Classical Mechanics
Phy 235, Lecture 03.

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A great image, to start a great lecture.

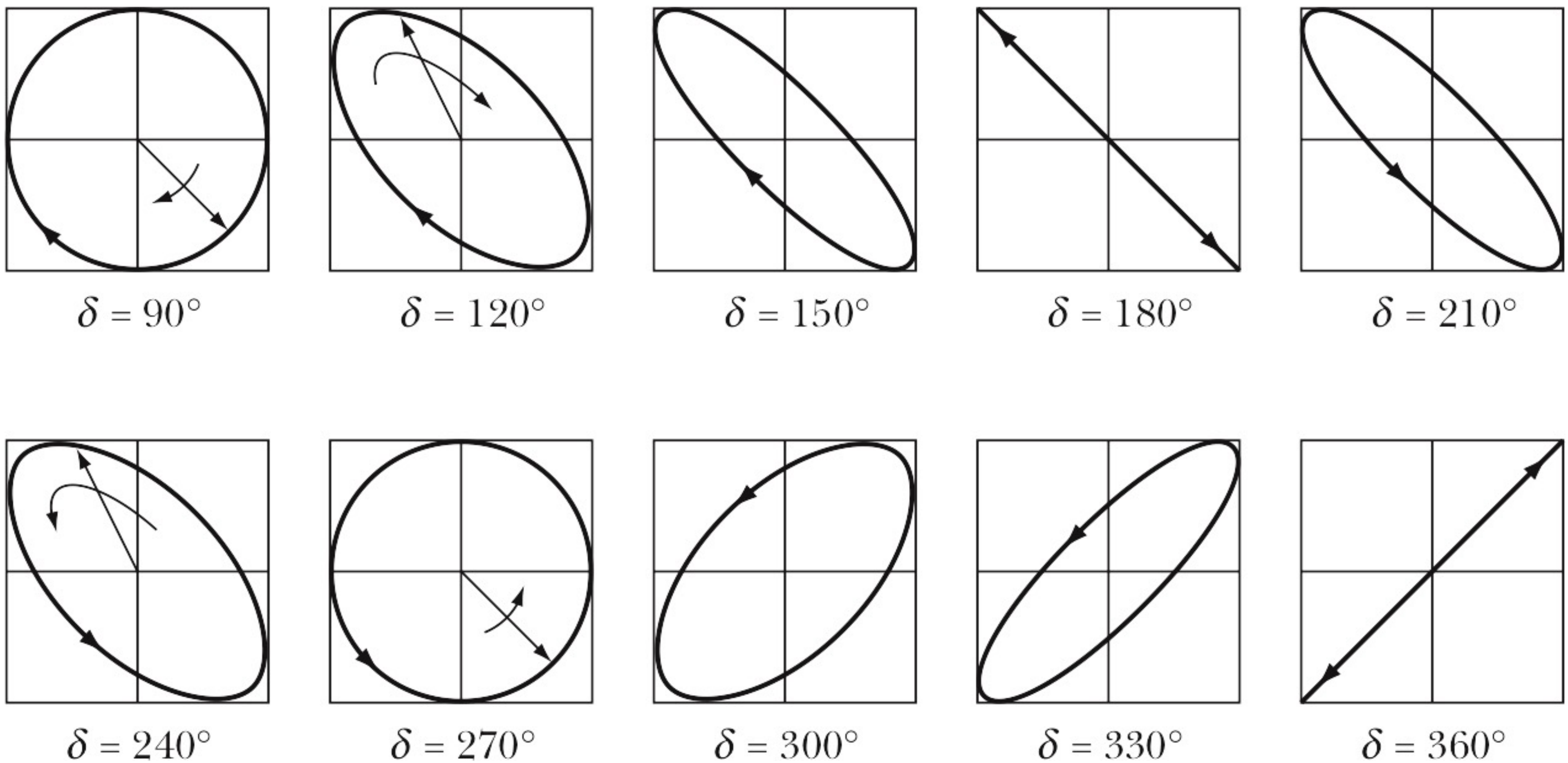
Course Information.

