

Computación I: intro to Matlab

Francesca Maria Marchetti



UAM, 14 September 2015

Subgroup 5165

- ❖ Units 1, 2, 3, 5 (control 1)

Francesca Maria Marchetti

Departamento de Física Teórica de la Materia Condensada

Facultad de Ciencias - modulo 05

6th floor office 606

tel.: 91 497 5590

e-mail: francesca.marchetti@uam.es

web: <http://www.uam.es/francesca.marchetti>

14-Sept
till
16 Dec

- ❖ Units 4 (controls 2&3) & project

Fabrice Laussy

Departamento de Física Teórica de la Materia Condensada

Facultad de Ciencias - modulo 05

5th floor office

tel.: 91 497 2665

e-mail: fabrice.laussyl@gmail.com

web: <http://laussy.org/wiki/Fabrice>

25 Jan
till
15 Apr

Web page

<http://www.uam.es/francesca.marchetti/lectures.html>

1. Contacts
2. Course contents
3. Bibliography & useful links
4. Evaluation
5. Timetable & calendar
6. Complementary material:
 - ✓ notes & handouts
 - ✓ exercises
 - ✓ solutions

Web page

<http://www.uam.es/francesca.marchetti/lectures.html>

Teaching: Lectures & Tutorials

[Francesca Maria Marchetti](#)



Courses at UAM

2015 --- 2016	Computacion I Metodos experimentales y computacionales en Biofisica
2014 --- 2015	Computacion I Metodos experimentales y computacionales en Biofisica
2013 --- 2014	Computacion I Tecnicas Experimentales I (Laboratory)
2012 --- 2013	Advanced Statistical Mechanics: An introduction to superfluidity and superconductivity
2011 --- 2012	Computacion I Advanced Statistical Mechanics: An introduction to superfluidity
2010 --- 2011	Computacion I Advanced Statistical Mechanics: An introduction to superfluidity
2009 --- 2010	Computacion I Advanced Statistical Mechanics: An introduction to superfluidity
2008 --- 2009	Tecnicas Experimentales I (Laboratory) Mecanica y Ondas II (clases de problemas)



Intro to Computación I

Web page

[http://www.uam.es/francesca.marchetti/
computacion1_15-16.html](http://www.uam.es/francesca.marchetti/computacion1_15-16.html)

Computación I

[Francesca Maria Marchetti](#)



**Profesores grupo
5165**

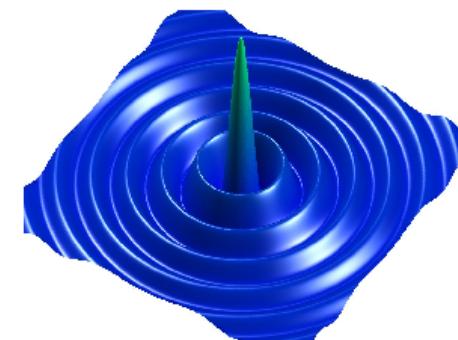
[Francesca Maria Marchetti](#)
[\(Unidades 1, 2, 3, 5, control 1\)](#)

Tel. 91 497 5590
e-mail: francesca.marchetti (at) uam.es

[Fabrice Laussy](#)
[\(Unidad 4, control 2 & 3, proyecto\)](#)

Tel. 91 497 2665
e-mail: fabrice.laussyl (at) gmail.com

[Departamento de Física Teórica de la Materia
Condensada](#)



[Programa](#)

[Bibliografía](#)

[Evaluación](#)

[Horarios y aulas](#)

[Material
complementario](#)



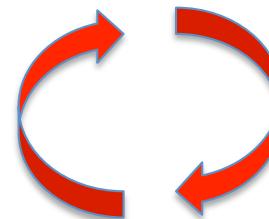
Intro to Computación I

Objectives of the course

- ✧ To understand how to write and use a program
(in a language relevant for scientific calculations)
- ✧ To process, interpret, and present numerical data graphically
- ✧ To understand how to use computers as a tool to solve physical problems
- ✧ To develop the capability to model and implement a simple physical problems
- ✧ Public presentation of scientific results

Content

- ✧ Unit 1:
Basic Numerical Concepts & First Applications
- ✧ Unit 2:
Matrices, functions & Advanced Plotting/Scripting
- ✧ Unit 3:
Linear Systems & Root Finding
- ✧ Unit 4:
Probability, Data Analysis & Statistics
- ✧ Unit 5:
Differential Equations, integration of Newton law
- ✧ Applications:
Physical Systems



Unit 1

- ❖ Introduction and basic concepts
 - ⇒ introduction to MATLAB
 - ⇒ MATLAB as a calculator (command line usage)
 - ⇒ variables, vectors, and (in-built) functions
 - ⇒ plotting
 - ⇒ scripts
 - ⇒ numerical derivatives
 - ⇒ numerical integration

Application examples:

- Tiro parabolico, movimiento harmonico simple, movimiento armonico amortiguado
- Posicion, aceleracion, trayectoria, energia

Unit 2

- ✧ Matrices & functions
 - ⇒ matrix operations and representations
 - ⇒ user-defined functions
 - ⇒ loops: for & while
 - ⇒ if-else conditions
 - ⇒ representation of scalar and vector fields

Application examples:

- translation and rotation of vectors
- discrete charge and mass distributions

Unit 3

- ✧ Solving equations
 - ⇒ linear systems
 - ⇒ root finding

Application examples:

- conservation of energy
- circuitos con resistencias y/o fuentes de voltaje que pueden variarse

Unit 5

- ✧ Differential equations
 - ⇒ 1st and 2nd ordinary differential equations
 - ⇒ Euler method & Runge-Kutta method
 - ⇒ systems of coupled equations

Application examples:

- Harmonic oscillator, friction, damping, ...
- 1D equations of motion

Unit 4

- ✧ Data analysis & statistics
 - ⇒ handling of large data sets
 - ⇒ statistical analysis of data sets
 - ⇒ data fitting
 - ⇒ probability distribution functions and random numbers

Application examples:

- your lab (Técnicas Experimentales I) data analysis!
- lanzamiento de monedas, dados
- caminos aleatorios
- calculos de areas y volumenes

