

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

Plan for Lecture 1:

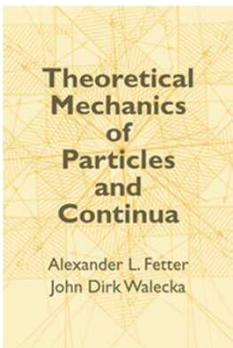
1. Welcome & overview
 2. Class structure & announcements
 3. Introduction to Maple software
 4. Chapter 1 – scattering theory

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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 Laplace (1749-1827)
 Adrien Marie Legendre (1752-1833)
 Jean Baptiste Joseph Fourier (1768-1830)
 Karl Friedrich Gauss (1777-1855)
 Samuel Denis Poisson (1781-1840)
 Augustin-Louis Cauchy (1789-1846)
 George Green (1793-1841)
 Carl Gustav Jacob Jacobi (1804-1851)
 William Rowan Hamilton (1805-1865)
 Joseph Liouville (1809-1882)
 Georges Gabriel Stokes (1819-1901)
 Hermann Ludwig Ferdinand Helmholtz (1821-1894)
 Gustav Robert Kirchhoff (1824-1887)
 William Thomson (Lord Kelvin) (1824-1907)
 Georg Friedrich Bernhard Riemann (1826-1866)

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Fall 2013 Schedule
for [N. A. W. Holzwarth](#)

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

Travel dates:

- Oct. 27 – Nov. 1, 2013 Electrochemical Society Meeting

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Comment about Physics Colloquia

WAKE FOREST UNIVERSITY

Department of Physics

News

Thonhauser group receives funding to investigate MOFs for carbon capture and catalysis

Brian Shoemaker and Prof. Thonhauser featured on WFU homepage

Congratulations to Graham Lopez, Recent Ph.D. Recipient

Kim-Shapiro Group Members Win Awards at Conference

Events

Tues. Aug 27, 2013 Fall Classes begin

Wed. Aug 28, 2013 Welcoming Tea and Summer Research Presentations 3:45 PM in Olin 101 Refreshments at 3:15 in Lobby

WFU Physics Nationally recognized for teaching excellence, nationally recognized for research advances, a focused emphasis on interdisciplinary study and close faculty-student collaboration.

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WFU Physics Colloquium

TITLE: "Welcome to the WFU Physics Department"

TIME: Wednesday Aug. 28, 2013 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.

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PHY 711 Classical Mechanics and Mathematical Methods

MWF 10 AM-10:50 PM | OPL 103 | <http://www.wfu.edu/~natalie/f13phy711/>

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 Walecke (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 be a new assignment after each lecture, as far as optimal learning. It would be best to complete each assignment before 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.

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The image shows the Maple 17 logo. The word "Maple" is written in a large, blue, serif font, and the number "17" is in a smaller, red, bold, sans-serif font. Below the logo is a horizontal grey bar.

Available from the webpage:
<http://help.wfu.edu/public/vcl>

If you have any trouble with this installation and setup,
please contact Ching-Wan Yip at yipcw@wfu.edu

Note: This is a remote server that the university is
testing. If you are off campus you will need to use
VPN to gain access.

Systems Knowledge Base

Communication & Collaboration Network Password/Access Management Desktop/Laptop Sakai File & Printer Hosting Banner
Multimedia & Cable TV WiFi Departmental Applications Reporting Handheld Devices/Non-Standard Equipment

[Public](#)

Get The Help You Need:

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Log in & Submit a Request

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[Learning Resources](#)

[Visit Us At The Bridge](#)

Call 336-758-4357 (HELP)

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Installing and Connecting to Virtual Computing Labs

Beginning Fall of 2013 certain academic departments at Wake Forest University will begin utilizing Virtual Computing Labs to access specific software programs needed for coursework. This page will include the instructions as well as the files needed to download and install the VMware View client and establish a connection for the first time.

Instructions

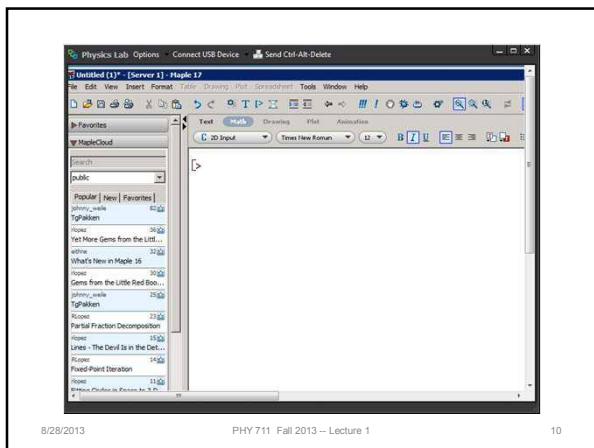
[Installing and Connecting with Windows](#)
[Installing and Connecting with Macintosh](#)

Downloads

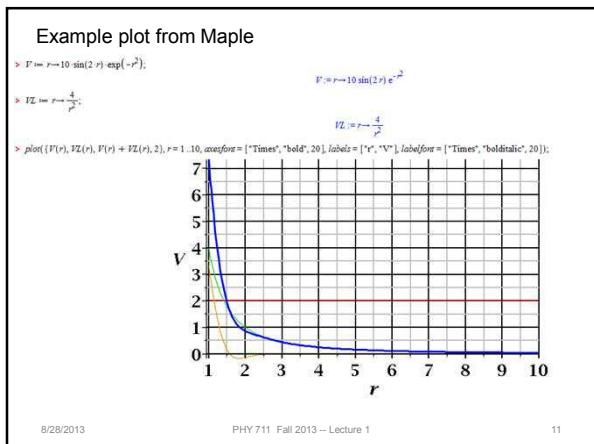
[VMware View Client 32-Bit](#) (ThinkPad T430s and lower)
[VMware View Client 64-Bit](#) (ThinkPad X1 Carbon and newer)

