Periodic Motion Concepts

Pendulum, Mass on a Spring, Uniform Circular Motion
Chapter 7, Section 2 of *Physics: Principles and Problems.*

- Any motion that repeats itself may be labeled periodic motion. For introductory physics, we concern ourselves with relatively uncomplicated situations: the simple pendulum, mass on a linear spring, uniform circular motion. The first two are examples of Simple Harmonic Motion (SHM).

- Uniform circular motion occurs when an object travels in a circular path with a constant speed. Since the path is a circle, the object constantly changes direction as it moves around the path. This means it has a constantly changing velocity. A constantly changing velocity implies a constant acceleration.

- Acceleration must have a force causing it. The force on an object in uniform circular motion may come from various sources: friction for a car rounding a curve, the string for a weight whirled around, gravity for a satellite orbiting a planet, etc. We call both the force and the acceleration in uniform circular motion “centripetal,” meaning center-seeking. As the object travels in a circular path, it constantly turns towards the center. Try it yourself, by walking in a circle.

- Suppose you hang a small mass from a spring. The spring stretches slightly, and reaches a new length. Left alone for a time, it will stay in equilibrium at this new length. Now move the mass up or down, either compressing or stretching the spring. The compression or extension creates a force on the mass. The spring tries to regain its equilibrium position, but it overshoots it and now either extends or compresses (depending on what you did to it). Once again there is a force opposing the motion, and the process repeats itself over and over, the mass bobbing up and down, and the force always opposing the motion. If the force vs. position graph is linear, we call this Simple Harmonic Motion. Simple because the mathematics are simple than “non-linear” springs, harmonic because it repeats itself.

- If you look at uniform circular motion from the side, we only see one component of the motion. Either the *x* or the *y* motion will look like SHM viewed in this manner. SHM can be seen as circular motion viewed from the side. This is the reason why SHM makes sinusoidal graphs of position and velocity (a point moved around the circle also makes sinusoidal graphs, remember).

- A pendulum consists of a mass (called the bob), on the end of a string or cord. When displaced from its stable, resting position, the pendulum swings back and forth in a regular manner.

- For our description of the simple pendulum to be completely accurate, we make the following assumptions: the pendulum must be displaced about 20° or less from the vertical, the mass of the string must be small enough to be negligible, and we must be able to neglect air resistance or other frictional forces.

- The component of gravitational force accelerating the pendulum is proportional to the sine of the angle. This would produce a sine wave graph of force. However, we are interested in SHM. The reason the pendulum must only be displaced about 20° is that at small angles, the sine of the angle is approximately equal to the angle. This makes the graph of *F* vs. *x* is linear. The farther the pendulum is displaced from zero, the greater the force making it swing back towards the center. The force is not constant, but varies continuously as the pendulum moves back and forth. This makes it ”simple harmonic motion”.

- The graphs of position, and velocity for SHM are sine waves, ¼ period out of phase.