Project

- ❖ Physical systems

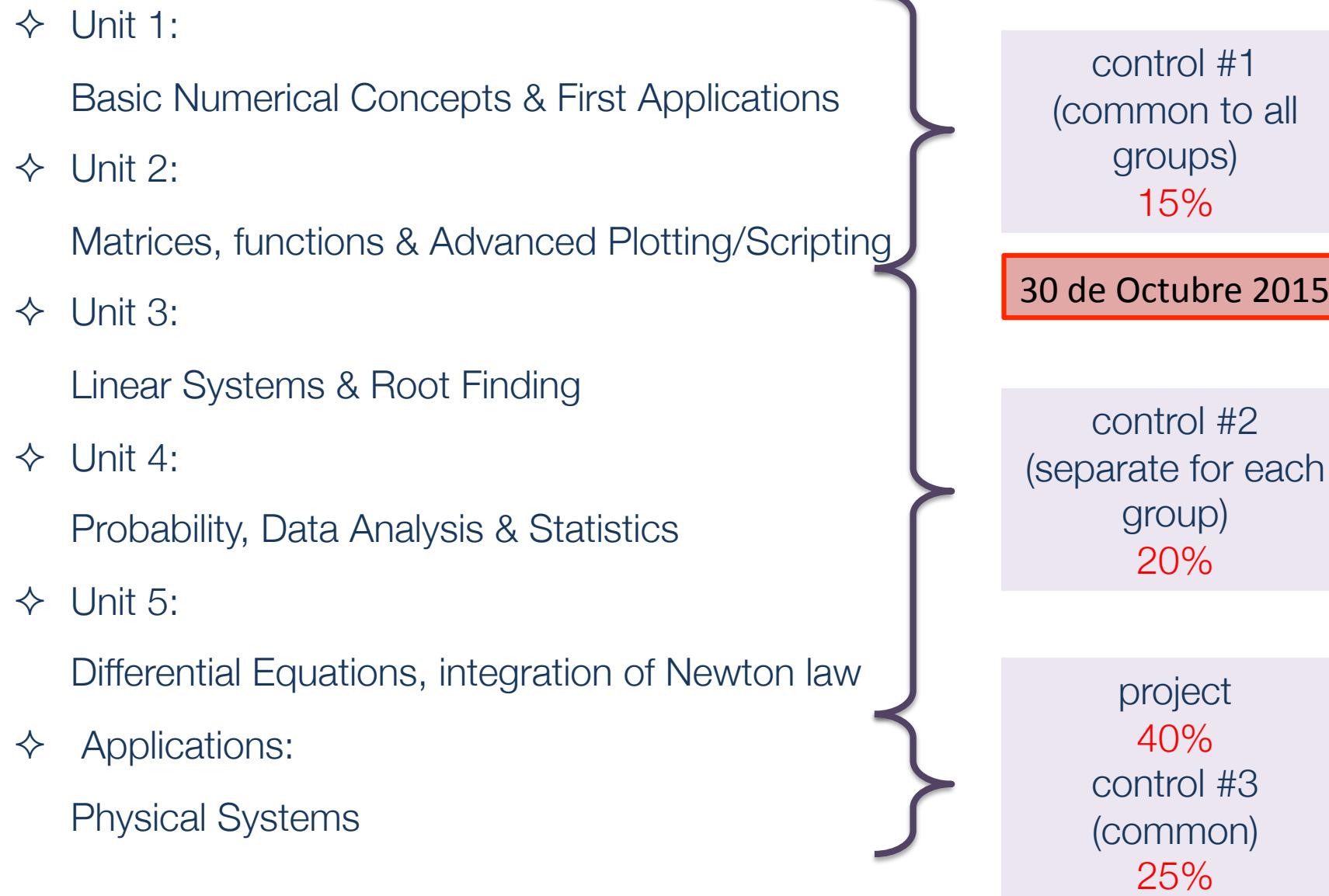
Physical applications: some examples in the class, but most importantly:

your very own project!!!

Content

- ❖ Unit 1:
Basic Numerical Concepts & First Applications
- ❖ Unit 2:
Matrices, functions & Advanced Plotting/Scripting
- ❖ Unit 3:
Linear Systems & Root Finding
- ❖ Unit 4:
Probability, Data Analysis & Statistics
- ❖ Unit 5:
Differential Equations, integration of Newton law
- ❖ Applications:
Physical Systems

Evaluation



When and where

Grupo 5165
10:30-13:30

Aula:
CIE3
modulo 15
4^a planta
aula 403
Sala 3
(20 ordenadores)

September				
Mon 14 (unit 1)		Wed 16 (unit 1)		
Mon 21 (unit 1)		Wed 23 (unit 1)		
Mon 28 (unit 2)		Wed 30 (unit 2)		
October				
Mon 19 (unit 2)		Wed 21 (unit 2)		
				Fri 30 control n. 1
November				
	Tue 10 (unit 3)	Wed 11 (unit 3)		
Mon 30 (unit 3)				
December				
		Wed 2 (unit 5)		
Mon 14 (unit 5)		Wed 16 (unit 5)		
January				
Mon 25 (unit 4)		Wed 27 (unit 4)		
February				
Mon 8 (unit 4)		Wed 10 (project)		Fri 12 control n. 2
Mon 22 (project)		Wed 24 (project)		
March				
Mon 7 (project)		Wed 9 (project)		
April				
Mon 4 presentations	Tue 5 presentations			
				Fri 15 control n. 3

Why useful?

..., i.e., why you should care....

Computation in physics

- Graphic representation of trajectories

$$x(t) = A\cos(\omega t)$$
$$y(t) = A\sin(\omega t)$$

$$y(x)$$

Computation in physics

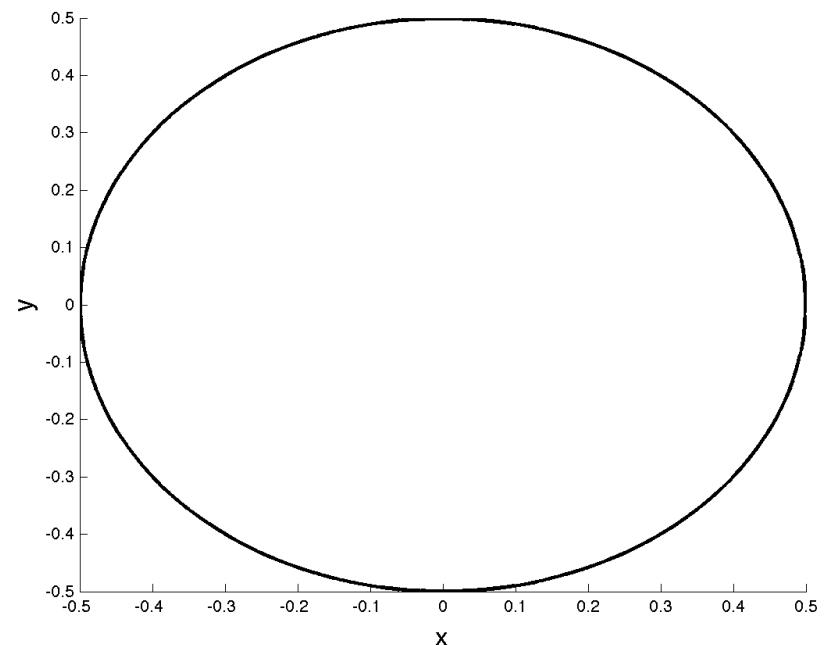
- Graphic representation of trajectories

$$x(t) = A \cos(\omega t)$$

$$y(t) = A \sin(\omega t)$$



$$y(x)$$



Computation in physics

- Graphic representation of trajectories

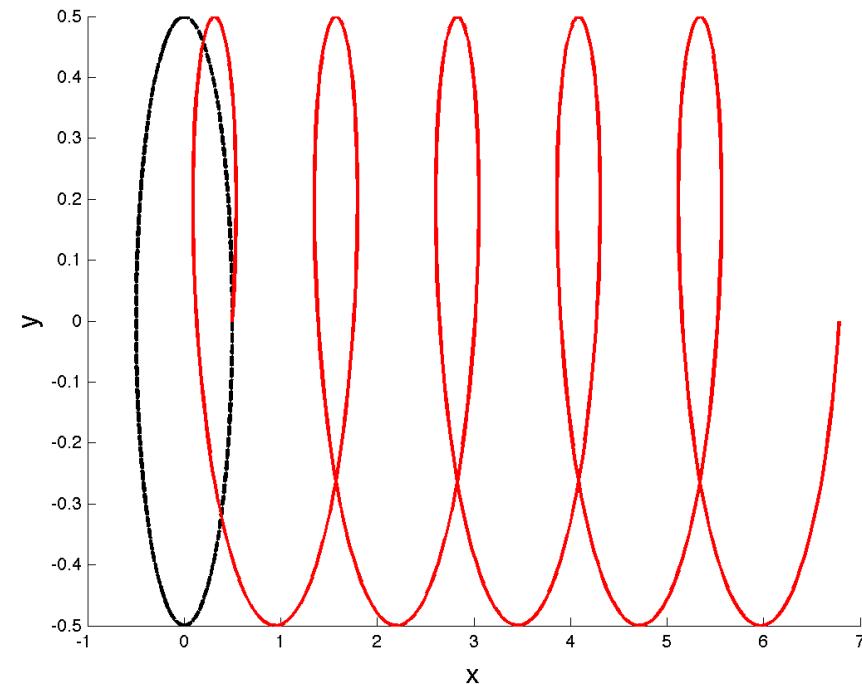
$$\begin{aligned}x(t) &= \nu t + A \cos(\omega t) \\y(t) &= A \sin(\omega t)\end{aligned}\quad \longrightarrow \quad y(x)$$

