UNIT: Waves

- **Chapter 11-14 Waves and Sound**

Waves and Sound

- 11 Waves and Oscillators
- 12 Properties of Waves
- 13 Sound
- 14 Light

Chapter 11 Learning Goals

- Identify examples of simple oscillators.
- Use a formula to determine the frequency and period of an oscillator.
- Analyze graphs of harmonic motion.
- Explain the meaning of natural frequency.

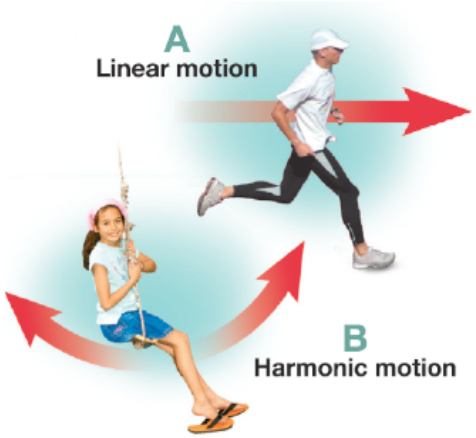
Investigation 11

Harmonic Motion

- **Key Question:**

  How do we describe the back and forth motion of a pendulum?

11 Harmonic motion

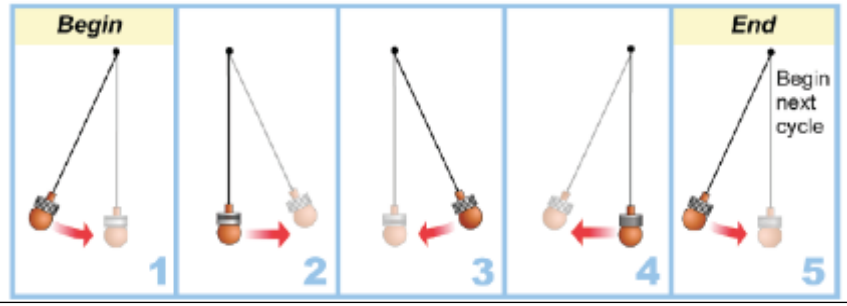


A. **Linear motion gets us from one place to another.**

B. **Harmonic motion is motion that repeats over and over.**

Harmonic motion

- A pendulum is a device that swings back and force.
- A cycle is one unit of harmonic motion.



Harmonic motion

- Harmonic motion can be fast or slow, but speed constantly changes during its cycle.
- We use period and frequency to describe how quickly cycles repeat themselves.
- The time for one cycle to occur is called a period.

Harmonic motion

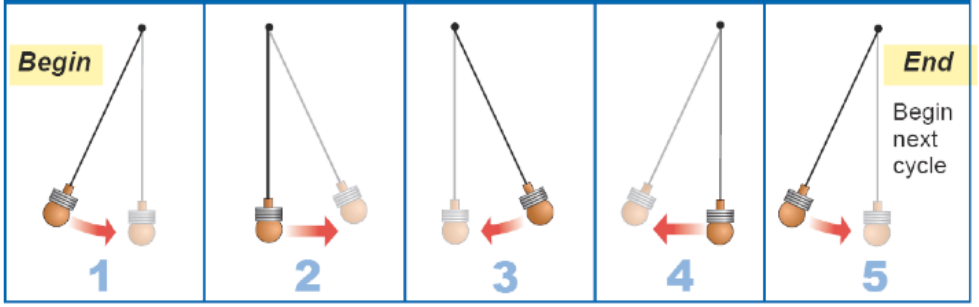
- The frequency is the number of complete cycles per second.
- Frequency and period are inversely related.
- One cycle per second is called a hertz, abbreviated (Hz).

Period and Frequency

$$\text{Period (seconds)} \rightarrow T = \frac{1}{f} \leftarrow \text{Frequency (hertz)}$$

$$\text{Frequency (hertz)} \rightarrow f = \frac{1}{T} \leftarrow \text{Period (seconds)}$$

A period is the time to complete one cycle of harmonic motion.



