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# Oscillatory Motion and Chaos

Simplest example of oscillatory motion is in a pendulum because it swings freely due to gravity.

**-3.1 Simple Harmonic Motion**

Only 2 forces acting in a pendulum, gravity and tension. The perpendicular force is represented by Theta = -m g sin(theta).

General solution → theta = that's not sin(Omega t + phi)

Lowercase Omega is angular velocity

Energy of a Pendulum will increase with any deltaT

In this case with energy increasing with time the Euler Solution is always incorrect.

The Euler-Cromer method has a very subtle change and many problems make no difference but in problems with oscillatory motion it conserves energy over each period of motion.

**-3.2 Adding Dissipation, NonLinearity, and A Driving Force**

Making a pendulum more realistic by adding resistance called damping.

Adding a driving force to the pendulum.

When the amplitude of the pendulum is large it spends a longer time at the turning points where theta is largest.

**-3.3 Chaos in the Driven NonLinear Pendulum**

When all added together the pendulum is called the Physical Pendulum.

The motion of this pendulum can be viewed as an interplay of the natural frequency of the pendulum and the frequency of the driving force.

Example of chaotic behavior is when the driving force never repeats and simple harmonic oscillation never happens even if you were to (wait longer).

Chaotic systems have a common property that they generally exhibit phase-space trajectories with significant structure.

It is possible for a system to be both deterministic and unpredictable which is chaos.

The behavior in the chaotic regime is not completely random