- All homework and exam solutions will be available on the Phy 235 website. They are password protected (see email for details).
    - http://teacher.pas.rochester.edu/PHY235/HomeWork/Solutions/
- If graphs are required to solve homework problems, they can be made using various programs (including Excel). The installation package of Igor is available on the Phy 235 website:
    - http://teacher.pas.rochester.edu/PHY235/DownloadFolder/Software/SoftwareIndex.htm
- The VPython code used during lectures can be found at the following URL:
    - http://teacher.pas.rochester.edu/PHY235/ComputingTools/ComputingToolsIndex.htm

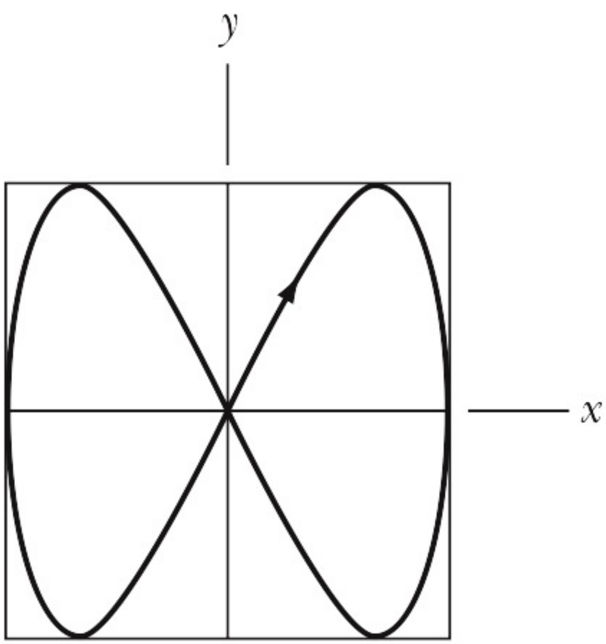
Chapter 3

- Harmonic motion:
  - Motion around a position of stable equilibrium.
  - Simple harmonic motion (the focus today):
    - At small distances around the equilibrium position, the force is approximately equal to $-kx$.
    - The total energy of the system is constant. The kinetic and potential energy will be time dependent.
  - Damped and driven harmonic motion (the focus of Monday's lecture next week):
    - Damped harmonic motion occurs when friction or drag forces are acting on the system. Energy is dissipated and the system will gradually come to rest.
    - Driven harmonic motion adds a driving force in order to compensate for damping losses.

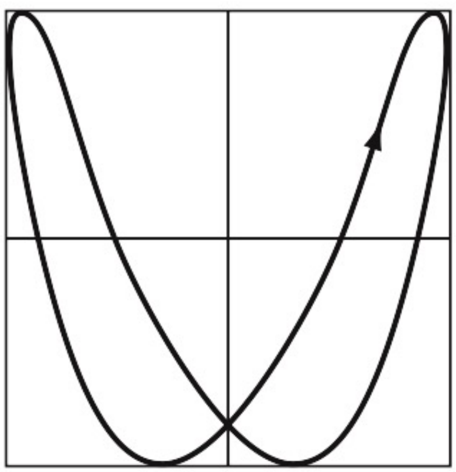
Two-dimensional Simple Harmonic Motion.
y vs x for single restoring force.



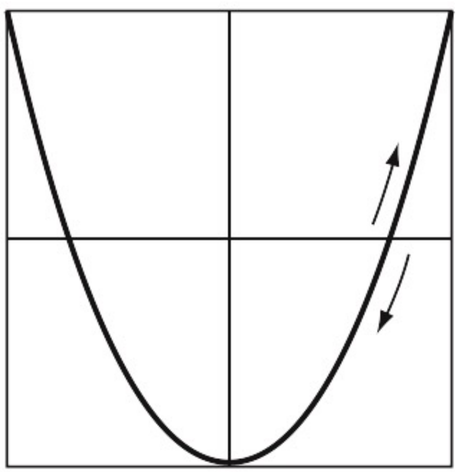
Two-dimensional Simple Harmonic Motion. y vs x for different restoring forces.