Solving Problems: Period and Frequency

PERIOD AND FREQUENCY

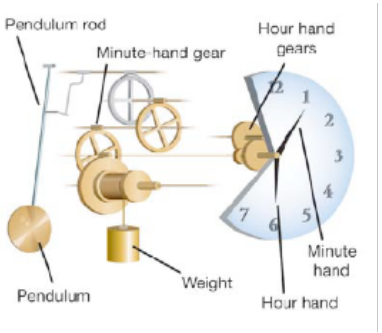
Period (seconds) $T = \frac{1}{f}$ ***Frequency*** (hertz)

Frequency (hertz) $f = \frac{1}{T}$ ***Period*** (seconds)

Solving Problems

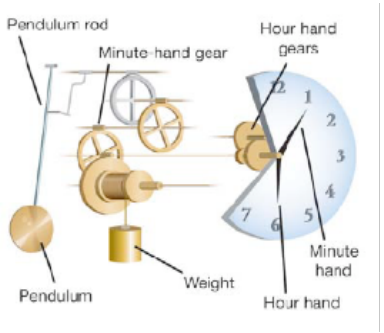
The period of an oscillator is 2 minutes.

What is the frequency of this oscillator in hertz?



Solving Problems

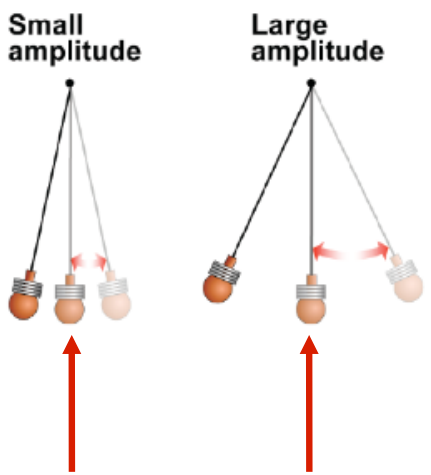
1. **Looking for:**
   - …frequency in hertz
2. **Given**
   - …period = 2 min
3. **Relationships:**
   - …60 s = 1 min
   - … f = 1/T
4. **Solution**
   - … f = 1/120 s



***f* = .008 Hz**

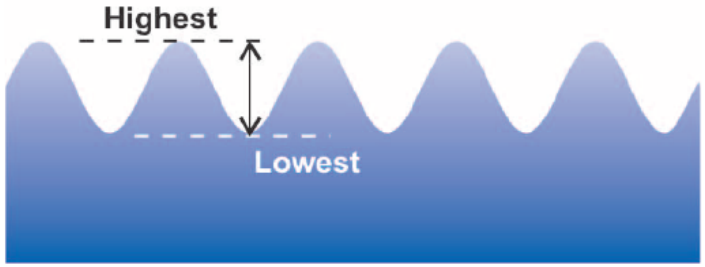
Amplitude

- Amplitude describes the "size" of a cycle.
- The amplitude is the maximum distance the oscillator moves away from its equilibrium position.



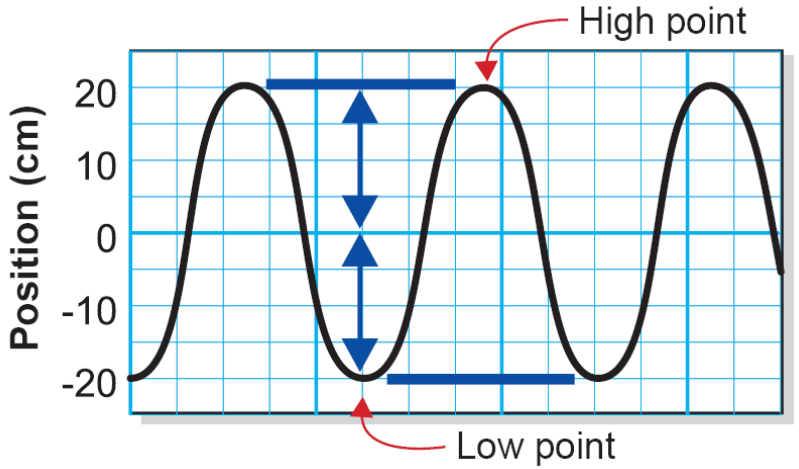
Amplitude

- The amplitude of a water wave is found by measuring the distance between the highest and lowest points on the wave.
- The amplitude is half this distance.



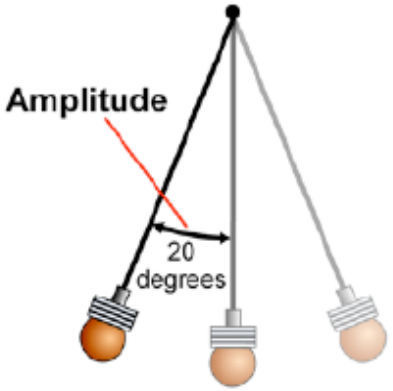
Amplitude

$$Amplitude = \frac{1}{2}\left(\begin{matrix}\text{high}\\ \text{point}\end{matrix} - \begin{matrix}\text{low}\\ \text{point}\end{matrix}\right)$$



Amplitude

- A pendulum with an amplitude of 20 degrees swings 20 degrees away from the center in either direction.