Computation in physics

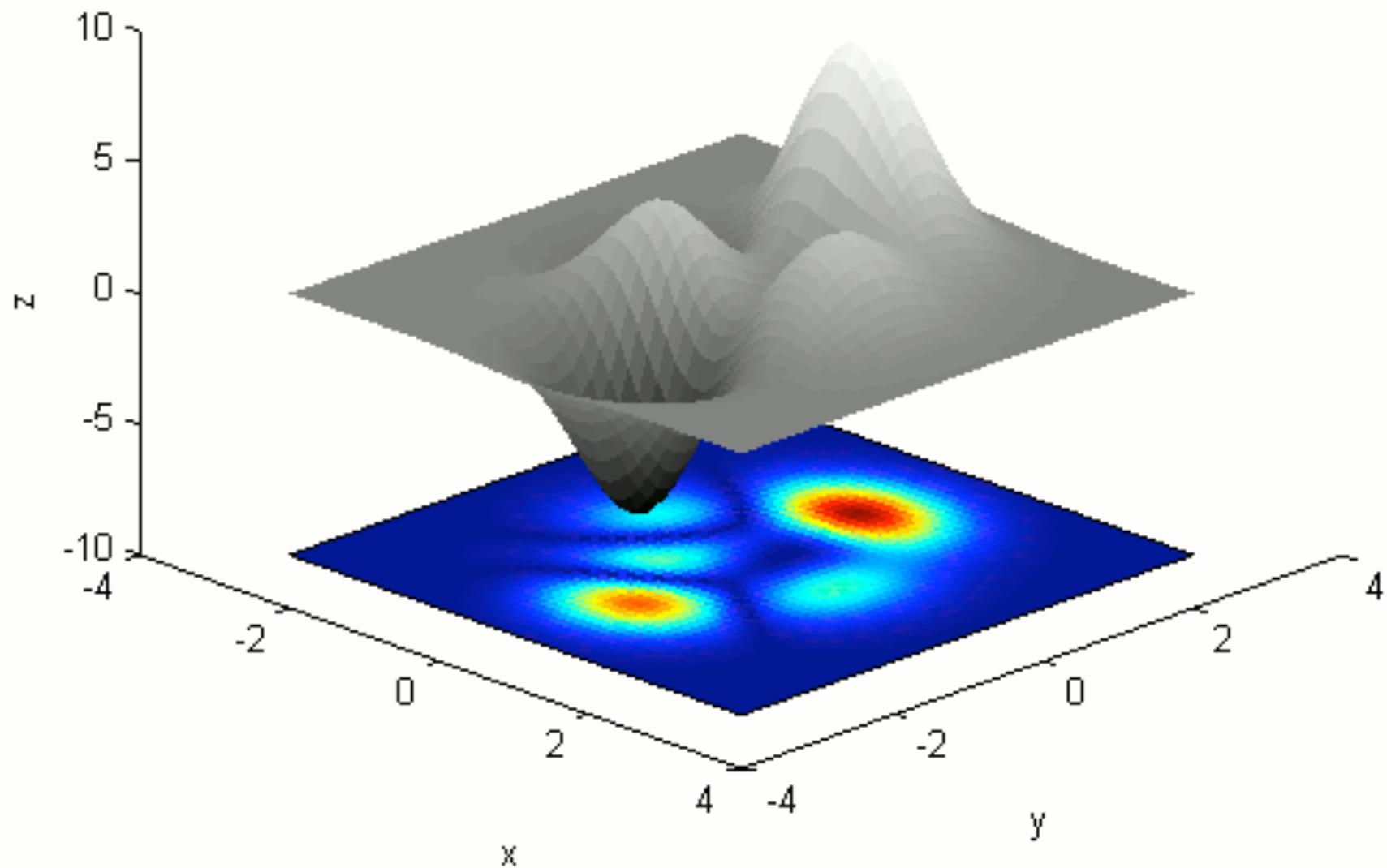
- Graphic representation of trajectories

$$x(t) = \nu t + A \cos(\omega t)$$
$$y(t) = A \sin(\omega t)$$

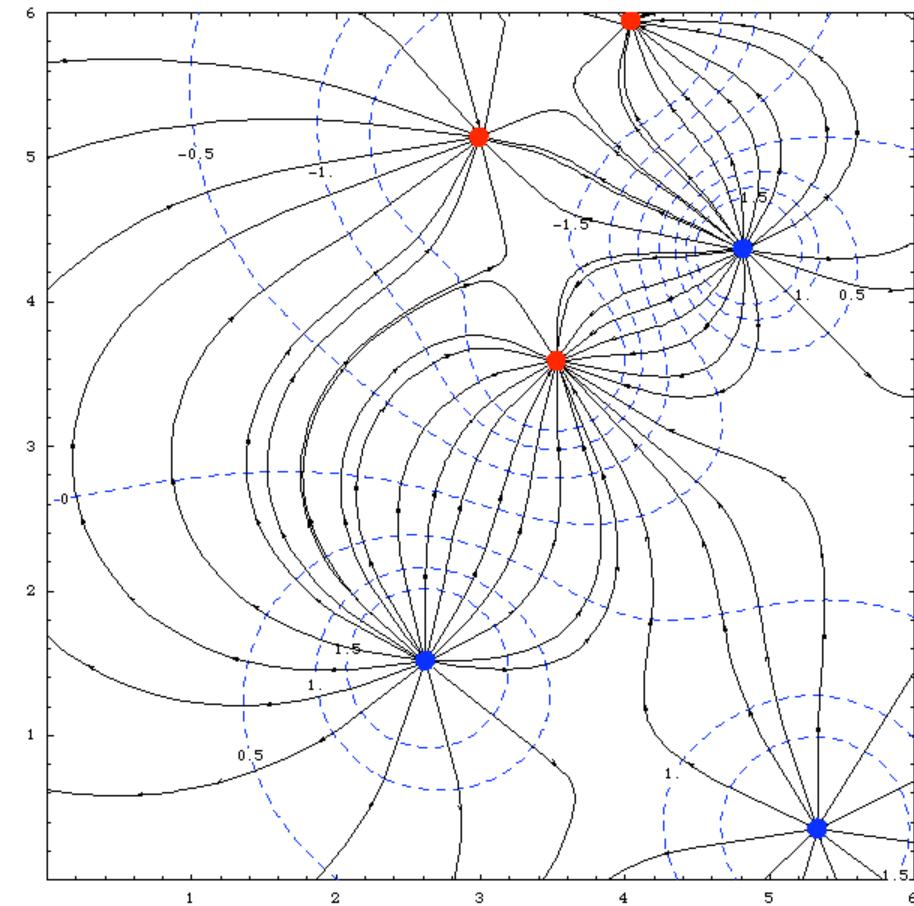
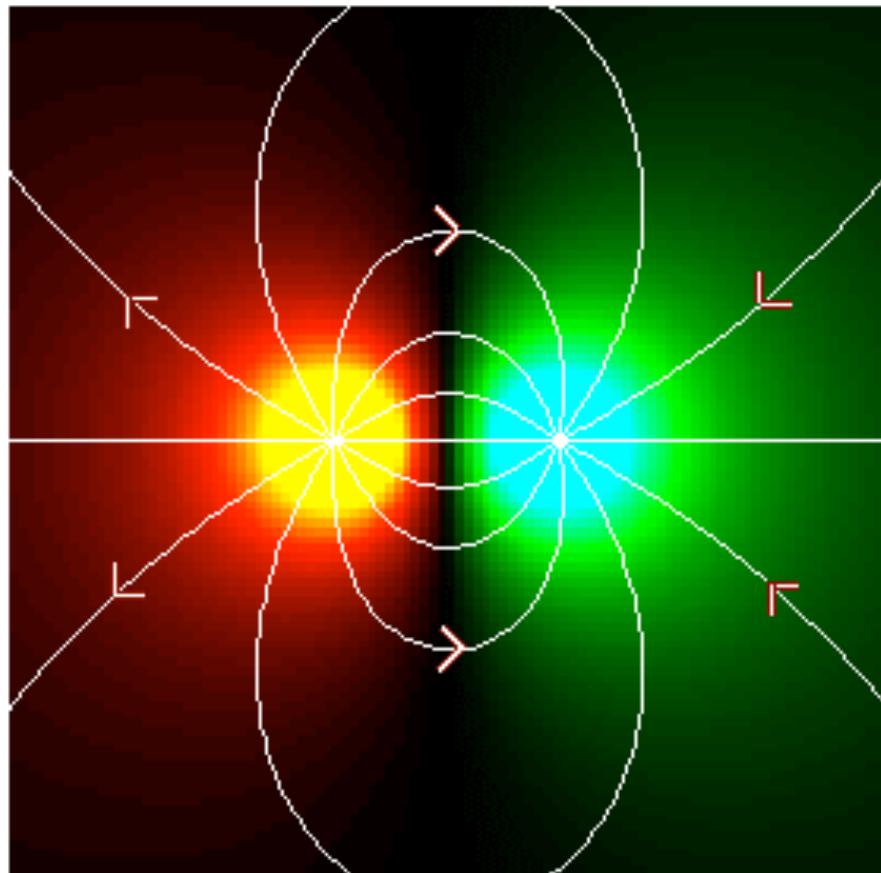
→ $y(x)$



