Computación I: intro to Matlab

Francesca Maria Marchetti

UAM UNIVERSIDAD AUTONOMA DE MADRID

Subgroup 5165

- Units 1, 2, 3, 5 (control 1)

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14-Sept till 16 Dec

- Units 4 (controls 2&3) & project

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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

UNIVERSIDAD AUTONOMA DE MADRID

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)

Web page

http://www.uam.es/francesca.marchetti/computacion1_15-16.html

Computación I

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UNIVERSIDAD AUTONOMA DE MADRID

Profesores grupo 5165

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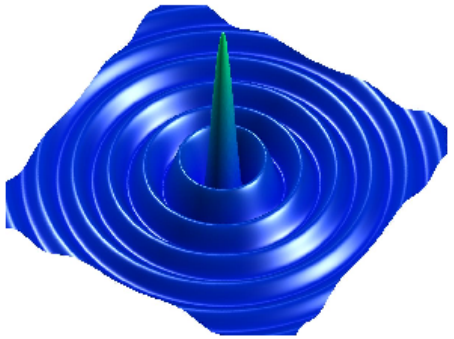
Departamento de Física Teórica de la Materia Condensada



Programa	Bibliografía	Evaluación	Horarios y aulas	Material complemen.

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:

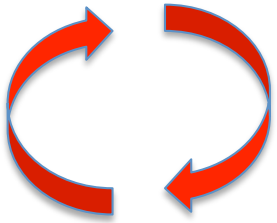
  Matrices, functions & Advanced Plotting/Scripting

- 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, moviemiento 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

- ✧ 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:

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- Unit 3:

  Linear Systems & Root Finding

- Unit 4:

  Probability, Data Analysis & Statistics

- Unit 5:

  Differential Equations, integration of Newton law

- Applications:

  Physical Systems

Evaluation

- Unit 1:

  Basic Numerical Concepts & First Applications
- Unit 2:

  Matrices, functions & Advanced Plotting/Scripting

control #1 (common to all groups) 15%

30 de Octubre 2015

- Unit 3:

  Linear Systems & Root Finding
- Unit 4:

  Probability, Data Analysis & Statistics

control #2 (separate for each group) 20%

- Unit 5:

  Differential Equations, integration of Newton law
- Applications:

  Physical Systems

project 40%
control #3 (common) 25%

When and where

Grupo 5165
10:30-13:30

Aula:
CIE3
modulo 15
4ª 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

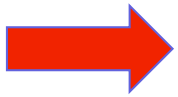
Why useful?

..,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

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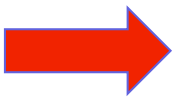
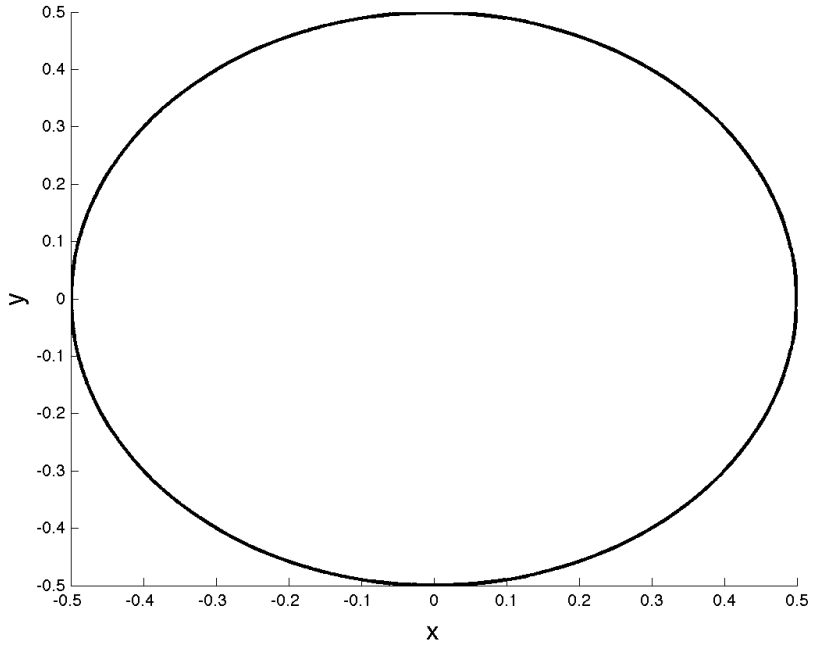


