
Classical Mechanics

Phy 235, Lecture 03.

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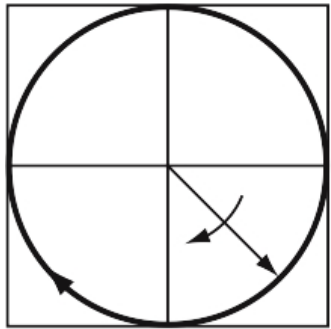
Course Information.

- The solutions of homework set # 1 are now available on the Phy 235 website. They are password protected (see email for details).
 - <http://teacher.pas.rochester.edu/PHY235/HomeWork/Solutions/Set01/SolutionsSet01.htm>
- The graphs required for homework set # 2 can be made using various programs (including Excel). The installation package for 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>
- Note: these links may not work until the website is updated on Monday morning.

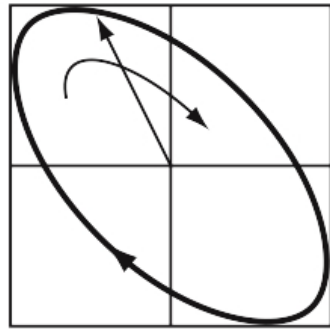
Chapter 3

- **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 on Wednesday):
 - 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.

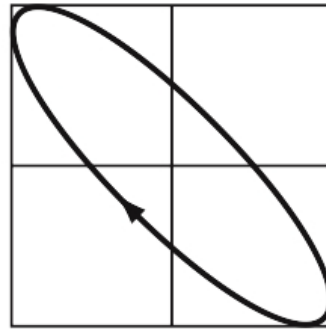
Two-dimensional Simple Harmonic Motion. y vs x for single restoring force.