2D and 3D plotting



2D and 3D plotting

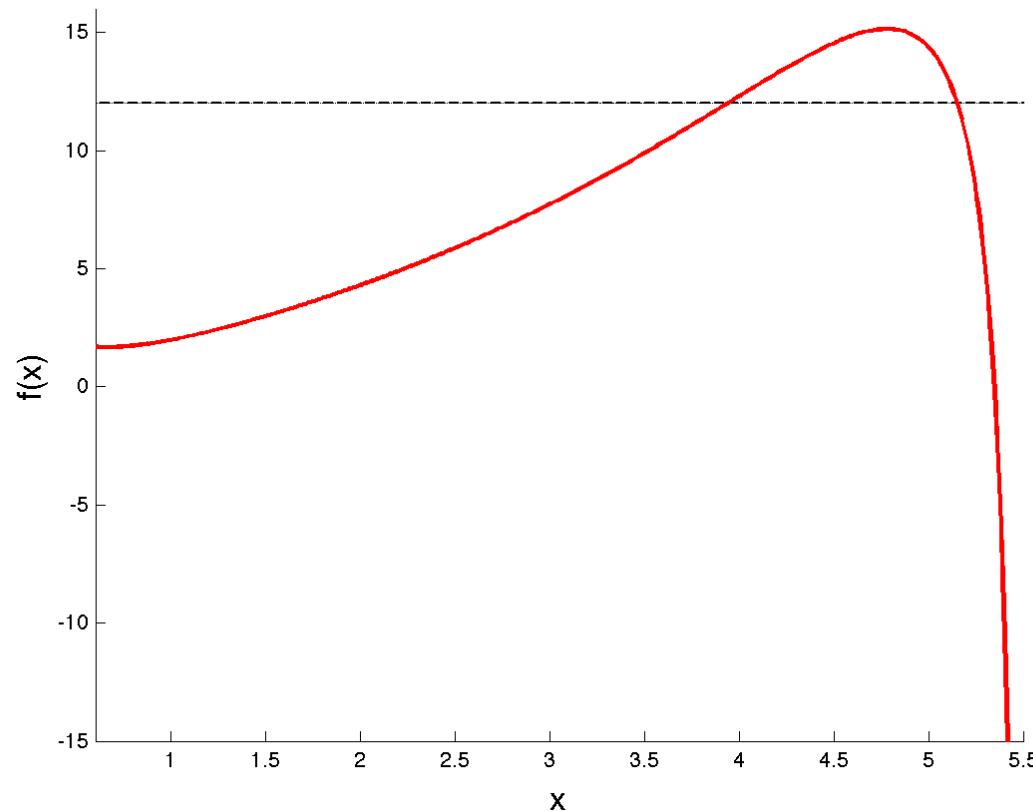


Computation in physics

- Analysis of complex functions

$$f(x) = \sin(x) + x^2 - \tan(3 + \log(x))$$

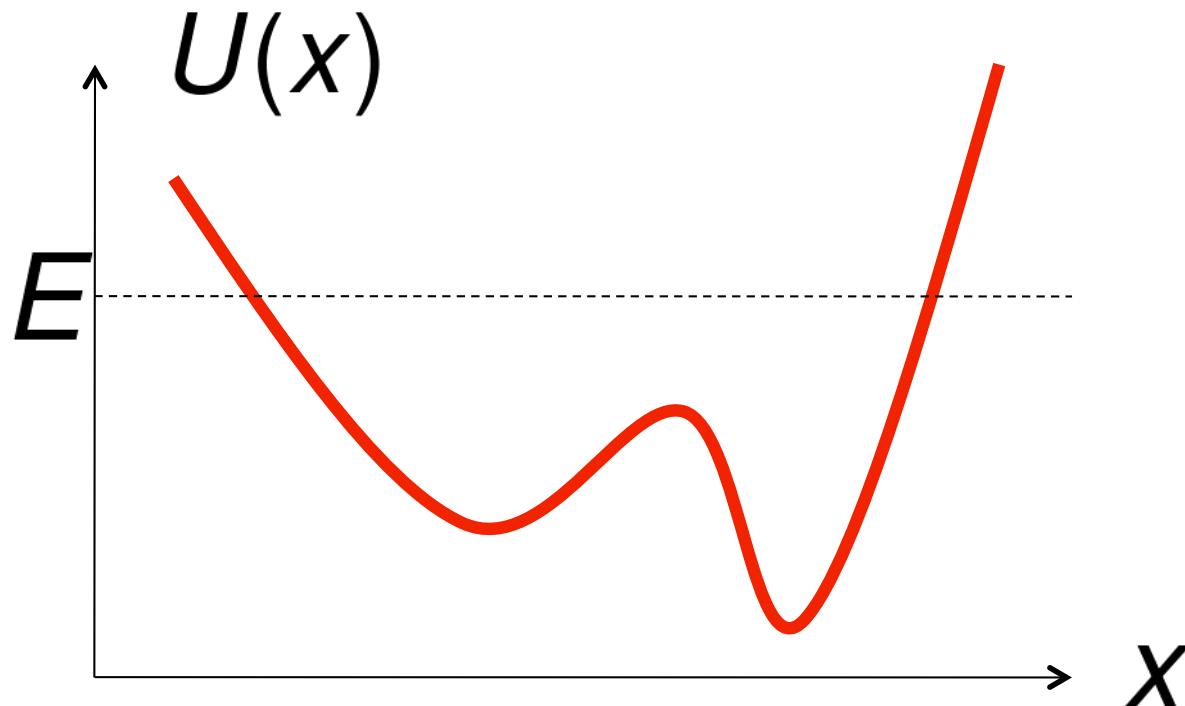
- Zeros
- Max & min
- ...



