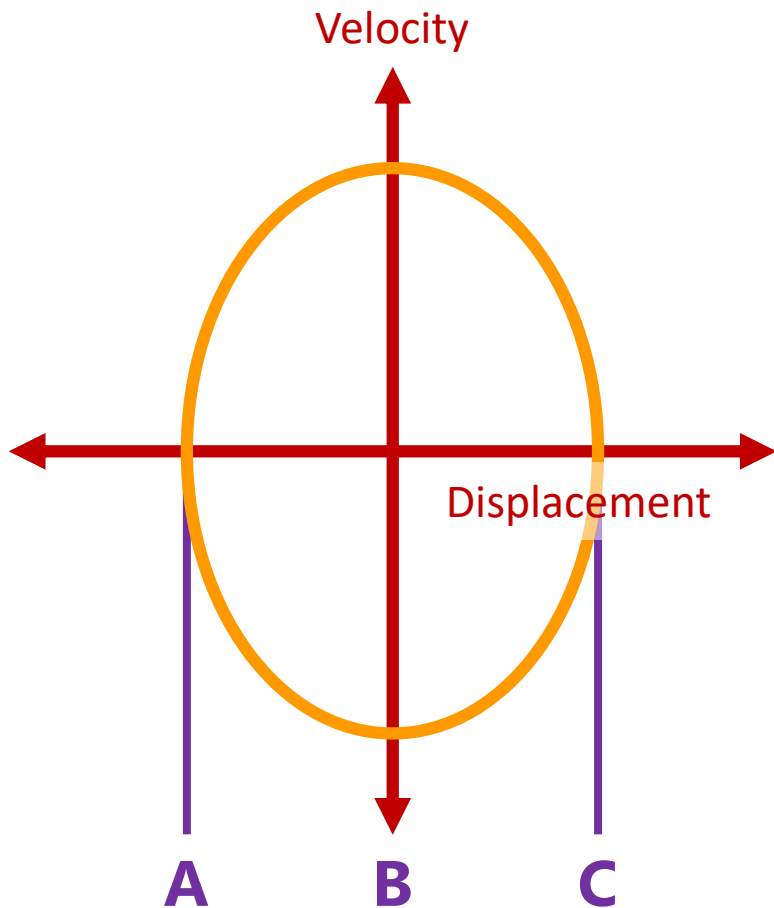
# Acceleration vs Displacement



# Velocity vs Displacement

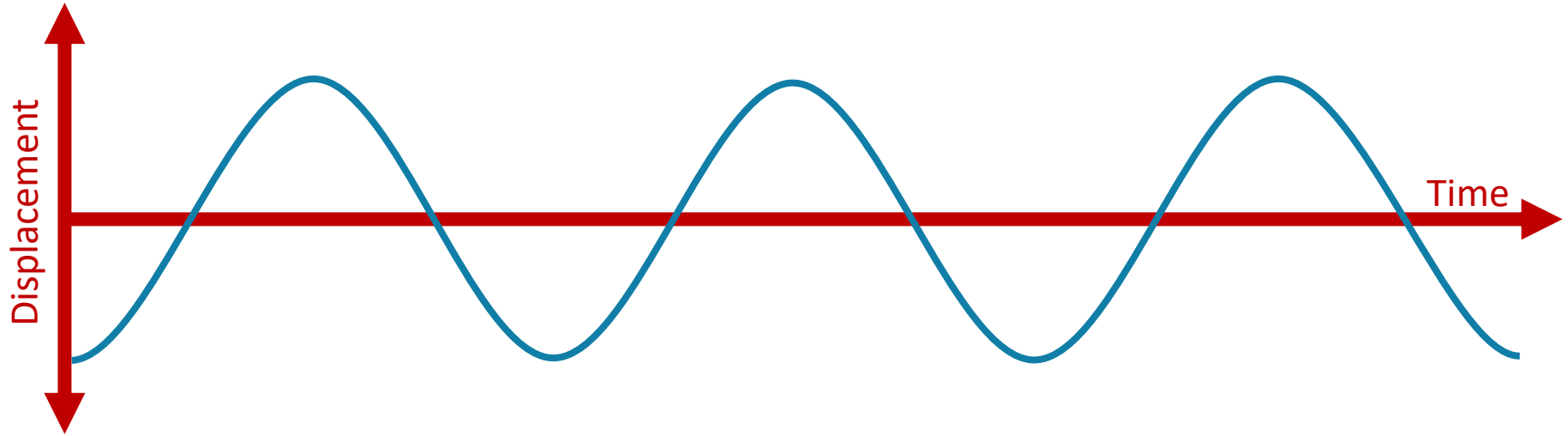


# \_\_\_\_\_ vs Displacement





# Properties of SHM



Property	What is it?	Symbol	Unit
Period	Time per cycle	$T$	[s]
Frequency	Cycles per second	$f$	[Hz]