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A screenshot of a Windows desktop environment. The taskbar at the bottom shows several pinned icons: 'Physics Labs Options' (selected), 'Connect USB Device', 'Send Ctrl-Alt-Delete', 'Classic Workbench...', 'Maple 17 World', 'Maple 17', and 'Google Chrome'. The desktop background is blue. On the left side, there are three desktop icons for 'Physics Labs' with different versions: 'Classic Workbench...', 'Maple 17 World', and 'Maple 17'. A vertical scroll bar is visible on the right edge of the screen.



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Maple example:
Evaluation of algebraic and integral expressions

```
> assume(k > 0); assume(b > 0);
> solve(1 - b2·u2 - k·u = 0, u);
      -k + √(4 b2 + k2)   - 1   k + √(4 b2 + k2)
      2   b2           2   b2
> int(1/sqrt(1 - b2·u2 - k·u), u = 0 .. 1/b · (( -k/(2 b) + sqrt((k/(2 b))2 + 1)));
      -2 arcsin(k/(√(k2 + 4 b2))) + π
      1
      2   b

```

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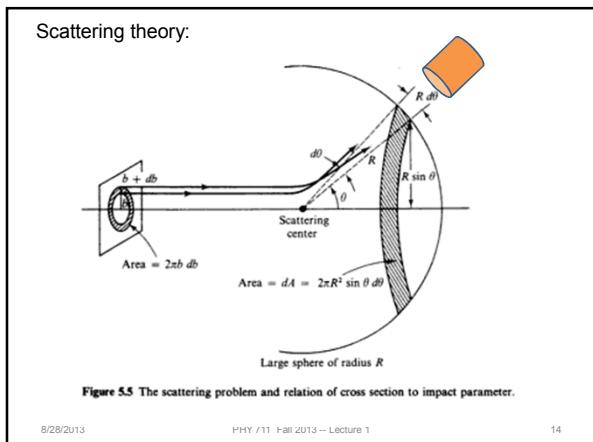
http://www.wfu.edu/~natalie/f13phy711/lecturenote/maple_example.mw

```

> f := x -> exp(-x^2);
f := x -> e^-x^2
> g := x -> int(f(u), u = 0 .. x);
g := x -> \int_0^x f(u) du
> g(x);
1/2 \sqrt{\pi} erf(x)
> evalf(g(2.0));
0.8820813908
> plot([f(x), g(x)], x = 0 .. 10);

```

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Differential cross section

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

= Area of incident beam that is scattered into detector at angle θ

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

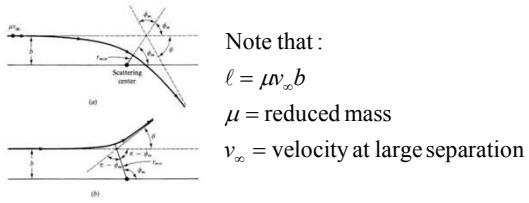
Figure from Marion & Thornton, Classical Dynamics

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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

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Conservation of energy in the center of mass frame:

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

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

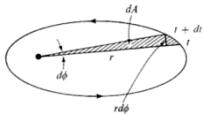
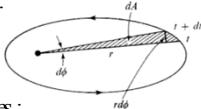


Figure 3.2 The areal velocity in a central field.

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Conservation of angular momentum:

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



Transformation of trajectory variables:

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

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

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

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

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

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

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

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

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

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

Further simplification at large separation:

$$\ell = \mu v_\infty b$$

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

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

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When the dust clears :

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

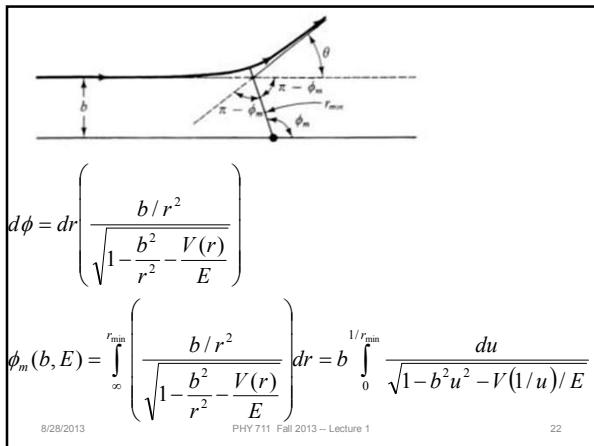
$$d\phi = dr \sqrt{\frac{b/r^2}{\sqrt{1 - \frac{b^2}{r^2} - \frac{V(r)}{E}}}}$$

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

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Evaluation of scattering expression:

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



$$\theta + 2(\pi - \phi_m) = \pi$$

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$\phi = dr \left(\frac{b/r^2}{\sqrt{1 - b^2/r^2 - V(r)/E}} \right)$
 $\sigma(b, E) = \int_{\infty}^{r_{\min}} \left(\frac{b/r^2}{\sqrt{1 - b^2/r^2 - V(r)/E}} \right) dr = b \int_0^{1/r_{\min}} \frac{du}{\sqrt{1 - b^2 u^2 - V(1/u)/E}}$

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Evaluation of scattering expression:

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

$\theta + 2(\pi - \phi_m) = \pi$