Computation in physics

- Analysis of complex functions: energy conservation

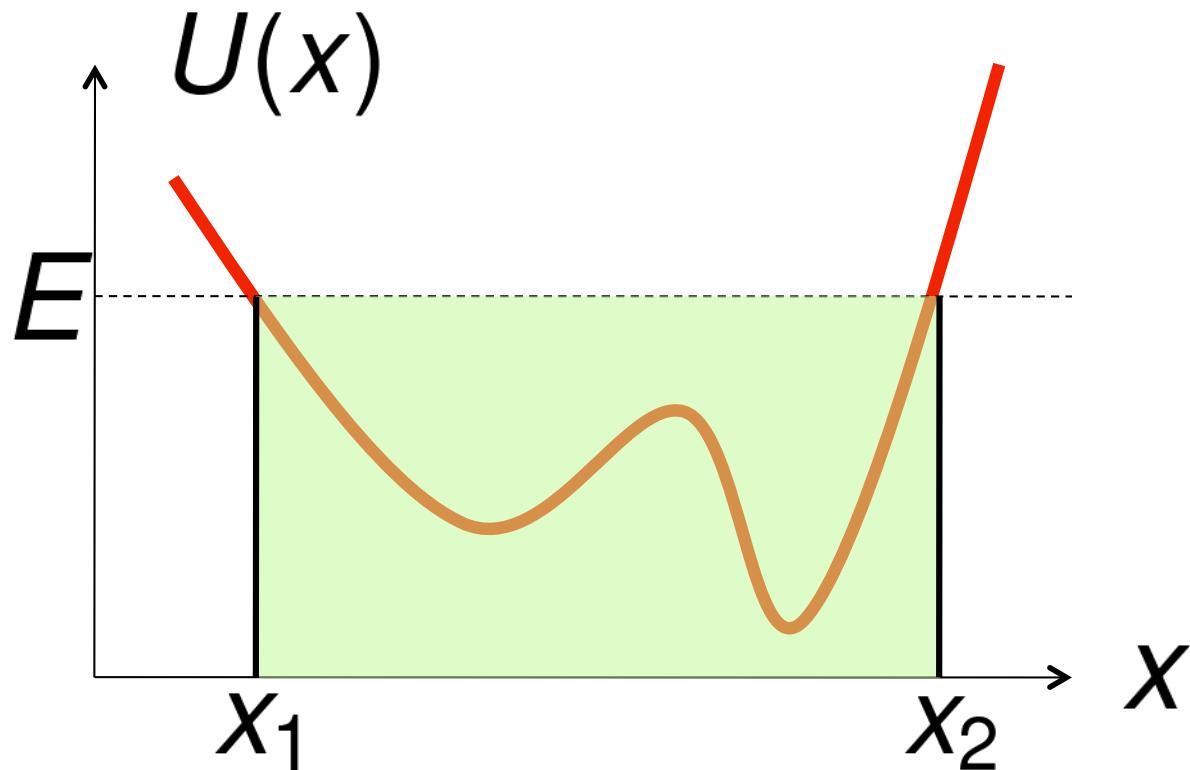
$$E = \frac{1}{2}m \left(\frac{dx}{dt} \right)^2 + U(x)$$



Computation in physics

- Analysis of complex functions: energy conservation

$$E = \frac{1}{2}m \left(\frac{dx}{dt} \right)^2 + U(x)$$



Computation in physics

Numerical solutions of differential equations

- ❖ Mechanics (Newton)

$$\mathbf{F} = m \frac{d\mathbf{v}}{dt} = m\mathbf{a}$$

- ❖ Quantum mechanics (Schrödinger)

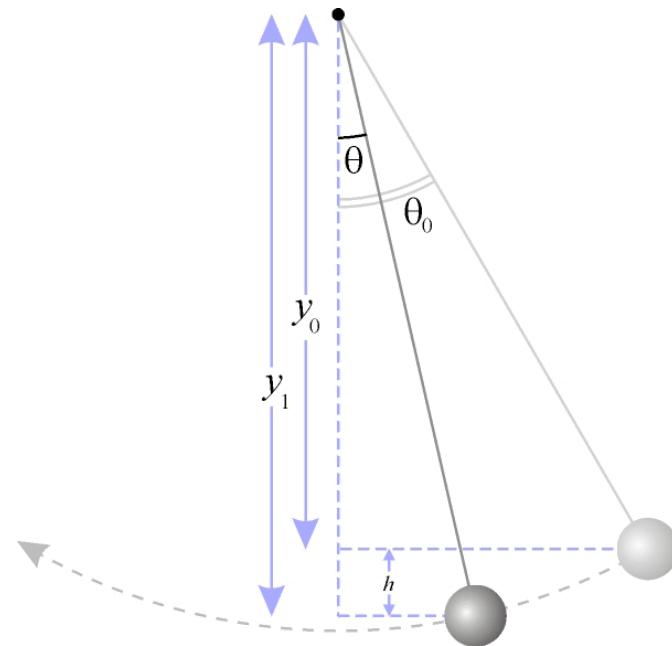
$$i\frac{\partial\psi(\mathbf{r}, t)}{\partial t} = \left[-\frac{\hbar^2\nabla}{2m} + V(\mathbf{r}) \right] \psi(\mathbf{r}, t)$$

- ❖ Fluidodynamics (Navier-Stokes)

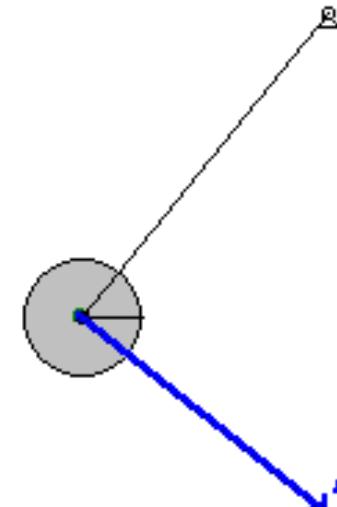
- ❖ Electrodynamics (Maxwell)

- ❖ ...

Pendulum



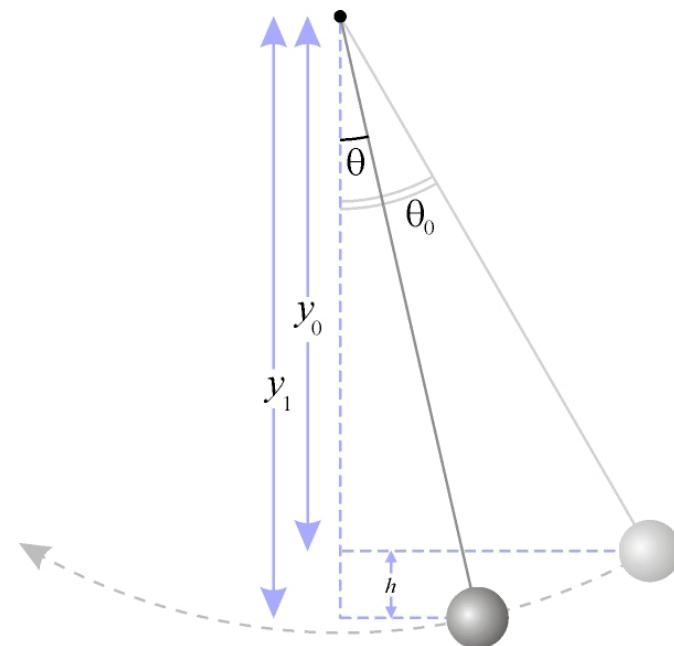
$$\frac{d^2\theta}{dt^2} + \frac{g}{\ell} \sin \theta = 0$$



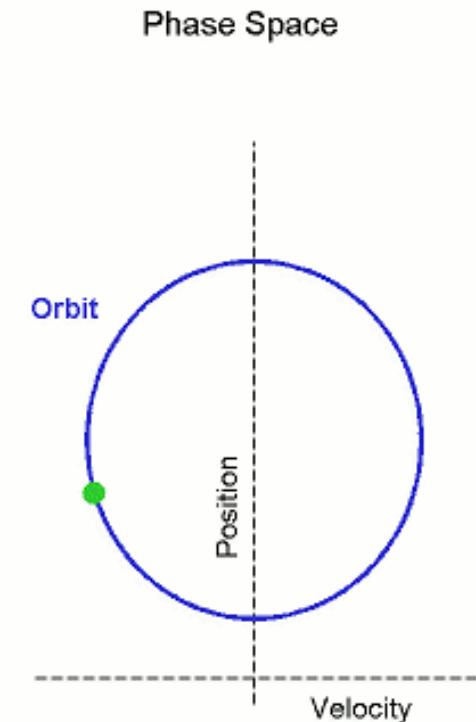
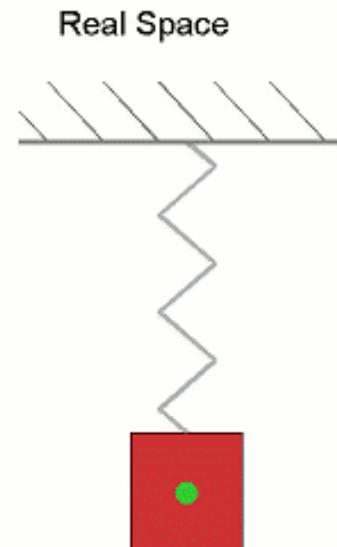
$$\begin{aligned}\theta(0) &= \theta_0 \\ \left. \frac{d\theta}{dt} \right|_0 &= \dot{\theta}_0\end{aligned}$$