# Period is related to Frequency

$$\text{Period} = 1 / \text{Frequency}$$

Sub-topic 4.1 – Oscillations

$$T = \frac{1}{f}$$

Sub-topic 4.2 – Travelling waves

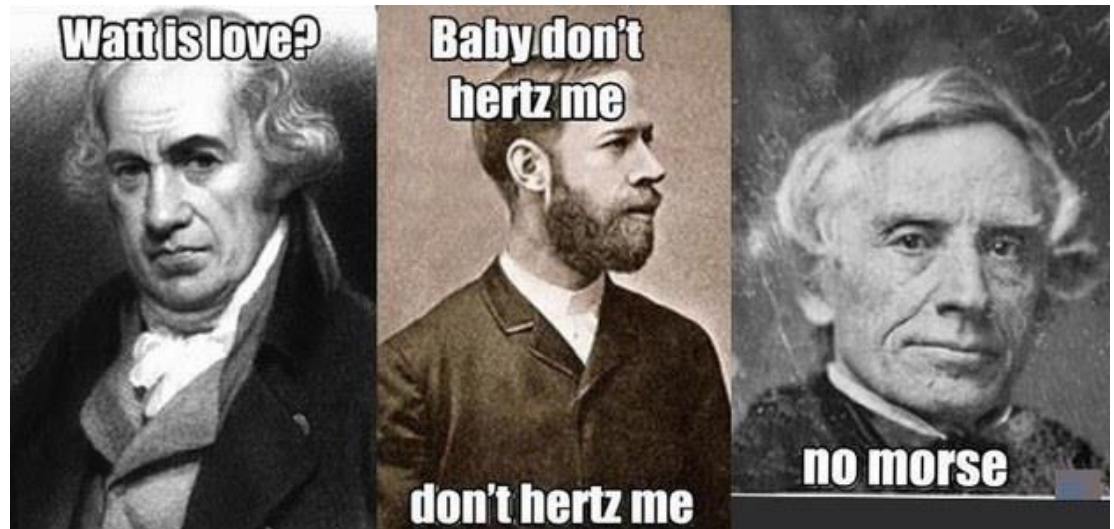
$$c = f\lambda$$

Sub-topic 4.3 – Wave characteristics

$$I \propto A^2$$

$$I \propto x^{-2}$$

$$I = I_0 \cos^2 \theta$$



# Period is related to Frequency

Period = 1 / Frequency

$$f = \frac{1}{T} \quad T = \frac{1}{f}$$

$$f = \frac{1}{T}$$

Try this...

$$T = \frac{1}{f}$$

Taylor Swift's song Shake it Off has a tempo of 160 beats per minute (2.67 Hz) how many seconds are in between each beat (the **period**)



$$f = 2.67 \text{ Hz}$$

$$T = ??$$

$$T = \frac{1}{f} = \frac{1}{2.67 \text{ Hz}} = \mathbf{0.37 \text{ s}}$$

$$f = \frac{1}{T}$$

Try this...

$$T = \frac{1}{f}$$



You are standing on the beach with your feet in the water and notice that a new wave comes crashing in every 4 seconds, what is the **frequency** of these waves?

$$T = 4 \text{ s}$$

$$f = ??$$

$$f = \frac{1}{T} = \frac{1}{4 \text{ s}} = \mathbf{0.25 \text{ Hz}}$$

# A little harder...

You are pushing your younger brother on a swing and you end up pushing 12 times in one minute. What is the period and frequency of the swing?

$$T = \frac{60 \text{ seconds}}{12 \text{ times}} = 5 \text{ s}$$

$$f = \frac{1}{T} = \frac{1}{5 \text{ s}} = 0.2 \text{ Hz}$$

# Lesson Takeaways

- I can relate the acceleration of an object in simple harmonic motion to its position
- I can graph the displacement, velocity, and acceleration vs time for simple harmonic motion
- I can describe and relate the properties of period and frequency
- I can calculate period and frequency from a scenario