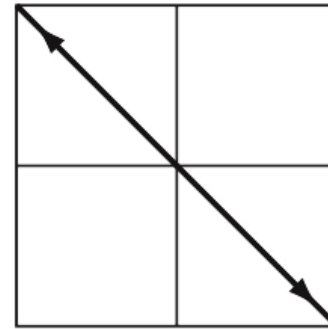
$\delta = 90^\circ$



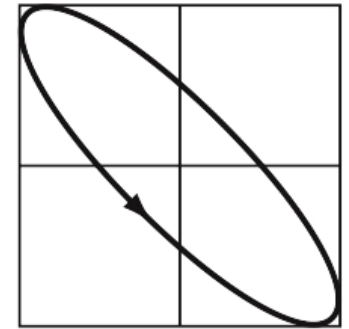
$\delta = 120^\circ$



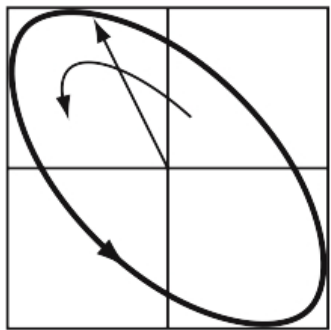
$\delta = 150^\circ$



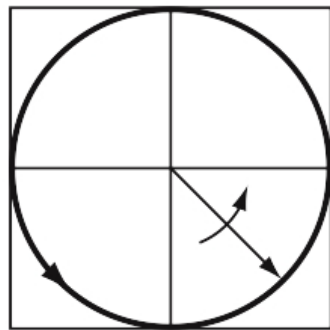
$\delta = 180^\circ$



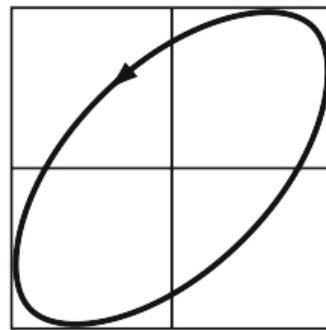
$\delta = 210^\circ$



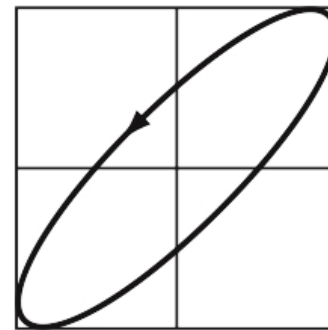
$\delta = 240^\circ$



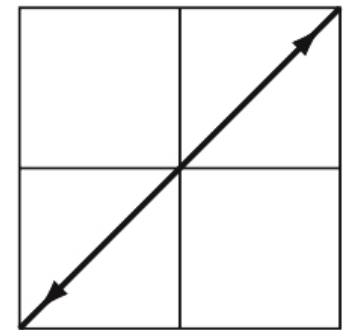
$\delta = 270^\circ$



$\delta = 300^\circ$

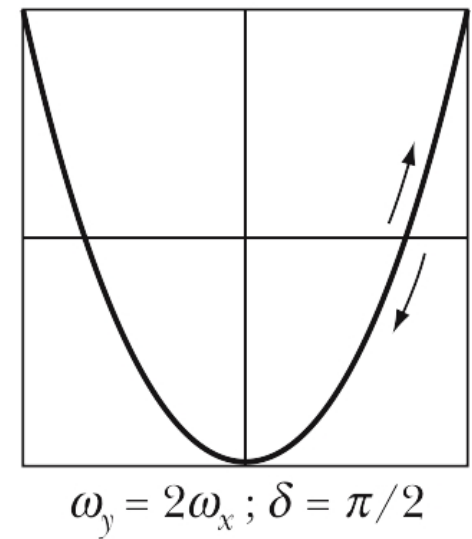
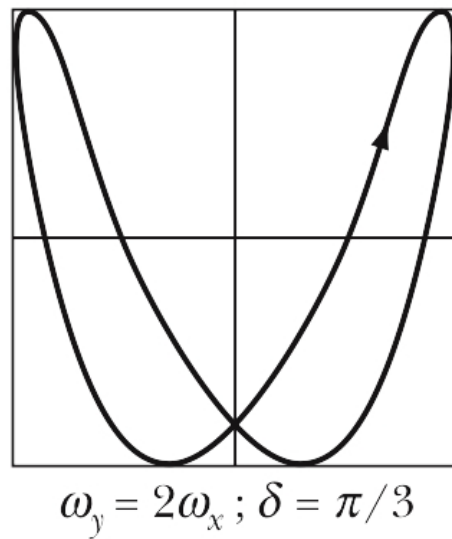
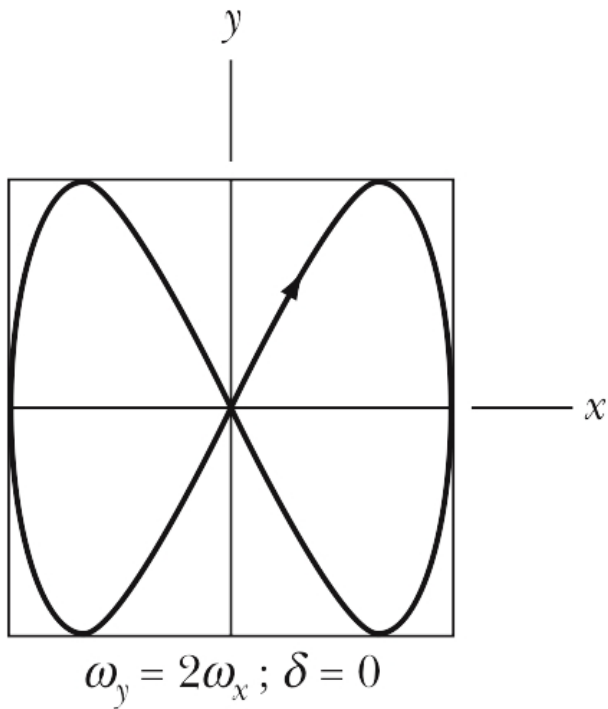


$\delta = 330^\circ$



$\delta = 360^\circ$

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



Numerical studies.