- ⇒ Not soluble in terms of elementary functions, but you will be able to solve it numerically before the end of the course

Pendulum: small angle approximation

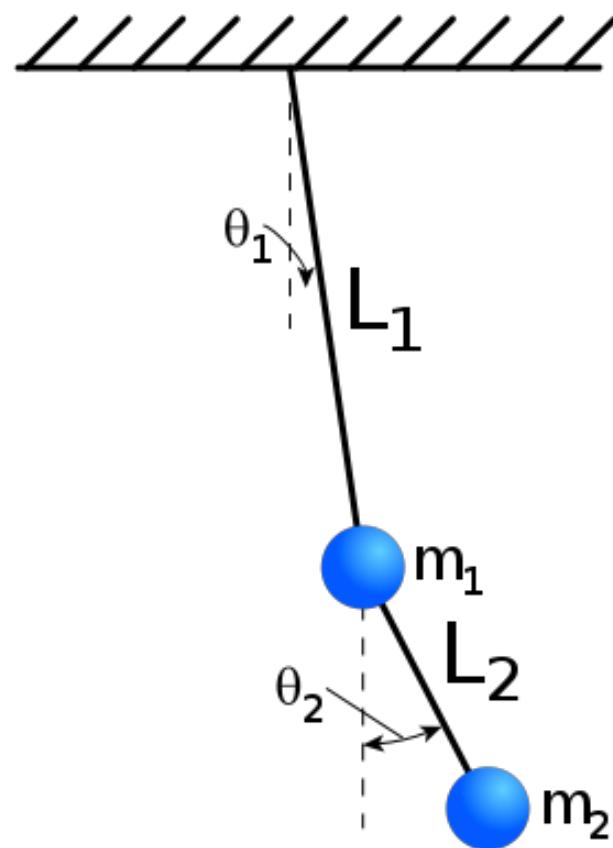


$$\frac{d^2\theta}{dt^2} + \frac{g}{\ell}\theta = 0$$

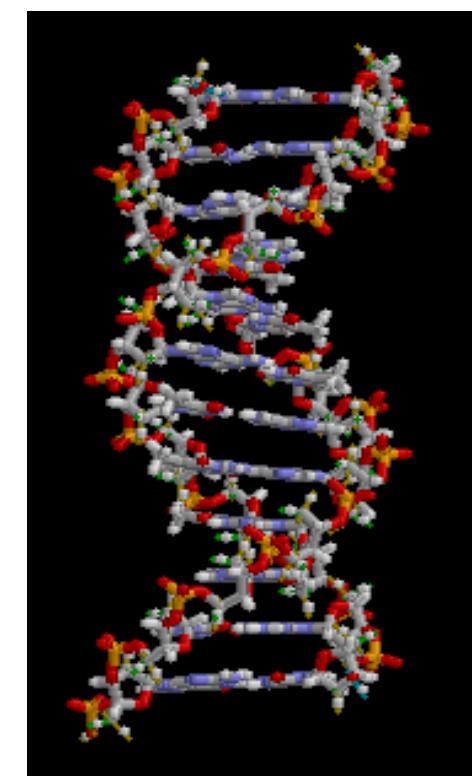
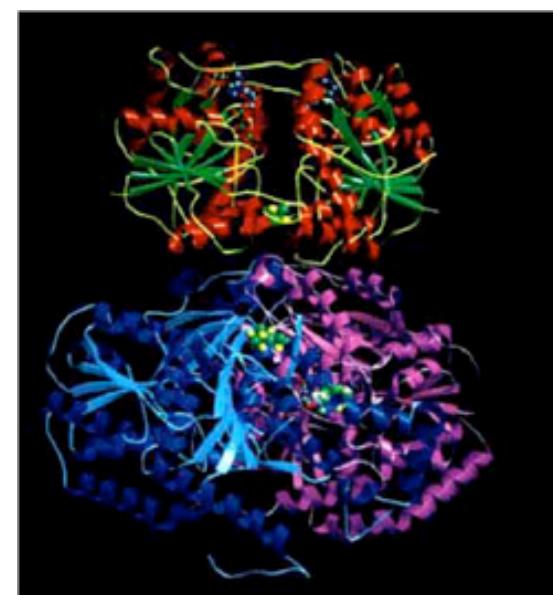
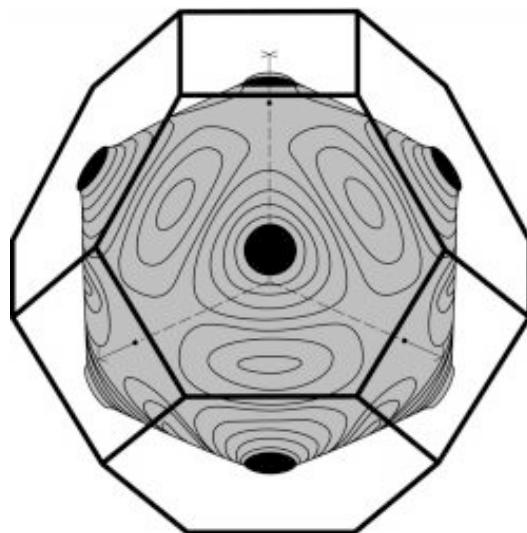
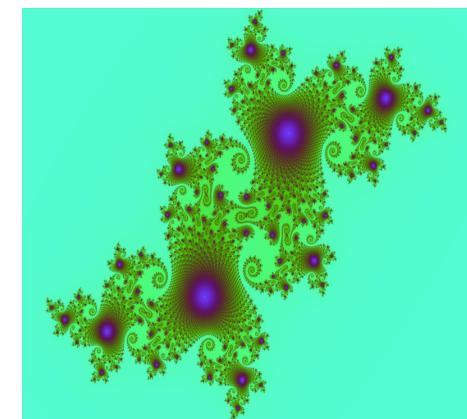
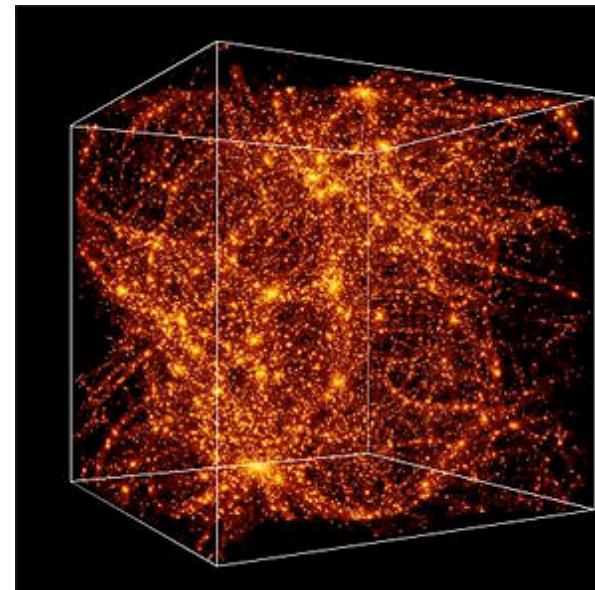
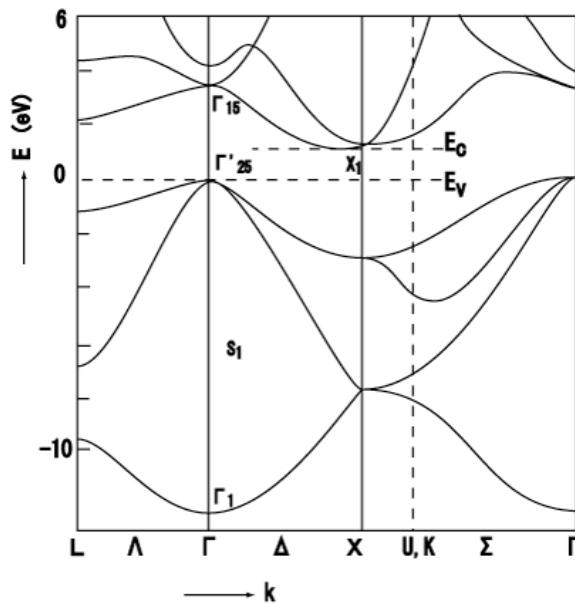