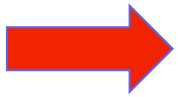
$$y(x)$$



Computation in physics

- Graphic representation of trajectories

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



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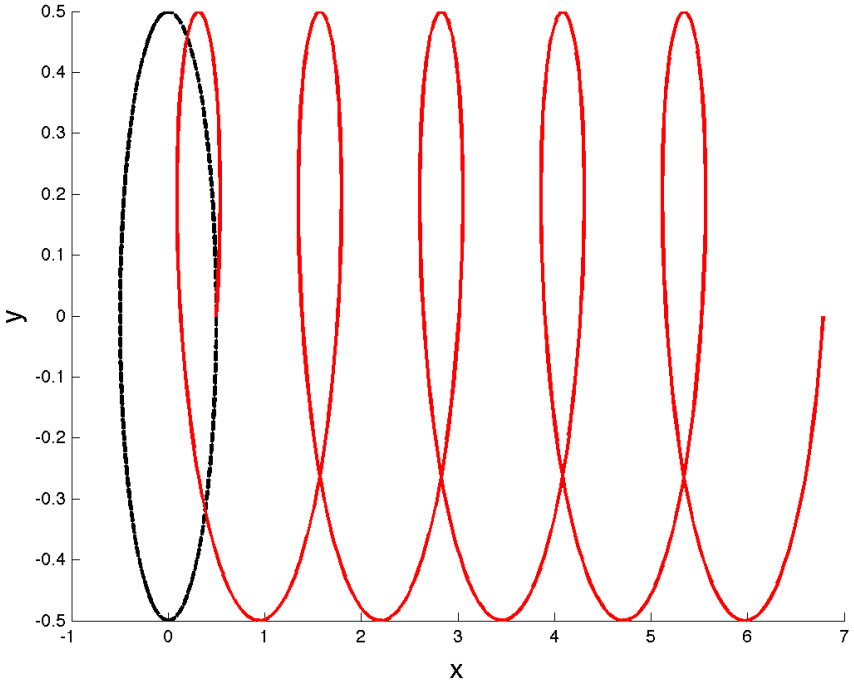
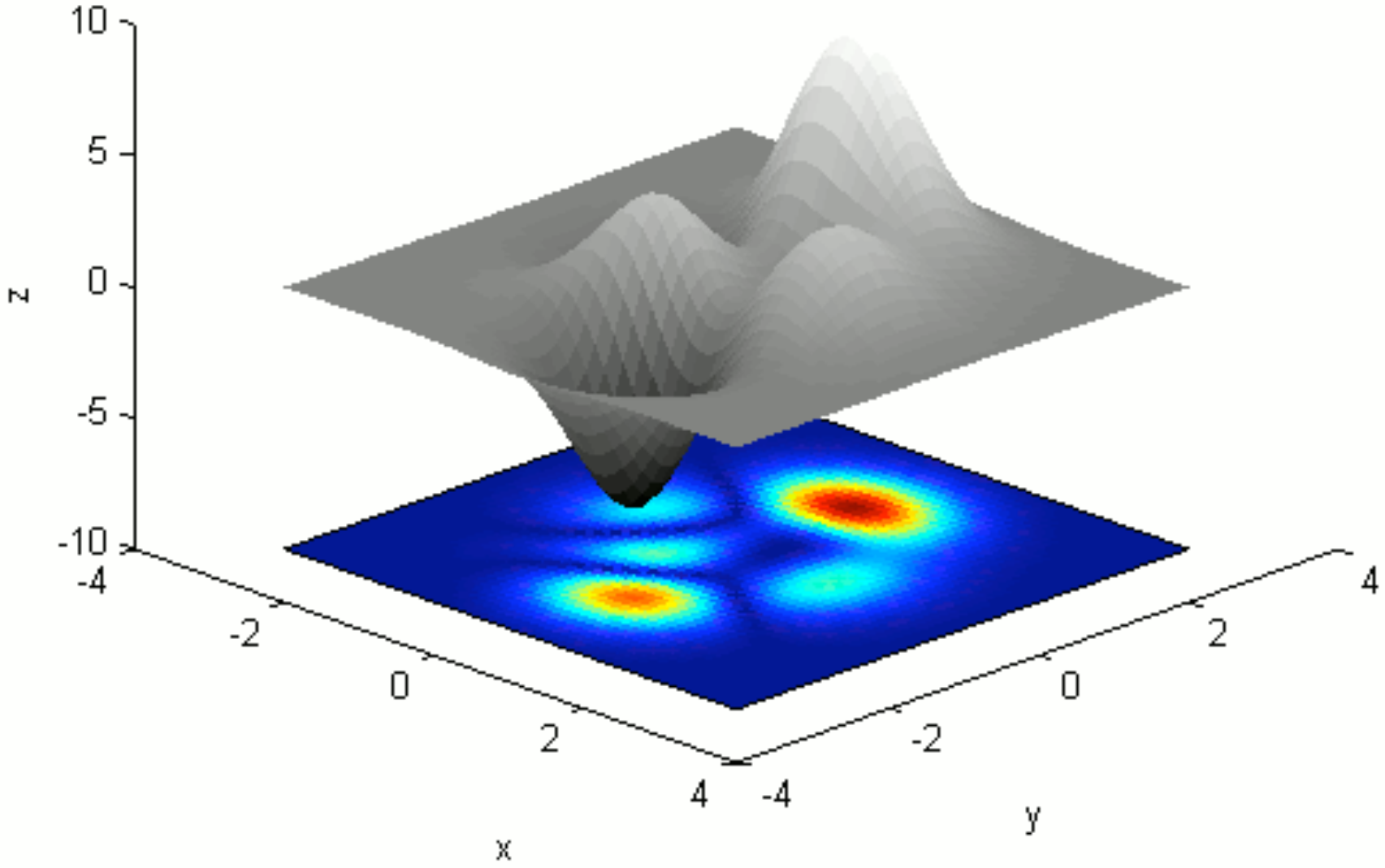