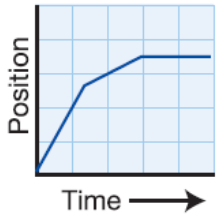


Damping

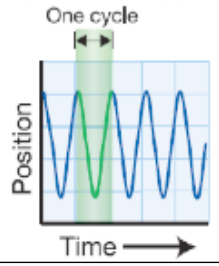
- Friction slows a pendulum down, just as it slows all motion.
- Damping is the gradual loss of amplitude.

Graphs of harmonic motion

Typical Linear Motion Graph

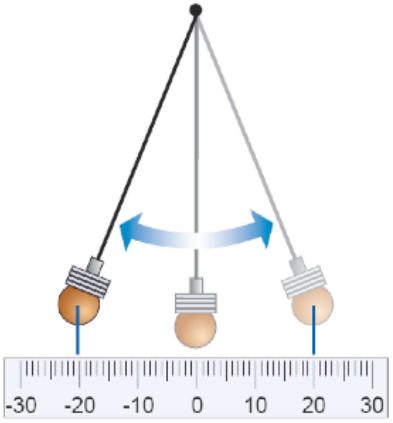


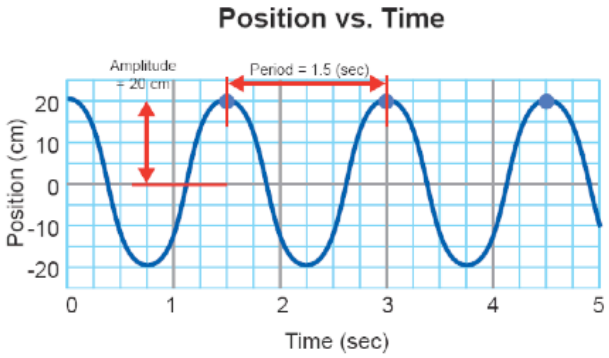
Typical Harmonic Motion Graph



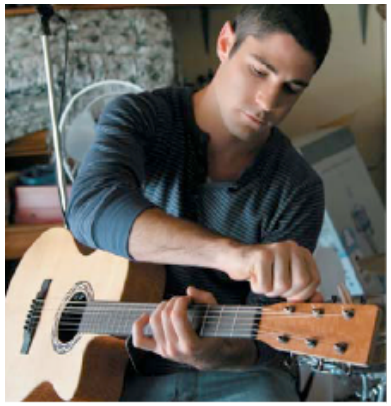
- A graph is a good way to show harmonic motion because you can quickly recognize cycles.
- Graphs of linear motion do not show cycles.

Harmonic Motion Graphs





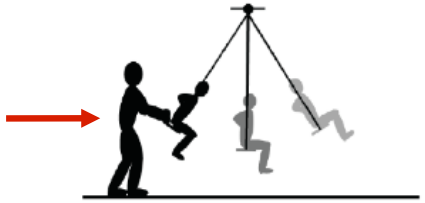
Natural frequency and resonance



- The natural frequency is the frequency (or period) at which a system naturally oscillates.
- Every system that oscillates has a natural frequency.

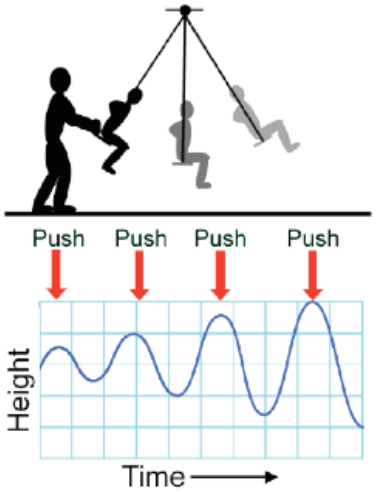
Natural frequency and resonance

- You can get a swing moving by pushing it at the right time every cycle.



- A force that is repeated over and over is called a periodic force.

Natural frequency and resonance



- Resonance happens when a periodic force has the same frequency as the natural frequency.
- When each push adds to the next one, the amplitude of the motion grows.