- Analytical solution (harmonic oscillator):
compare with previous results

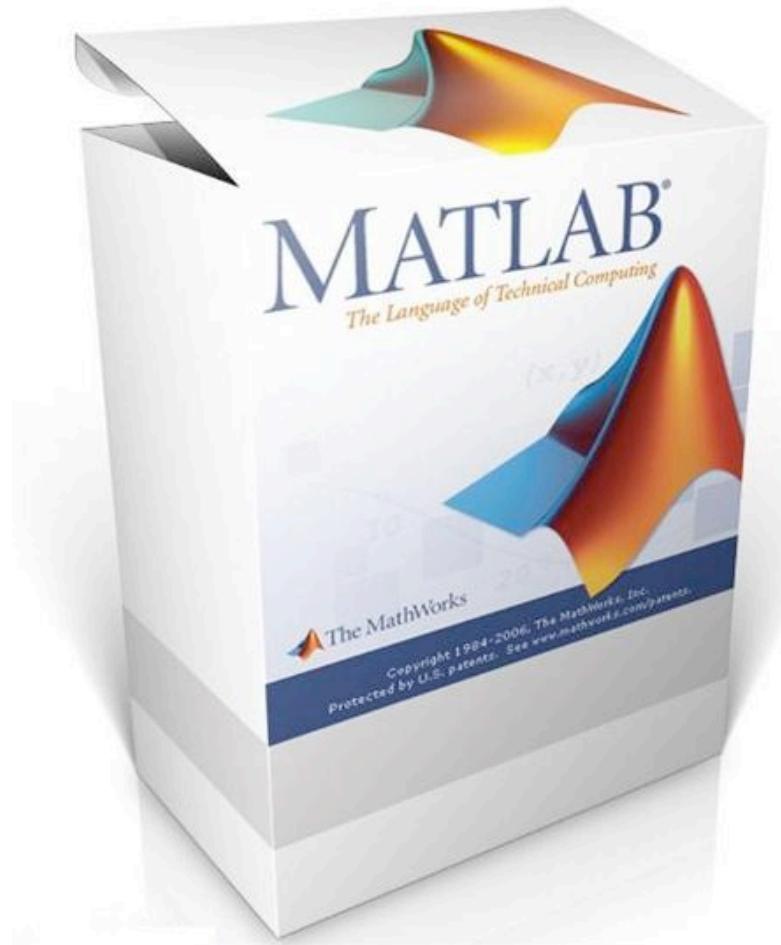
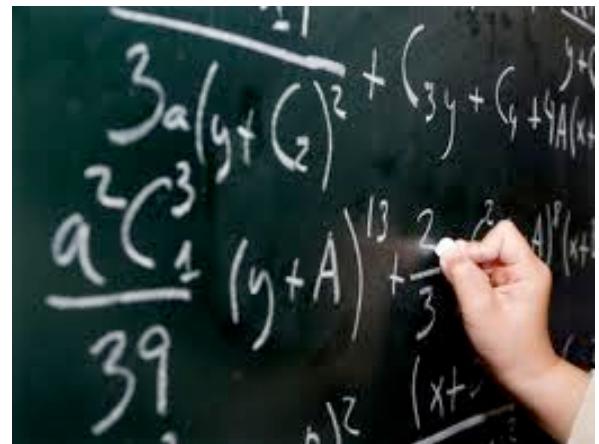
Double pendulum



Advanced numerics



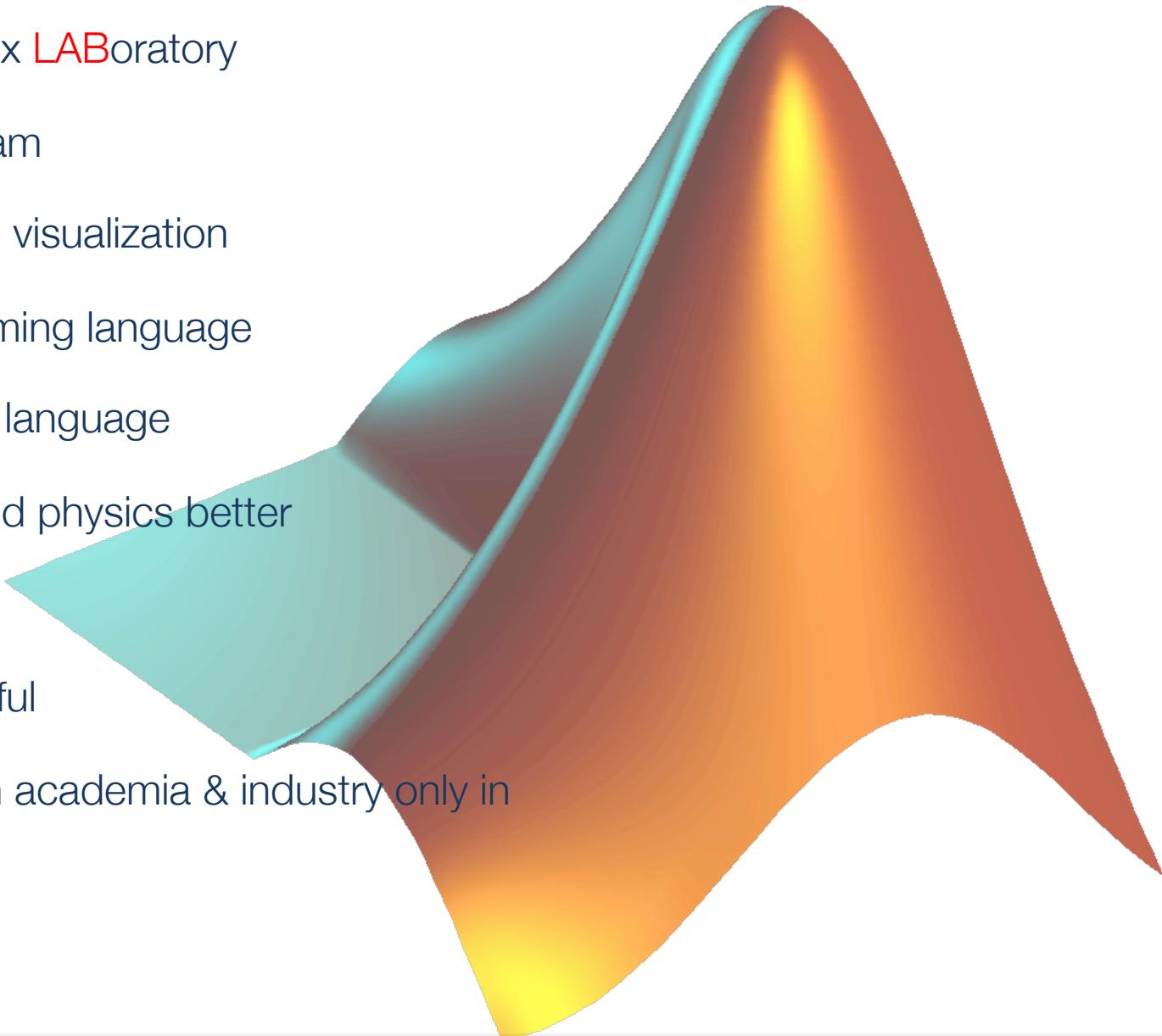
How?



