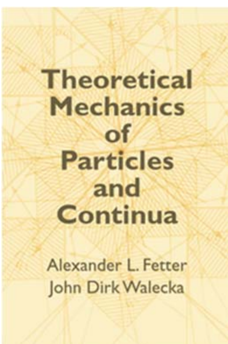
PHY 711 Classical Mechanics and Mathematical Methods
10-10:50 AM MWF Olin 103

Plan for Lecture 1:

1. Welcome & overview
2. Class structure & announcements
3. Introduction to Maple software
4. Chapter 1 – scattering theory

Textbook:



SIGNIFICANT NAMES IN MECHANICS AND MATHEMATICAL PHYSICS'

Isaac Newton (1642–1727)
Daniel Bernoulli (1700–1782)
Leonhard Euler (1707–1783)
Jean Le Rond d'Alembert (1717–1783)
Joseph Louis Lagrange (1736–1813)
Pierre Simon de Laplace (1749–1827)
Adrien Marie Legendre (1752–1833)
Jean Baptiste Joseph Fourier (1768–1830)
Karl Friedrich Gauss (1777–1855)
Siméon-Denis Poisson (1781–1840)
Friedrich Wilhelm Bessel (1784–1846)
Augustin-Louis Cauchy (1789–1857)
George Green (1793–1841)
Carl Gustav Jacob Jacobi (1804–1851)
William Rowan Hamilton (1805–1865)
Joseph Liouville (1809–1882)
George Gabriel Stokes (1819–1903)
Hermann Ludwig Ferdinand Helmholtz (1821–1894)
Gustav Robert Kirchhoff (1824–1887)
William Thomson (Lord Kelvin) (1824–1907)
Georg Friedrich Bernhard Riemann (1826–1866)
John William Strutt (Lord Rayleigh) (1842–1919)

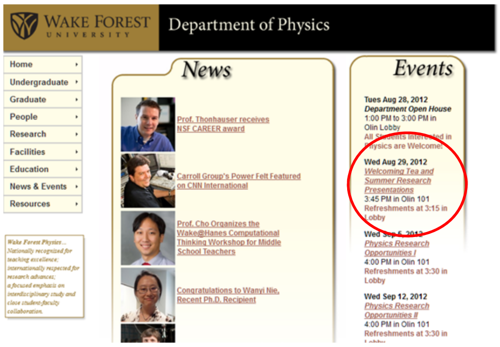
Fall 2012 Schedule
for N. A. W. Holzwarth

	Monday	Tuesday	Wednesday	Thursday	Friday
8:00-9:00	Lecture Preparation/ Office Hours	Lecture Preparation/ Office Hours	Lecture Preparation/ Office Hours	Lecture Preparation/ Office Hours	Lecture Preparation/ Office Hours
9:00-10:00	General Physics I PHY113		General Physics I PHY113		General Physics I PHY113
10:00-11:00	Classical Mech PHY711		Classical Mech PHY711		Classical Mech PHY711
11:00-12:30	Office Hours	Physics Research	Office Hours	Physics Research	Office Hours
12:30-2:00	Condensed Matter Theory Journal Club		Physics Research		Physics Research
2:00-3:30	Physics Research				
3:30-5:00			Physics Colloquium		CEES -- Renewable Energy Research

Travel dates:

- Oct. 17, 2012 Duquesne University

Comment about Physics Colloquia



WFU Physics Colloquium

TITLE: "Welcome to the WFU Physics Department"

TIME: Wednesday Aug. 29, 2012 at 3:45 PM*

PLACE: George P. Williams, Jr. Lecture Hall, (Olin 101)

* Note: early starting time.

Refreshments will be served at 3:15 PM in the lounge. All interested persons are cordially invited to attend.

PROGRAM

The purpose of this first seminar is to help new, returning, and prospective students (including both undergraduate and graduate students), faculty, and staff to become acquainted with each other and with the Physics Department. After refreshments in the lounge in the lobby of Olin Physical Laboratory (starting at 3:15), we will meet in the George P. Williams, Jr. Lecture Hall (Olin 101) at 3:45 PM for some announcements followed by presentations by some undergraduate students, highlighting their summer research experiences.

PHY 711 Classical Mechanics and Mathematical Methods

MWF 10 AM-10:50 PM	OPL 103	http://www.wfu.edu/~natalie/f12phy711/

Instructor: Natalie Holzwarth	**Phone:**758-5510	**Office:**300 OPL	**e-mail:**natalie@wfu.edu

General Information

This course is a one semester survey of Classical Mechanics and Mathematical Methods at the graduate level, using the textbook: **Theoretical Mechanics of Particles and Continua** by Alexander L. Fetter and John Dirk Walecka (McGraw-Hill, 1980) (now published by Dover) -- **F&W**.

It is likely that your grade for the course will depend upon the following factors:

Problem sets*	40%
Computational project	20%
Exams	40%

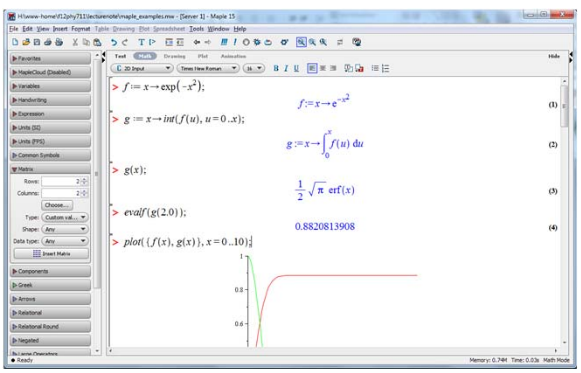
*In general, there will a new assignment after each lecture, so that for optimal learning, it would be best to complete each assignment before the the next scheduled lecture. According to the honor system, all work submitted for grading purposes should represent the student's own best efforts.

