Bachelor of Software Engineering - Game Programming

GD2P02 – Physics Programming

Harmonic Motion and Springs

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Overview

- Harmonic Motion and Springs
  - Springs
    - Hooke's Law
  - Simple Harmonic Motion
  - Pendulum
    - Simple and Physical

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Springs

- Springs are valuable in physics programming.
- Rigid bodies are good for representing collision detection and friction.

- Springs are good for absorbing.
  - Requires tuning
  - Stiffness could be a problem

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Springs: Hooke's Law

- When a spring is stretched or compressed, it reacts with a force in the opposite direction.
- Hooke's Law

$$F = -kx$$

  - Where:
    - k is the spring constant
      - The coefficient of elasticity
    - x is the displacement from equilibrium
    - Units:
      - F is in $kgms^{-2}$ or N
      - x is in metres
      - k is in kgs^{-2} or kg/s^2

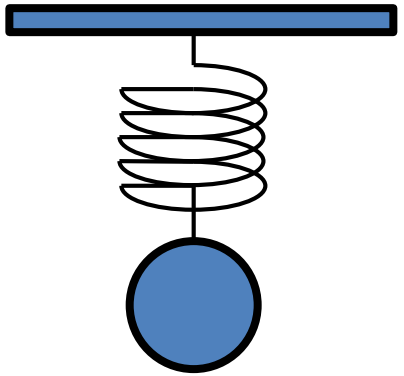

Fig 1: Spring with attached weight.

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Springs: Hooke's Law continued…

- F = -k (L - r), where r is the resting length(at equilibrium) and L is the stretched or compressed length of the spring.

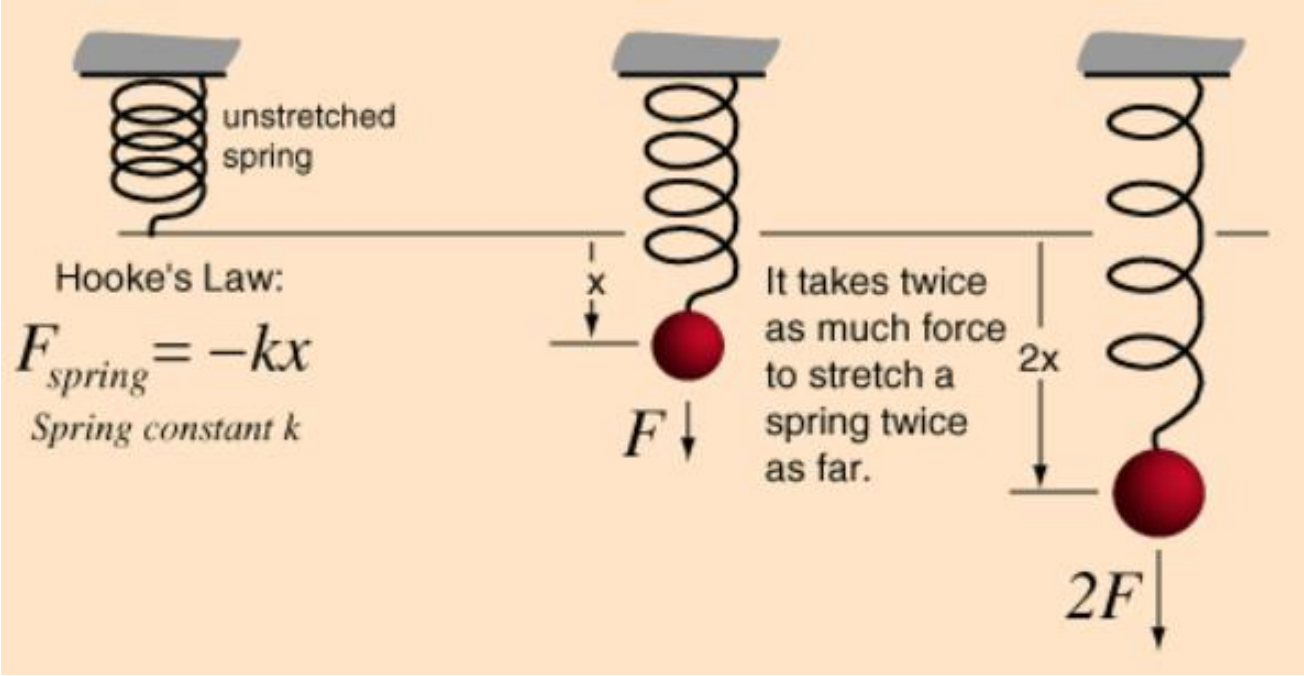

Fig 2: Illustration of Hooke's Law.