Matlab

- ✧ MATLAB = MATrix LABoratory
- ✧ interactive program
- ✧ computation and visualization
- ✧ ...not a programming language
- ✧ array processing language
- ✧ tool to understand physics better
- ✧ very user friendly
- ✧ as well as powerful

(1 million users in academia & industry only in 2004)



Free alternative

✧ <http://www.scilab.org>

The screenshot shows the official website for Scilab, a free software for numerical computation. The header features the Scilab logo and the tagline "The Free Software for Numerical Computation". A navigation bar includes links for "about us", "news", "products", "support", "communities", "projects", and "education". On the left, there's a "Download Scilab" section with links for Windows (122 MB) and Other Systems. The main banner features a mathematical integral equation $\int_0^{+\infty} e^{-x^2} dx = \frac{\sqrt{\pi}}{2}$ and a cartoon puffin. Below the banner, the "News" section highlights several recent developments: "Mailing Lists" (New for French users), "New version of module lycée" (Version 1.4 of French Module Lycée offers new functions in statistics and probability), "Scilab in the news" (An article on Scilab is available in #66 of the French Magazine Linux Pratique), and "Scilab 5.3.3" (The Scilab Consortium is glad to announce the release of Scilab 5.3.3). The "Quick links" sidebar provides links to "Scilab Enterprises", "Scilab Online Support", "Partner zone", "Developer zone", "Documentation", and "Scilab for high schools". A "Focus" box at the bottom discusses Scilab's interaction with other tools.

contact | languages

Search >

Scilab

The Free Software for Numerical Computation

about us | news | products | support | communities | projects | education

Download Scilab
(Windows 122 MB)

Other Systems

$\int_0^{+\infty} e^{-x^2} dx = \frac{\sqrt{\pi}}{2}$

Scilab is recognized as having educational value

Scilab and its module for High schools have been granted with the RIP label ("Reconnu d'intérêt pédagogique" - recognized as having educational value) by the committee decision of June 15, 2011.

Awarded by the French Department of Education, this label is designed to guide teachers in selecting tools that meet the needs and requirements of the educational system.

Consult the press release >>

Scilab Enterprises >

Scilab Online Support >

Partner zone >

Developer zone >

Documentation >

Scilab for high schools >

Interact Scilab with other tools

Did you know Scilab has functionalities to interact with other tools or facilitate the migration from other software?

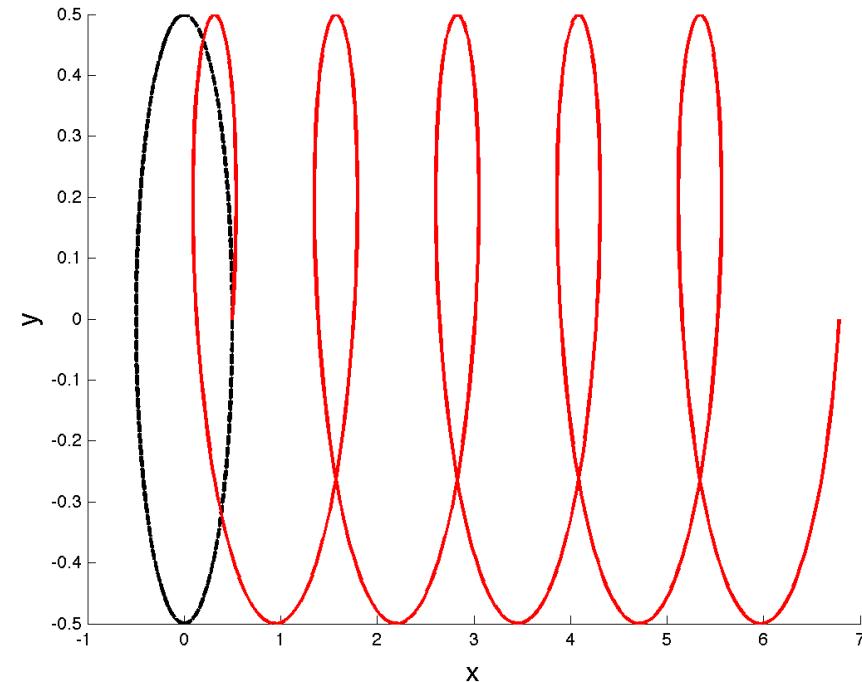
Consult the article >>

Example

- ❖ Graphic representation of trajectories

$$x(t) = \nu t + A \cos(\omega t)$$
$$y(t) = A \sin(\omega t)$$

→ $y(x)$



Example

```
%-----%
% Example: plot of trajectories %
%-----%
clear all

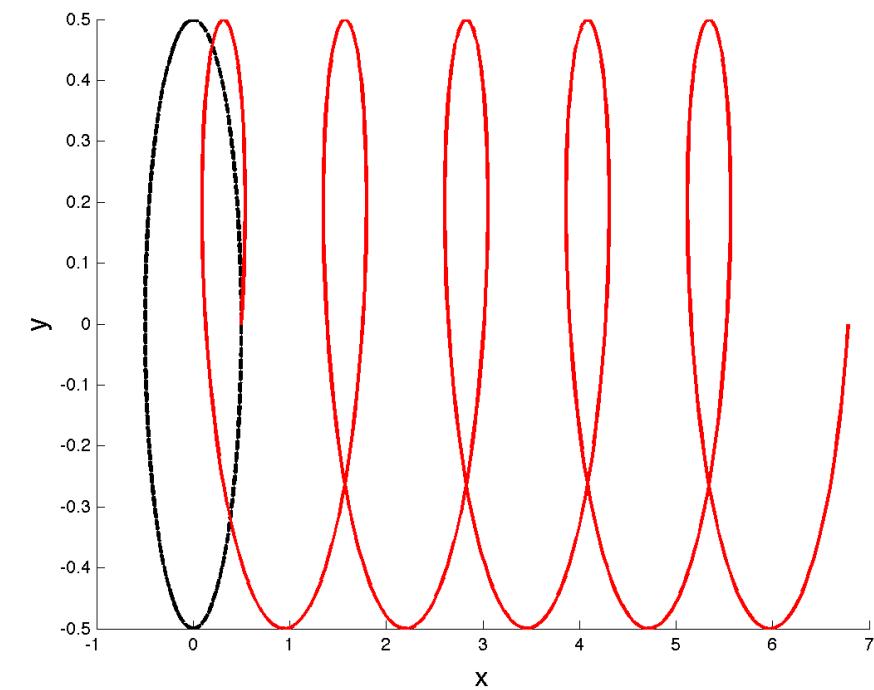
a=0; b=10*pi; M=500;
t=linspace(a,b,M);

x1=0.2*t+0.5*cos(t);
y1=0.5*sin(t);

x0=0.5*cos(t);
y0=0.5*sin(t);

hold on
plot(x0,y0,'k--','LineWidth',1)
plot(x1,y1,'r-','LineWidth',2)
xlabel('x','fontsize',16),ylabel('y','fontSize',16)
hold off

print -f -depsc 'plot2.eps'
print -f -dpng 'plot2.png'
```



Example

```
%-----%
% Example: plot of trajectories %
%-----%
clear all

a=0; b=10*pi; M=500;
t=linspace(a,b,M);

x1=0.2*t+0.5*cos(t);
y1=0.5*sin(t);

x0=0.5*cos(t);
y0=0.5*sin(t);

hold on
plot(x0,y0,'k--','LineWidth',
plot(x1,y1,'r-','LineWidth',2
xlabel('x','fontsize',16),yla
hold off

print -f -depsc 'plot2.eps'
print -f -dpng 'plot2.png'
```

1. Definition of a vector t in a given interval
2. Definition of the vectors $x(t)$ and $y(t)$
3. Plot

Bibliography

1. <http://www.mathworks>
2. http://www.mathworks.es/academia/student_center/tutorials/launchpad.html
3. <http://www.maths.dundee.ac.uk/~ftp/na-reports/MatlabNotes.pdf>
4. <http://www.lawebdelprogramador.com/cursos/enlace.phd?idp=3338&id=132&texto=Matlab>
5. <http://ocw.upm.es/ingenieria-aeroespacial/aerodinamica-numERICA/contenidos/introduccion-matlab/>
6. http://www.mathworks.es/access/helpdesk/help/pdf_doc/matlab/getstart.pdf
7. <http://mat21.etsii.upm.es/ayudainf/aprendainf/Matlab70/matlab70primero.pdf>
8. http://eupt2.unizar.es/cmedrano/manual_octave.pdf
9. ...and many more

Built-in help!!!!

<http://www.uam.es/francesca.marchetti/lectures.html>