Students should be confident that there is a contingency plan in place for continuing this class in the unlikely event of a major emergency. This plan includes the distribution of course materials by the web or by mail and the appropriate rescheduling of exams.

Return to main web page for PHY 711

Introduction to algebraic manipulation software

http://www.wfu.edu/~natalie/f12phy711/lecturenote/maple_example.mw



Scattering theory:

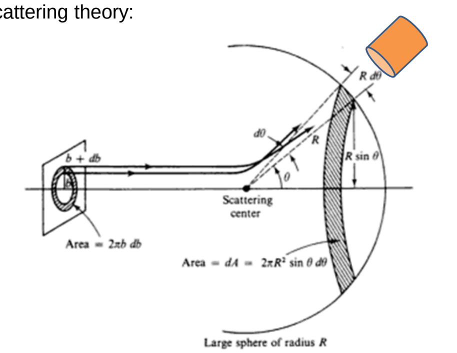
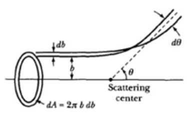


Figure 5.5 The scattering problem and relation of cross section to impact parameter.

Differential cross section

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{\text{Number of detected particles at } \theta \text{ per target particle}}{\text{Number of incident particles per unit area}}$$

$$= \text{Area of incident beam that is scattered into detector at angle } \theta$$



$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{2\pi\, b\, db}{2\pi \sin\theta\, d\theta} = \frac{b}{\sin\theta}\left|\frac{db}{d\theta}\right|$$

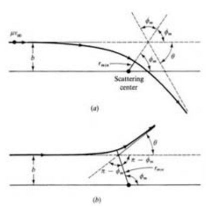
Figure from Marion & Thorton, Classical Dynamics

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 10

Differential cross section

$$\left(\frac{d\sigma}{d\Omega}\right) = \frac{2\pi\, b\, db}{2\pi \sin\theta\, d\theta} = \frac{b}{\sin\theta}\left|\frac{db}{d\theta}\right|$$

How can we find $b(\theta)$?



Note that:

$\ell = \mu v_\infty b$

μ = reduced mass

v_∞ = velocity at large separation

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 11

Conservation of energy in the center of mass frame:

$$E = \frac{1}{2}\mu\left(\frac{d\mathbf{r}}{dt}\right)^2 + V(r)$$

$$= \frac{1}{2}\mu\left(\frac{dr}{dt}\right)^2 + \frac{\ell^2}{2\mu r^2} + V(r)$$

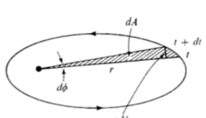
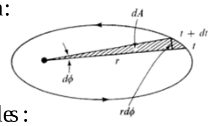


Figure 3.2 The areal velocity in a central field.

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 12

Conservation of angular momentum:

$$\ell = \mu r^2 \left(\frac{d\phi}{dt}\right)$$



Transformation of trajectory variables:

$r(t) \Leftrightarrow r(\phi)$

$$\frac{dr}{dt} = \frac{dr}{d\phi}\frac{d\phi}{dt} = \frac{dr}{d\phi}\frac{\ell}{\mu r^2}$$

$$\Rightarrow E = \frac{1}{2}\mu\left(\frac{dr}{dt}\right)^2 + \frac{\ell^2}{2\mu r^2} + V(r)$$

$$= \frac{1}{2}\mu\left(\frac{dr}{d\phi}\frac{\ell}{\mu r^2}\right)^2 + \frac{\ell^2}{2\mu r^2} + V(r)$$

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 13

$$\Rightarrow E = \frac{1}{2}\mu\left(\frac{dr}{dt}\right)^2 + \frac{\ell^2}{2\mu r^2} + V(r)$$

$$= \frac{1}{2}\mu\left(\frac{dr}{d\phi}\frac{\ell}{\mu r^2}\right)^2 + \frac{\ell^2}{2\mu r^2} + V(r)$$

Solving for $r(\phi) \Leftrightarrow \phi(r)$

$$\left(\frac{dr}{d\phi}\right)^2 = \left(\frac{2\mu r^4}{\ell^2}\right)\left(E - \frac{\ell^2}{2\mu r^2} - V(r)\right)$$

$$d\phi = dr\left(\frac{\ell / r^2}{\sqrt{2\mu\left(E - \frac{\ell^2}{2\mu r^2} - V(r)\right)}}\right)$$

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 14

$$d\phi = dr\left(\frac{\ell / r^2}{\sqrt{2\mu\left(E - \frac{\ell^2}{2\mu r^2} - V(r)\right)}}\right)$$

Further simplification at large separation:

$\ell = \mu v_\infty b$

$E = \frac{1}{2}\mu v_\infty^2$

$\Rightarrow \ell = \sqrt{2\mu E}\, b$

8/29/2012 PHY 711 Fall 2012 -- Lecture 1 15

When the dust clears :

$$d\phi = dr\left(\frac{\ell / r^2}{\sqrt{2\mu\left(E - \frac{\ell^2}{2\mu r^2} - V(r)\right)}}\right)$$

$$d\phi = dr\left(\frac{b / r^2}{\sqrt{1 - \frac{b^2}{r^2} - \frac{V(r)}{E}}}\right)$$

$$\Rightarrow \phi(b, E)$$