Fig 2: http://hyperphysics.phy-astr.gsu.edu/hbase/permot2.html#c3

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Springs: Simple Harmonic Motion

- Motion of a mass on a spring is an oscillation and follows a sinusoidal path.
  - Has a period $T = 2\pi\sqrt{m/k}$, $T = 1/f$. (*f* is in Hz)

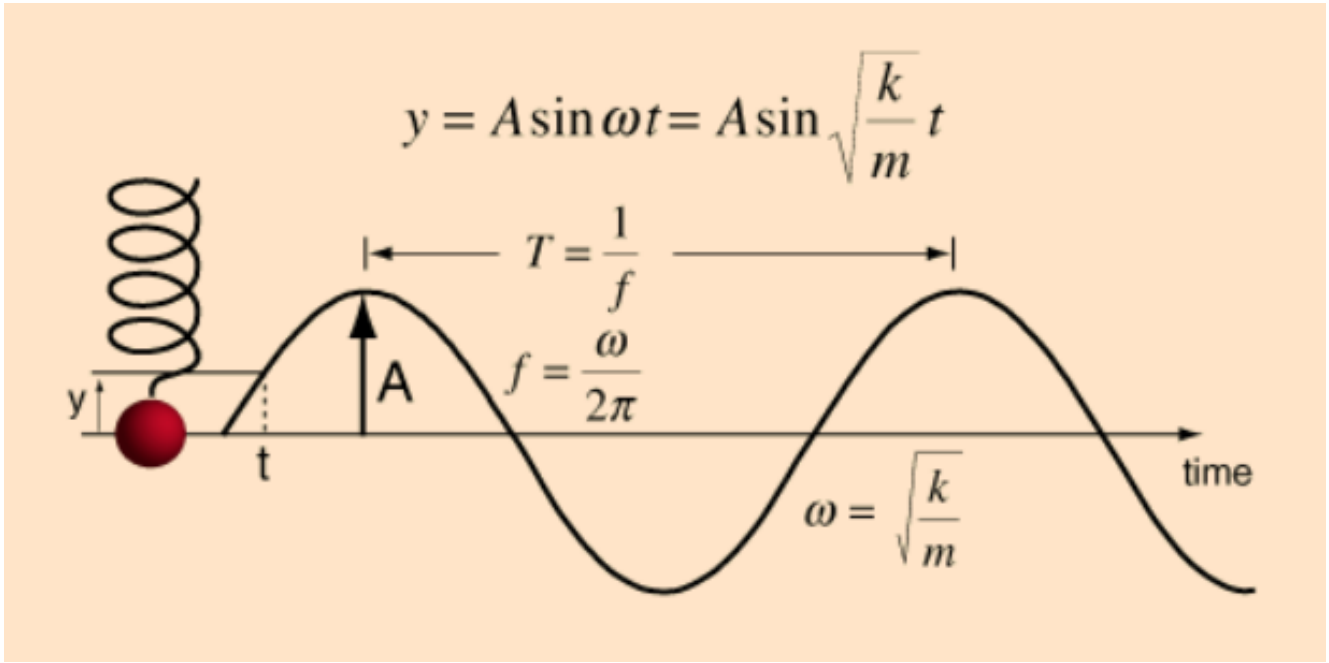

Fig 3: Springs and simple harmonic motion.

Fig 3: http://hyperphysics.phy-astr.gsu.edu/hbase/shm.html#c1

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Simple Harmonic Motion: Pendulum

- A point mass suspended from a string with a negligible mass is a simple pendulum.

