

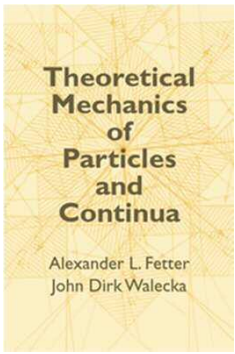
**PHY 711 Classical Mechanics and
Mathematical Methods
10-10:50 AM MWF Olin 103**

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 de Laplace (1749-1827)
 Adrien-Marie Legendre (1752-1833)
 Jean-Baptiste Joseph Fourier (1768-1830)
 Karl Friedrich Gauss (1777-1855)
 Siméon-Denis Poisson (1781-1842)
 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)

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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	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	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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Introduction to algebraic manipulation software

Maple 17

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.

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Systems Knowledge Base

[Communication & Collaboration](#) | [Network](#) | [Password/Access Management](#) | [Desktop/Laptop](#) | [Sakai](#) | [File & Printer Hosting](#) | [Banner](#)
[Multimedia & Cable TV](#) | [with](#) | [Departmental Applications](#) | [Reporting](#) | [Handheld Devices/Non-Standard Equipment](#)

Public >

Get The Help You Need: **Installing and Connecting to Virtual Computing Labs**

ResolveIT
Log in & Submit a Request

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Access
Learning Resources
Visit Us At The Bridge
Call 336-758-4357 (HELP)

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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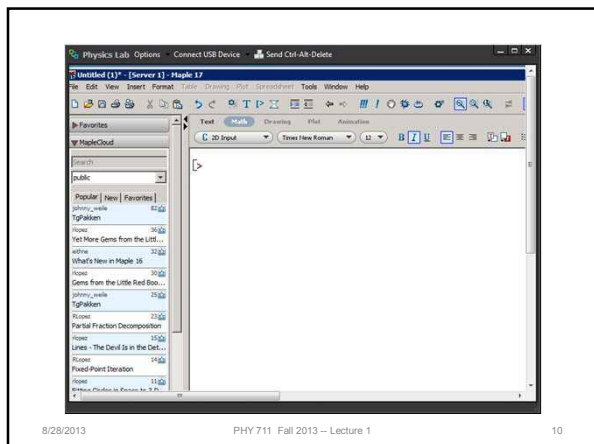
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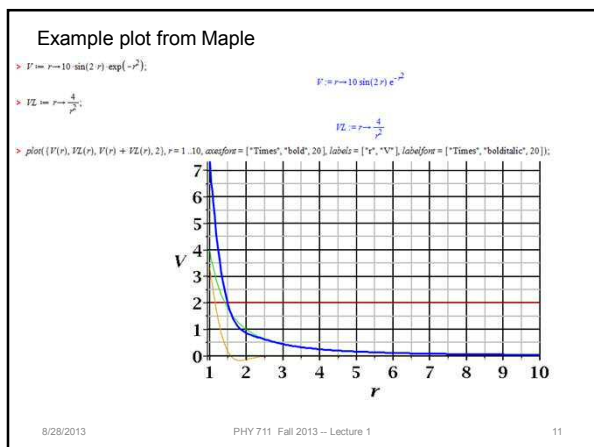
Physics Lab - Options - Connect USB Device - Send Ctrl-Alt-Del

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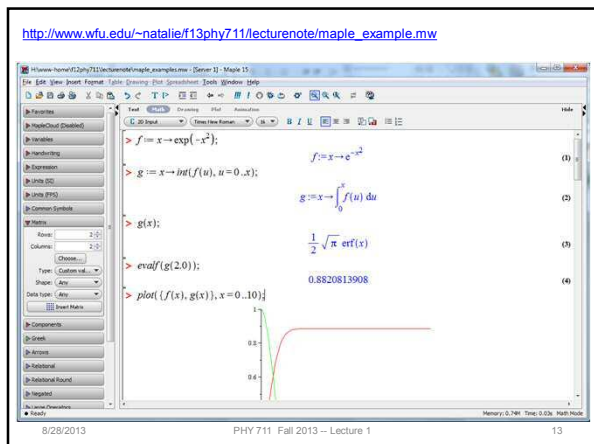
Maple example:
Evaluation of algebraic and integral expressions

```

> assume(k > 0); assume(b > 0);
> solve(1 - b^2*u^2 - k*u = 0, u);
      1 -k- + sqrt(4 b^2 + k^2)      -1 k- + sqrt(4 b^2 + k^2)
      2 b^2                      2 b^2
> int(1/sqrt(1 - b^2*u^2 - k*u), u = 0..1/b * (-k/(2*b) + sqrt((k/(2*b))^2 + 1)));
      -2 arcsin(k/sqrt(k^2 + 4 b^2)) + pi
      2 b
    
```

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



Scattering theory:

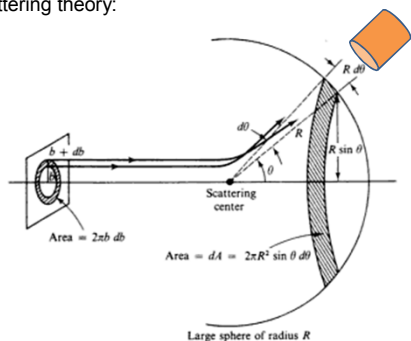


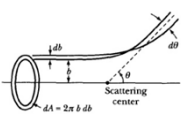
Figure 5.5 The scattering problem and relation of cross section to impact parameter.

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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 & Thorton, 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 :

- $\ell = \mu v_\infty b$
- $\mu =$ reduced mass
- $v_\infty =$ velocity at large separation

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

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

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

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

Further simplification at large separation:

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

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

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

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When the dust clears :

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

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

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

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

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

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Evaluation of scattering expression:

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

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

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