2D and 3D plotting



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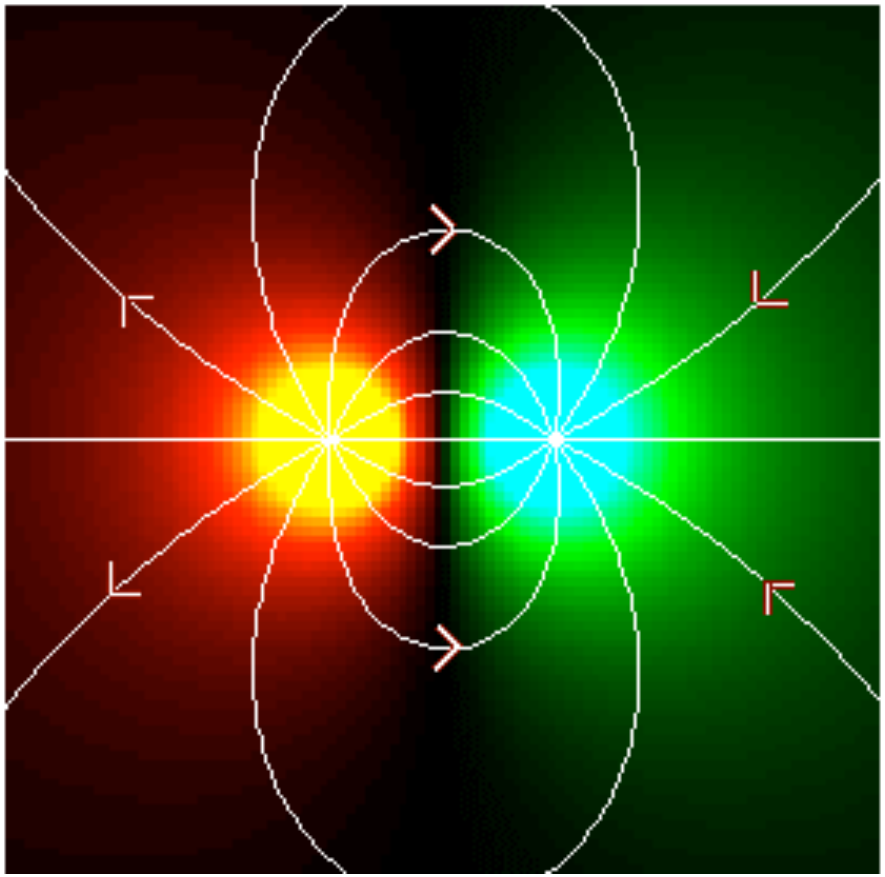
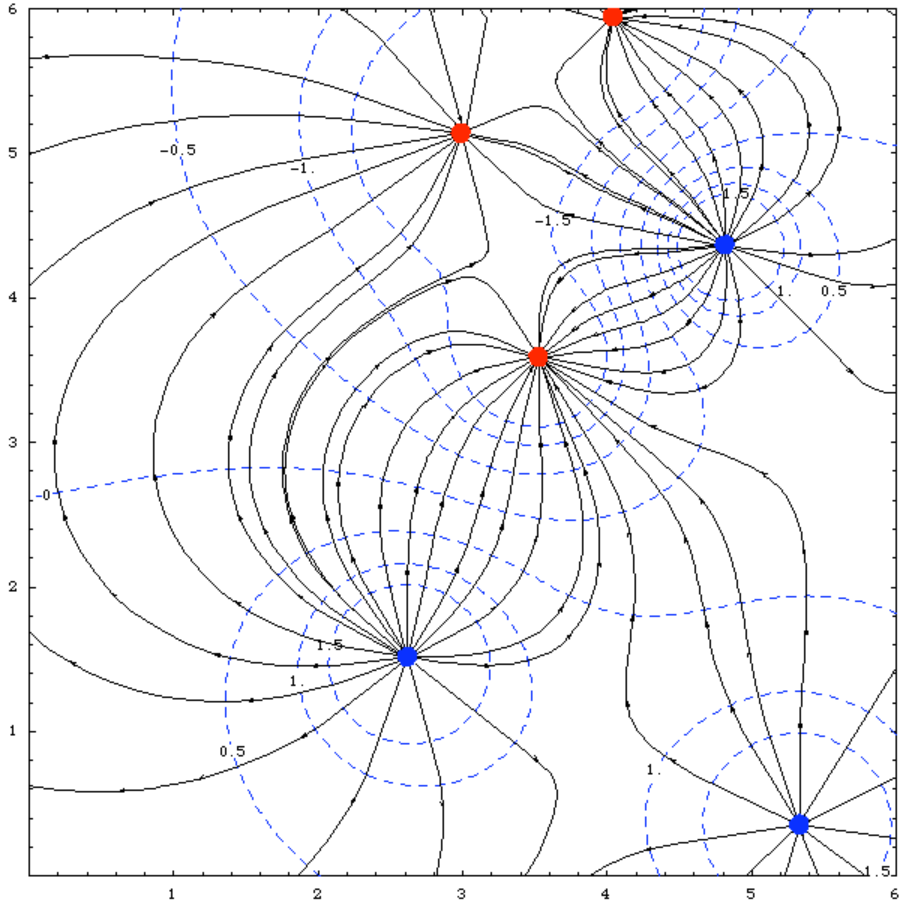


