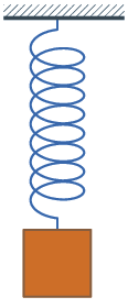
Periodic Motion
Lesson Notes

Learning Outcomes

- What traits characterize an object that undergoes periodic motion?
- How do the quantities period, frequency and amplitude describe an object undergoing periodic motion?

Vibrating Mass on a Spring



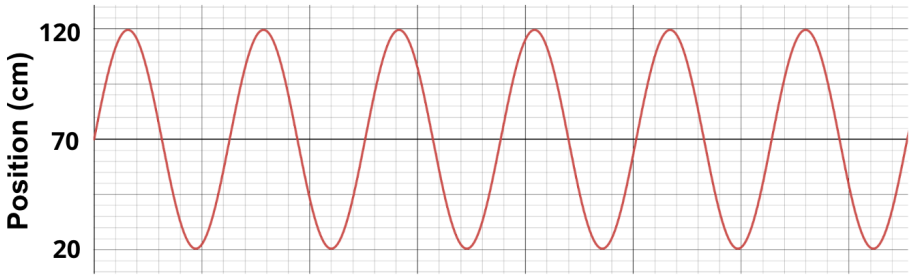
A mass vibrating back and forth on the end of a spring is an example of **periodic motion**. There are two important traits of all objects experiencing periodic motion.

- There is a **repeating** aspect to the motion. Each repetition is referred to as a **cycle**. The same cycle repeats itself in consecutive fashion.
- The repetitions occur **regularly**. It takes the same amount of time to complete each consecutive cycle. The time to complete one cycle is known as the **period**.

Other Examples: Vibrating pendulum, Earth rotating on its axis, Earth orbiting the sun.

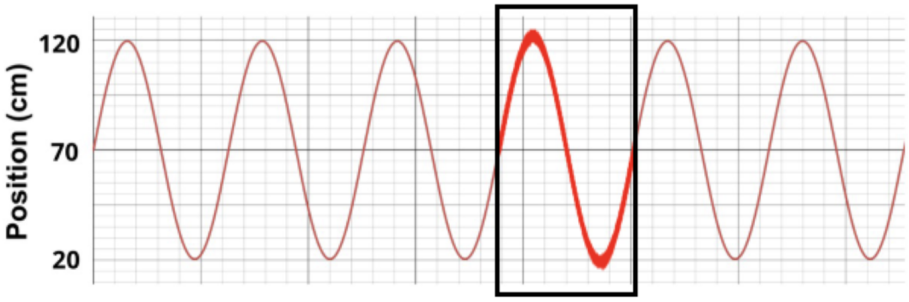
Sinusoidal Relationships

A motion detector placed below a vibrating mass can detect the position as a function of time. The mass vibrates about a fixed position known as the **resting position**. It oscillates back and forth from (for example) 20 cm above the detector to 120 cm above the detector. The position varies as a function of the sine of time.



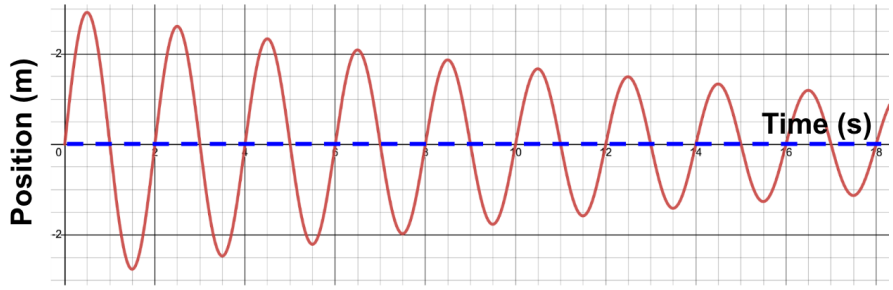
The Periodic Nature of the Mass's Vibrations

The motion of the vibrating mass repeats itself in a regular fashion, completing each consecutive period in 6.3 seconds. The period is constant – a.k.a., *regular*.



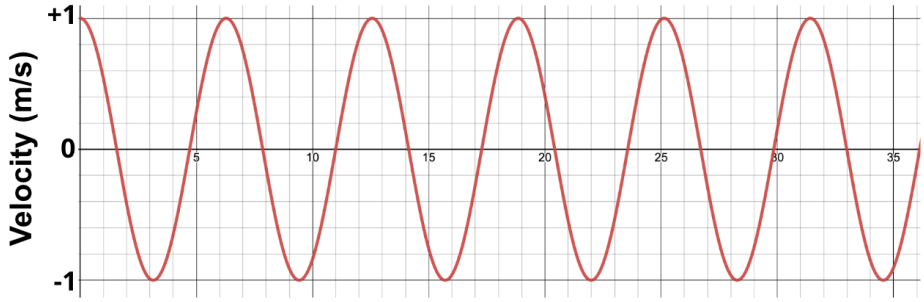
Damping, Amplitude, and Period

- **Damping** is the gradual decrease in the amplitude of vibration of an object. It results from the interaction of the vibrating system with the surroundings. Friction, air resistance and other forces dissipate energy to the surroundings.
- Damping has no effect upon the period of vibration. Being in periodic motion, the object still has a constant period.
- Damped vibrational systems show a position-time graph that looks like …



Speeding Up and Slowing Down

As a mass on a spring vibrates, it speeds up and slows down. These fluctuations in speed occur sinusoidally with respect to time.



Period versus Frequency

Period = time to complete a cycle of vibration. Answers the "How much time … ?" question.

Frequency = number of complete cycles of vibration per unit of time. Answers the "How often …? question.

Formulas:

$$\text{Period} = \frac{\text{Time (s)}}{\text{\# of cycles}} \qquad \text{Frequency} = \frac{\text{\# of cycles}}{\text{Time (s)}}$$

Example Problem: An object undergoing periodic motion completes 60 cycles in 15 seconds. What is the period and what is the frequency?

$$T = \frac{15\ \text{s}}{60\ \text{cycles}} = 0.25\ \text{s/cycle} \qquad f = \frac{60\ \text{cycles}}{15\ \text{s}} = 4.0\ \text{cycles/s}$$