$\omega_y = 2\omega_x\ ;\ \delta = 0$



$\omega_y = 2\omega_x\ ;\ \delta = \pi/3$



$\omega_y = 2\omega_x\ ;\ \delta = \pi/2$

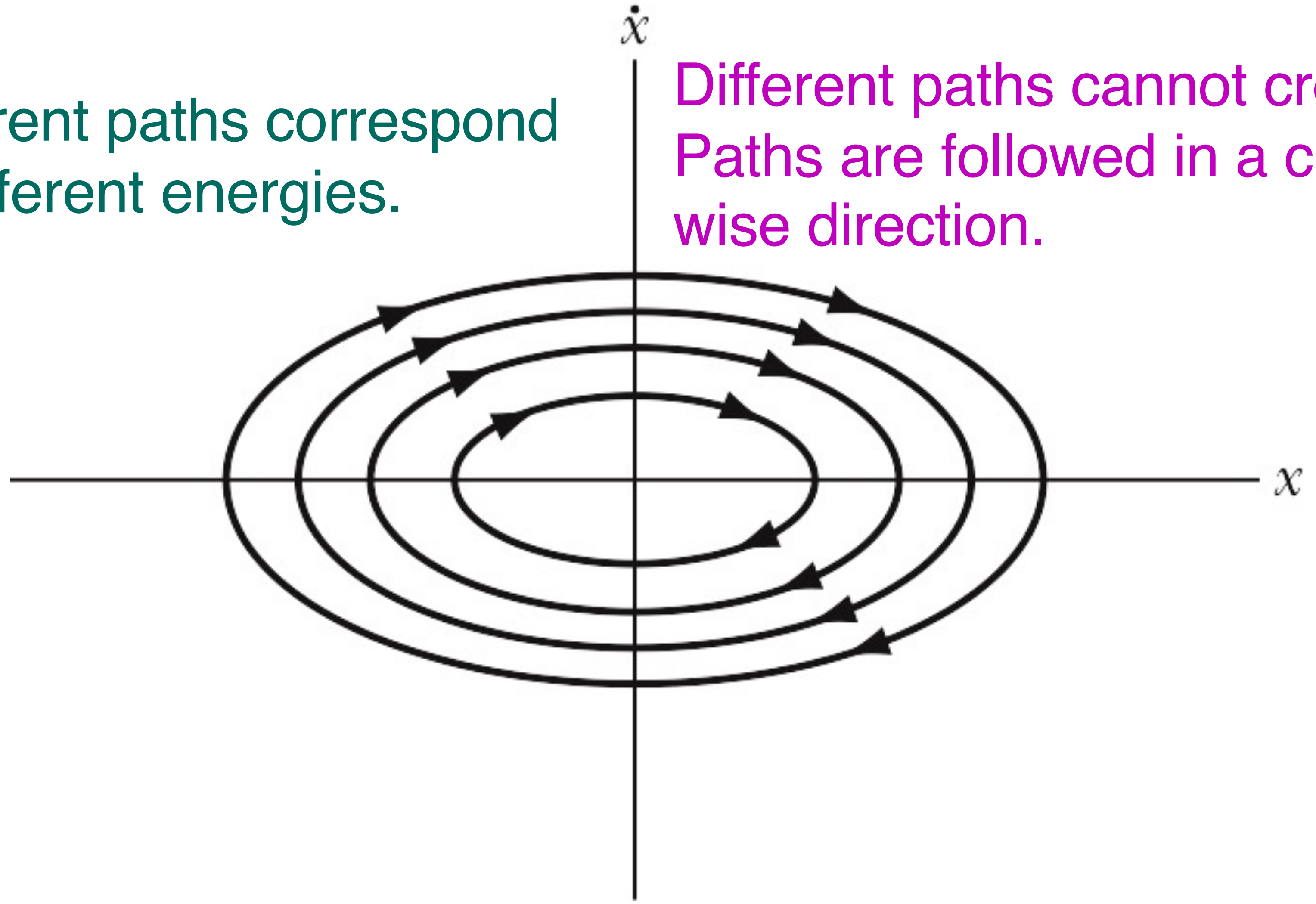
Numerical studies.

- Using tools such as VPython, it is easy to explore how harmonic motion changes as initial conditions are changed.
- Let us have a look:
  - https://www.glowscript.org/#/user/wolfs/folder/Public/program/Phy235-SimpleHarmonicMotion

Phase Diagrams.

Different paths correspond to different energies.

Different paths cannot cross. Paths are followed in a clock-wise direction.



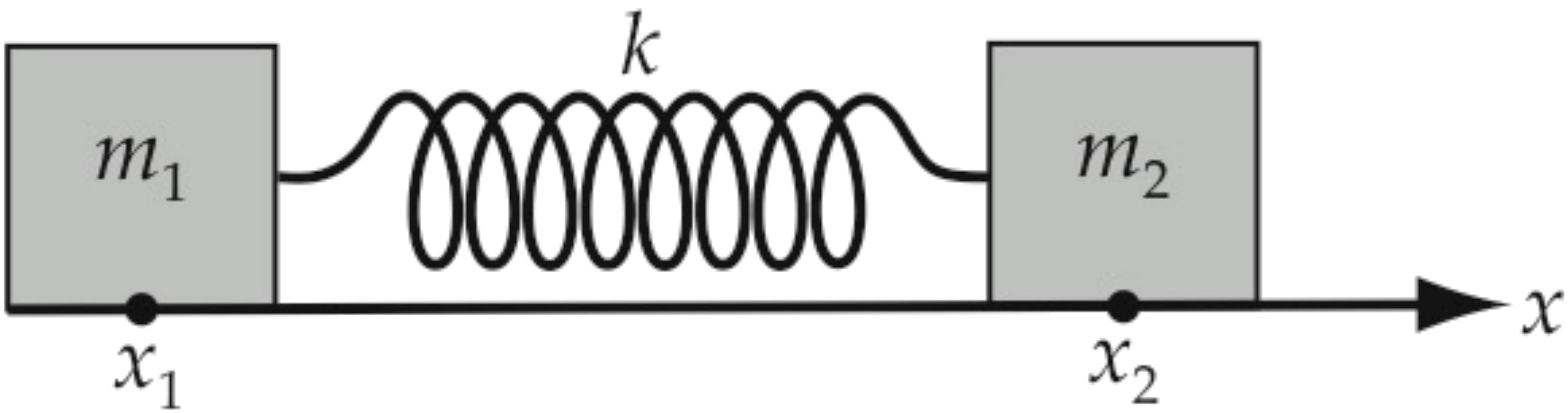
2 Minute 18 Second Intermission.