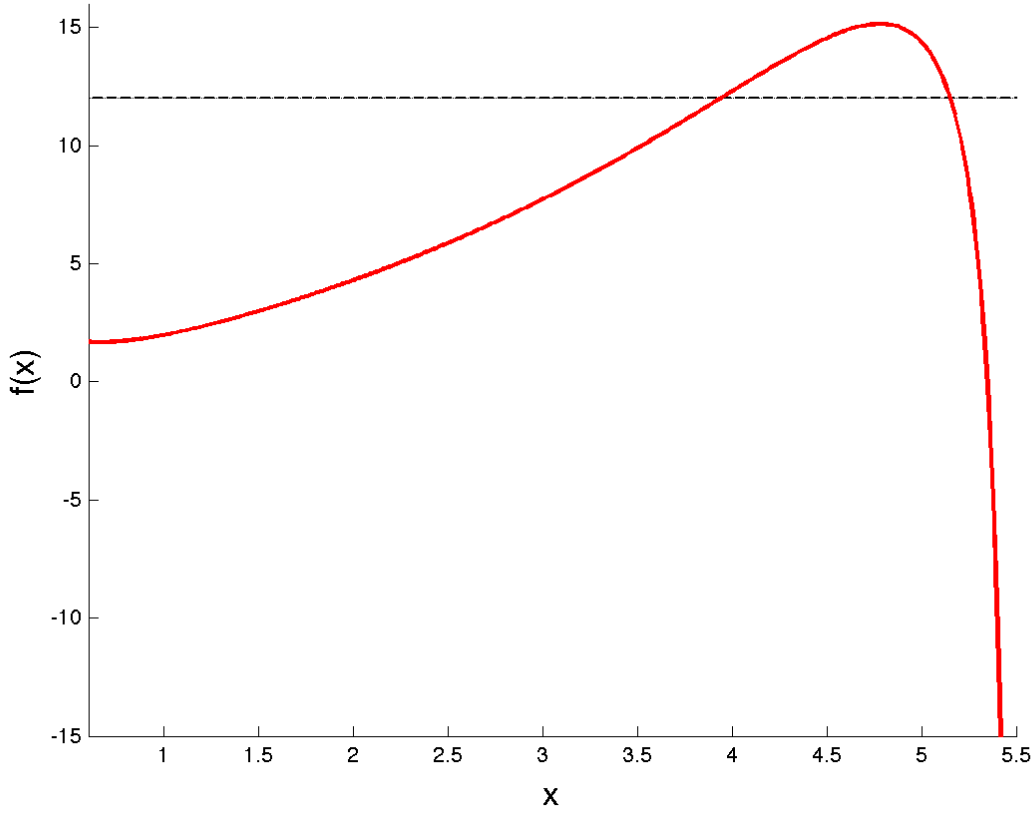


Computation in physics

- Analysis of complex functions

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

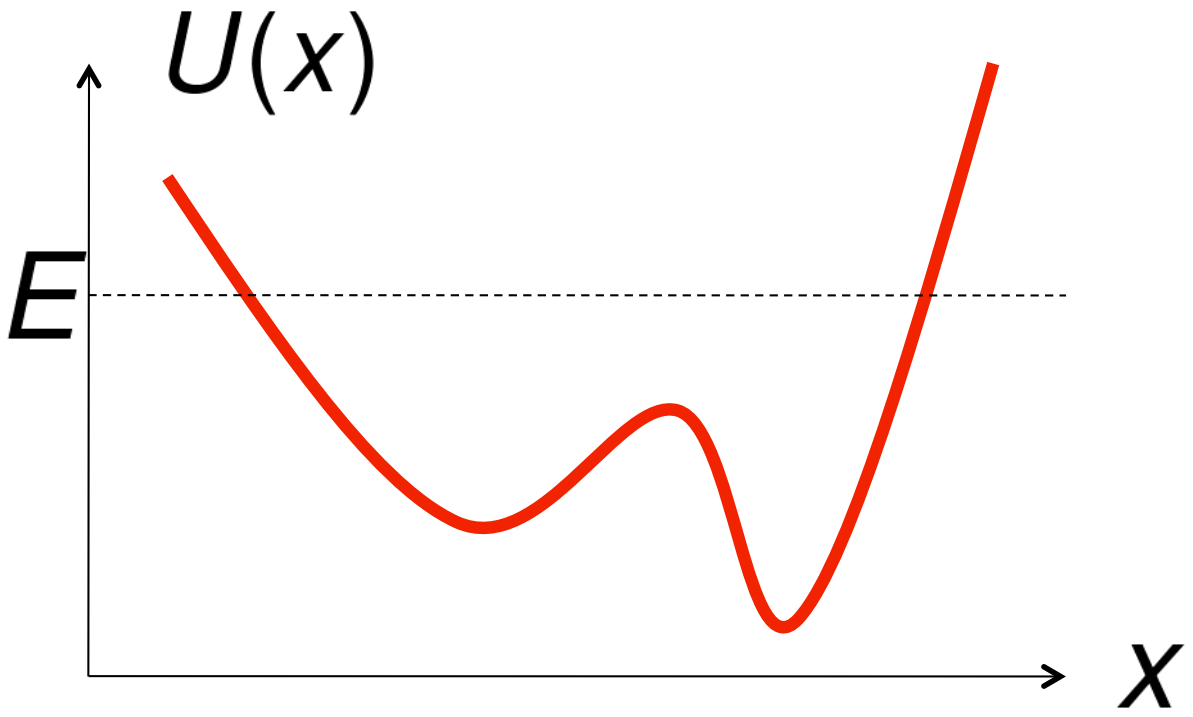
- Zeros
- Max & min