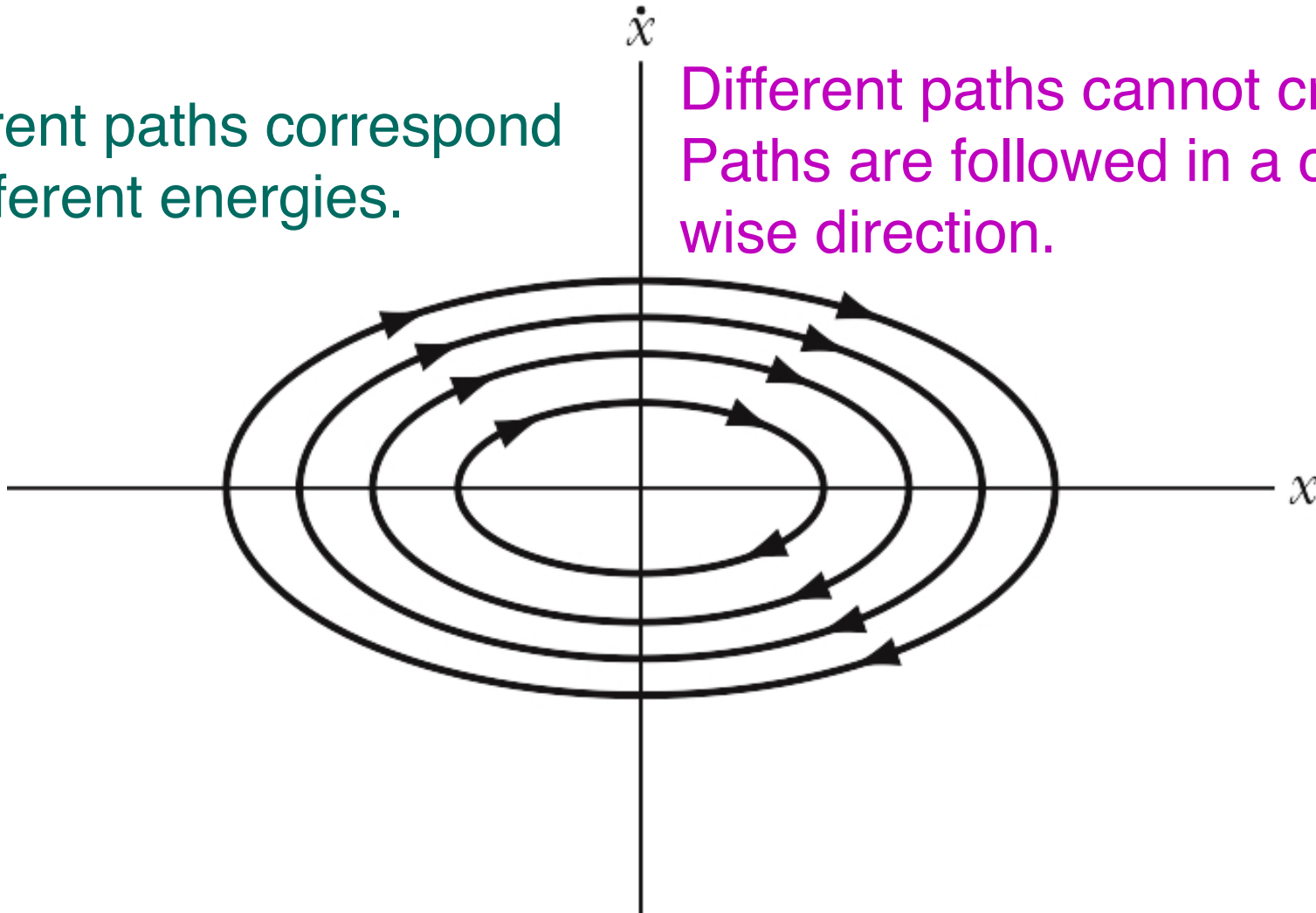
- Using tools such as VPython, it is easy to explore how harmonic motion changes as initial conditions are changed.
- Let us have a look:

<http://www.glowscript.org/#/user/wolfs/folder/Public/program/SimpleHarmonicMotion>

Phase Diagrams.

Different paths correspond to different energies.

Different paths cannot cross.
Paths are followed in a clockwise direction.