- Since paying attention for 1 hour and 15 minutes is hard when the topic is physics, let's take a 2 minute 18 second intermission.

- You can:
  - Stretch out.
  - Talk to your neighbors.
  - Ask me a quick question.
  - Enjoy the fantastic music.

Problem 3.6

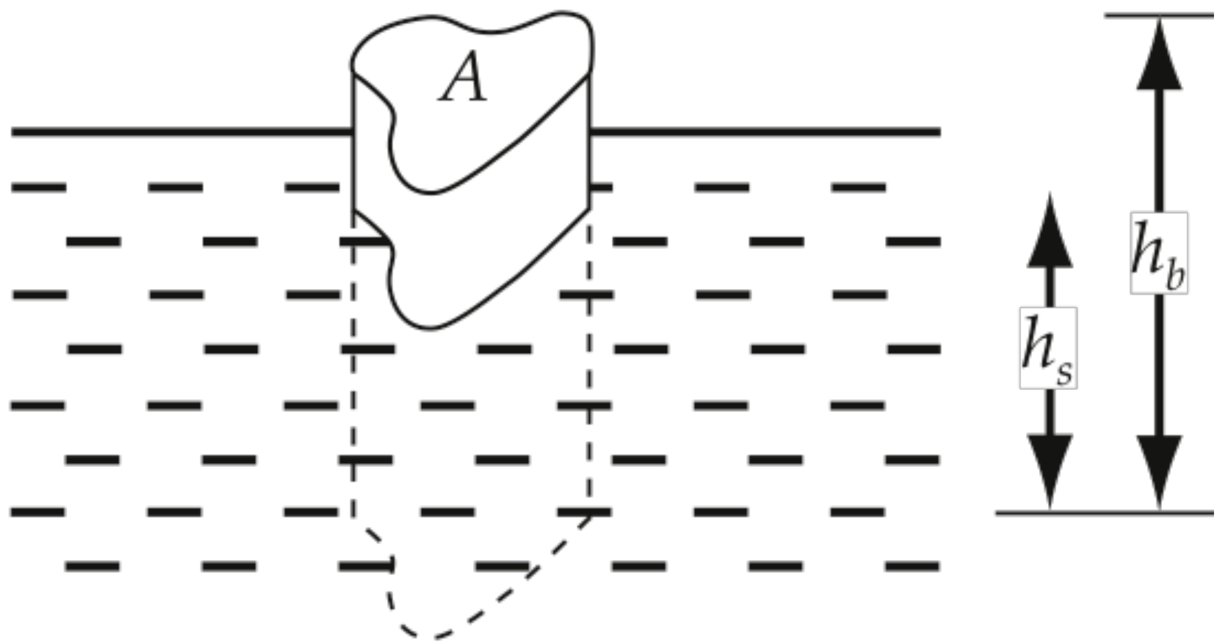
- Two masses m_1 and m_2 slide freely on a horizontal frictionless track and are connected by a spring whose force constant is k. Find the frequency of oscillatory motion for this system.



Problem 3.7

- A body of uniform cross-sectional area A and of mass density ρ floats in a liquid of density ρ_0. When it is in equilibrium, the body displaces a volume V. Show that the period of small oscillations about the equilibrium position is given by

$$\tau = 2\pi\sqrt{\frac{V}{gA}}$$



Solving Second-order Differential Equations.

- General form:

$$\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = f(x)$$

- If you find two linearly independent solutions, every other solution will be a linear combination of these two solutions.
- The general solution has two constants, defined by the initial conditions.

- **Homogeneous equation:**
  - *f(x)* is equal to 0.
- **Inhomogeneous equation:**
  - *f(x)* is not equal to 0.

Homogeneous Equation: $\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = 0$

- Three different scenarios:
  - $a^2 > 4b$
  - $a^2 = 4b$
  - $a^2 < 4b$

Inhomogeneous Equation: $\frac{d^2y}{dx^2} + a\frac{dy}{dx} + by = f(x)$

- Suppose:
  - v is a solution of the inhomogeneous equation.
  - u is the general solution of the homogeneous equation.
- Then:
  - $u + v$ is the general solution of the inhomogeneous equation.

ENOUGH FOR TODAY?