- …



Computation in physics

- Analysis of complex functions: energy conservation

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



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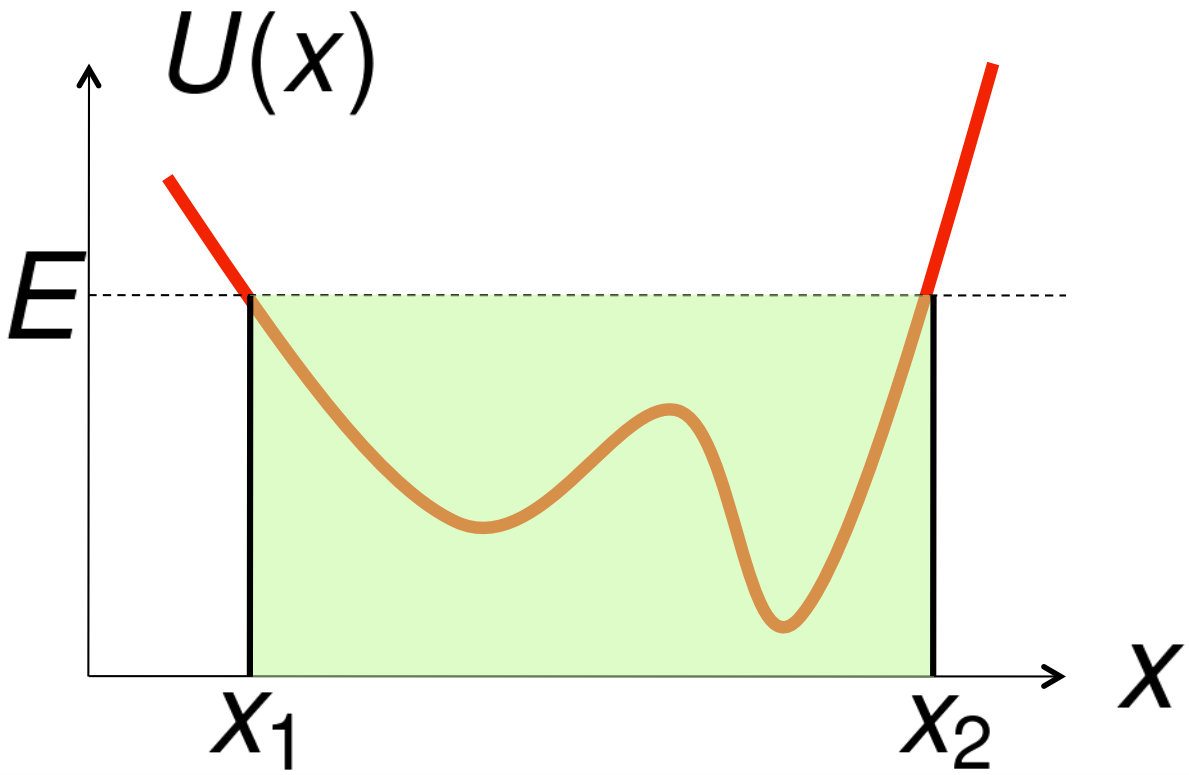