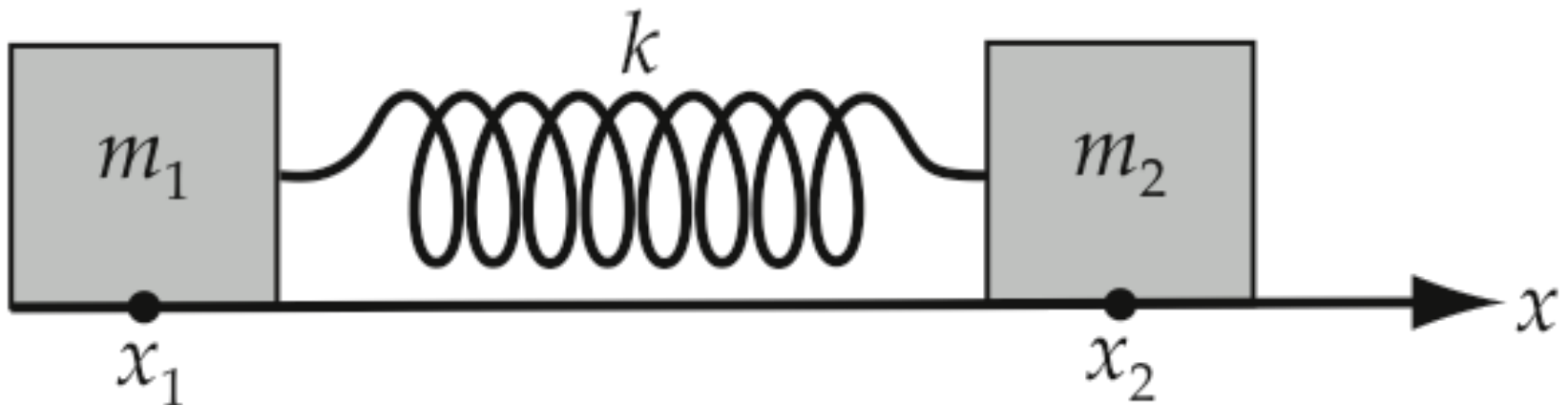
2 Minute 18 Second Intermission.

- 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

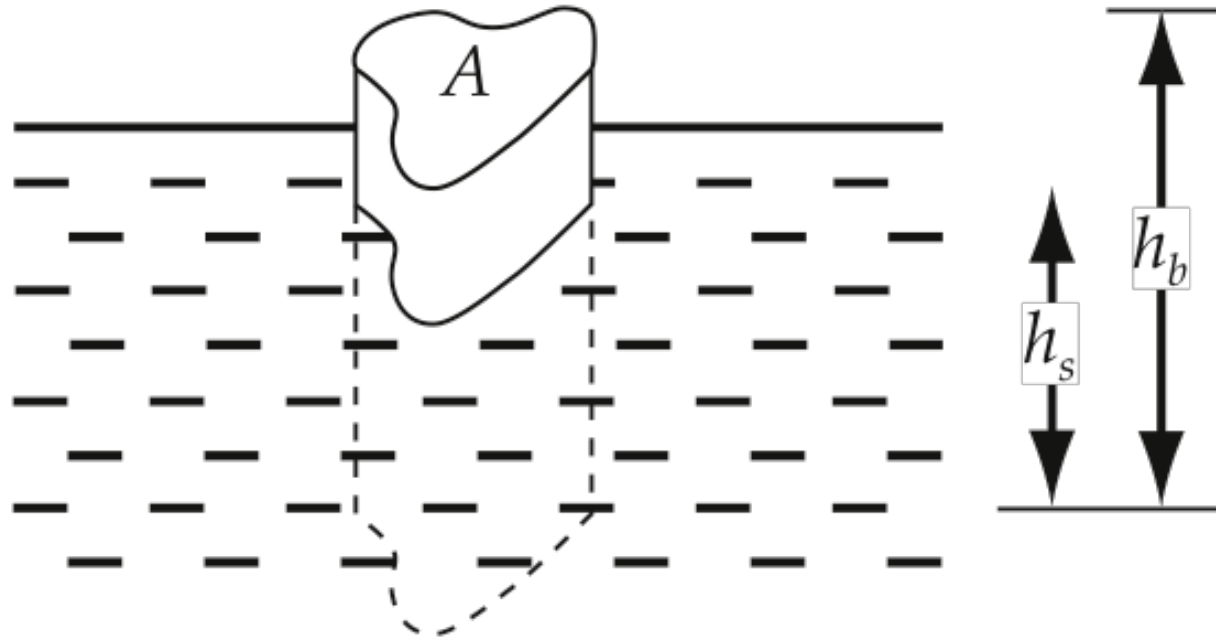
- Two masses m_1 and m_2 slide freely on a horizontal frictionless track and are connected by a spring whose force constant is k . Find the frequency of oscillatory motion for this system.



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:

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

- 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?