# PH202 Reading Guide

# Chapter 14: Oscillations

This chapter is the first of three chapters of Part 4 of our textbook in which you will study the physics of oscillation and waves. These concepts are closely related, as you can imagine. If you dip your finger repeatedly in a quite lake or a bathtub you will see that you will produce a wave in the water. You will see several examples in class. In PH201 you learned all about forces – mostly constant forces – and their effect on motion. We looked at linear motion, circular motion, and 2D parabolic motion. Now, you have the opportunity to revisit these concepts but in an oscillating situation where the motion (and its physics) is repeating itself over and over. Two very important parts are required for oscillations to occur are a restoring force and an equilibrium. In fact we will look at a special set of oscillations called simple harmonic motion (SHM). You will see that SHM is directly related to uniform circular motion and has a sinusoidal displacement, velocity and acceleration vs time curves. To have SHM you must have a *linear* restoring force. Or to say it the other way around: Whenever there is a physical system with an object under the action of a linear restoring force around an equilibrium position, the object will show simple harmonic motion around the equilibrium position if it is not in equilibrium. This applies to some spring and pendulum systems. Finally, we will a take a brief look at damped and driven oscillators.

**Student Learning Objectives**

In covering the material of this chapter, students will learn to

- Understand that oscillatory motion occurs in systems with a linear restoring force.
- Give examples of physical systems that support oscillatory motions and describe how the frequency of oscillation depends on physical properties of the system.
- Describe oscillatory motion with graphs and equations, and use these descriptions to solve problems of oscillatory motion.
- Understand how conservation of energy applies to simple harmonic motion.
- Apply concepts of damping and resonance to oscillatory systems.
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**Physics Tools**

- Diagrams:
  - x - t to show harmonic motion
  - F – x diagram to characterize restoring force
- Energy bar charts

**When reading the text**

- Answer all “Stop To Think” questions (the answers are in the back of the chapter)
- Understand all examples
- Answer the following questions to ensure you understood the text

**Some questions that successful students can answer after reading the text:**

*Section 14.1 (page 439-440): Equilibrium and Oscillation*

How would you define an oscillation? What is needed for oscillations to occur?

What are the units of frequency?

How are frequency and period related?

What is simple harmonic motion?

*Section 14.2 (page 441-443): Linear Restoring Forces and Simple Harmonic Motion*

What does a linear restoring force do?

What is the amplitude of an oscillation?

What role does gravity play in a spring system that is oscillating vertically?

Why does a pendulum only show simple harmonic motion for small angle amplitudes?

*Section 14.3 (page 443-448): Describing Simple Harmonic Motion*

What three equations for position, velocity and acceleration with respect to time describe simple harmonic motion?

How are the amplitudes of these equations ($x_{max}$, $v_{max}$, and $a_{max}$) related to the frequency and amplitude of SHM?

How is SHM connected to uniform circular motion?

What are key time points in SHM?

*Section 14.4 (page 448-453): Energy in Simple Harmonic Motion*

Can you describe the back-and forth transformation of energy in SHM?

How does the conservation of energy help you determine the frequency of a spring-mass system in terms of its *m* and *k*?

What is the frequency of a spring-mass system in terms of its *m* and *k*?

*Section 14.5 (page 453-455): Pendulum Motion*

What is the frequency of a simple pendulum in terms of its properties?

What is the frequency of a physical pendulum in terms of its properties?

What is the difference between a simple and physical pendulum?

*Section 14.6 (page 455-457): Damped Oscillations*

What is a damped oscillation?

What is the equation for the amplitude of a damped oscillation?

What is the time constant?

How is half-life related to the time constant?

What happens when τ>>T? when τ<<T?

*Section 14.7 (page 457-461): Driven Oscillations and Resonance*

What is a driven oscillation?

How are natural frequency and resonance related?

What happens when τ>>T? when τ<<T?

**Suggested Workbook Problems (best is answering all workbook questions)**

Chapter 14: 1, 2, 3, 5, 6, 7, 8, 9, 10, 11, 15, 16, 17