Computation in physics

Numerical solutions of differential equations

- Mechanics (Newton)

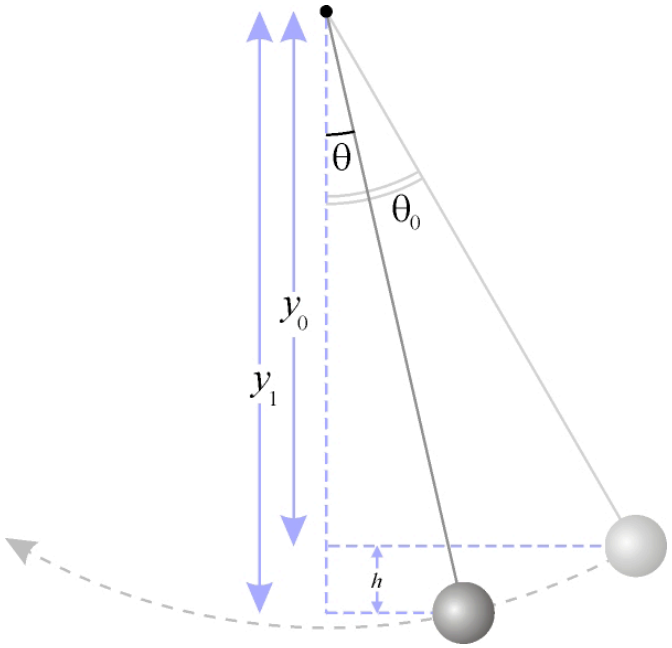
$$\mathbf{F} = m\frac{d\mathbf{v}}{dt} = m\mathbf{a}$$