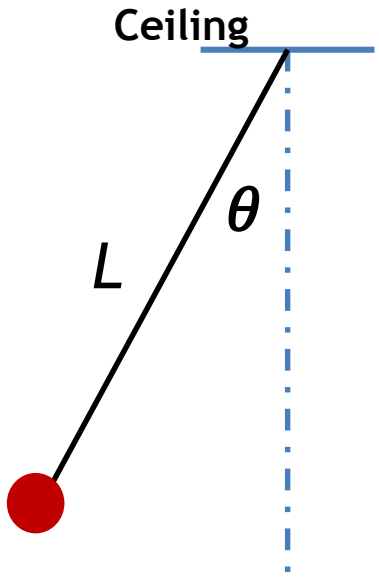

Fig 4: Simple pendulum.

- $T = 2\pi\sqrt{L/g}$
- $\omega = \sqrt{g/L}$
- $F_{net} = ma = mg \sin\theta$

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Simple Harmonic Motion: Physical Pendulum

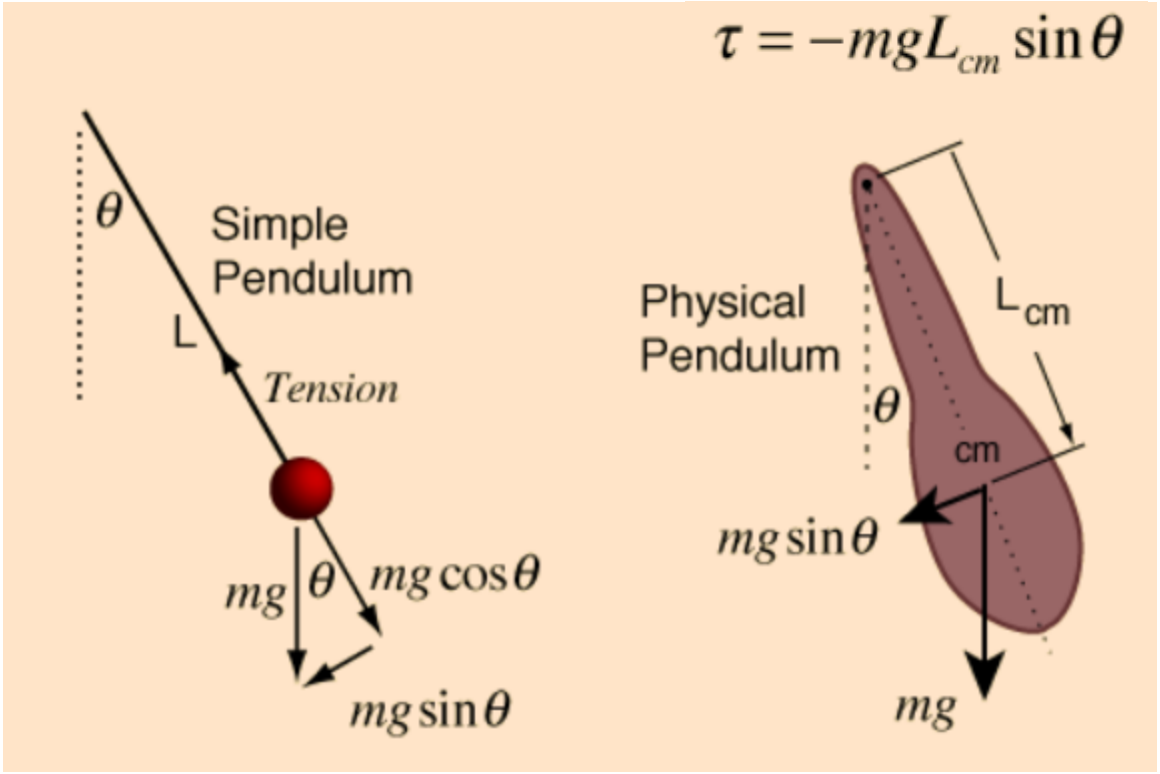

Fig 5: Simple and Physical Pendulum.

Fig 5: http://hyperphysics.phy-astr.gsu.edu/hbase/pend.html#c1

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Springs and Objects

- When a rigid body is attached to a spring,
  - the spring stretches or squashes when the body moves.
  - the spring applies a force to the attached point of the rigid body.
  - If the attached point is off-centre, the force does not pass through the body's centre of mass.
    - Linear and angular forces will be generated.

- Damping
  - A damping force will prevent the spring from oscillating forever.
  - The damping force has a direction that is the opposite of the velocity.
  - Think of it as friction…

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Summary

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