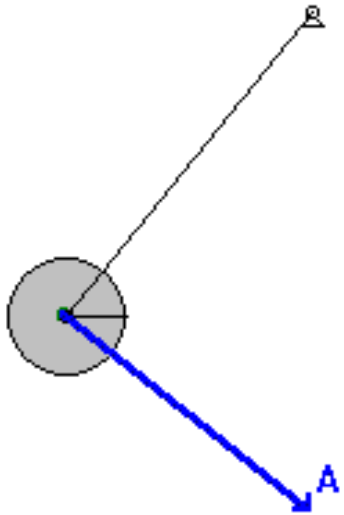
- Quantum mechanics (Schrödinger)

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

- Fluidodynamics (Navier-Stokes)
- Electrodynamics (Maxwell)
- ...

Pendulum





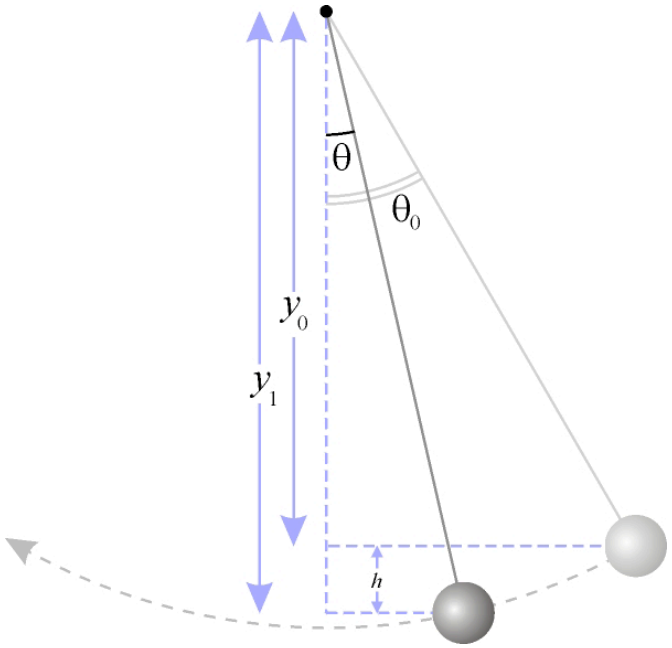
$$\frac{d^2\theta}{dt^2} + \frac{g}{\ell}\sin\theta = 0$$

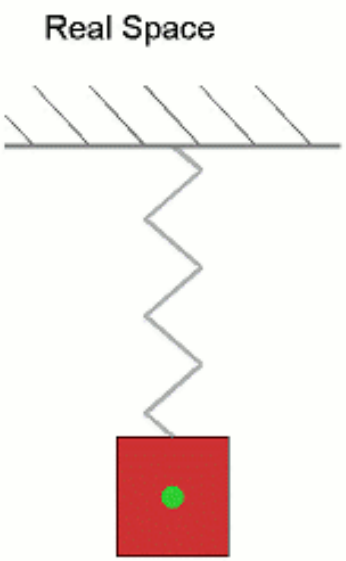
$$\theta(0) = \theta_0$$

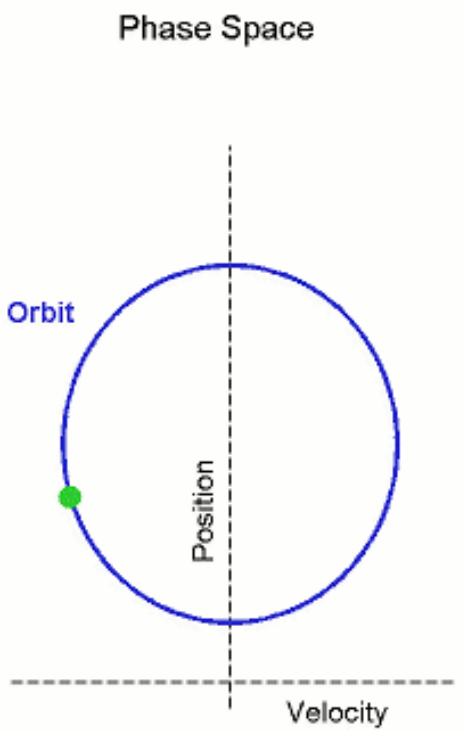
$$\left.\frac{d\theta}{dt}\right|_0 = \dot{\theta}_0$$

⇒ 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



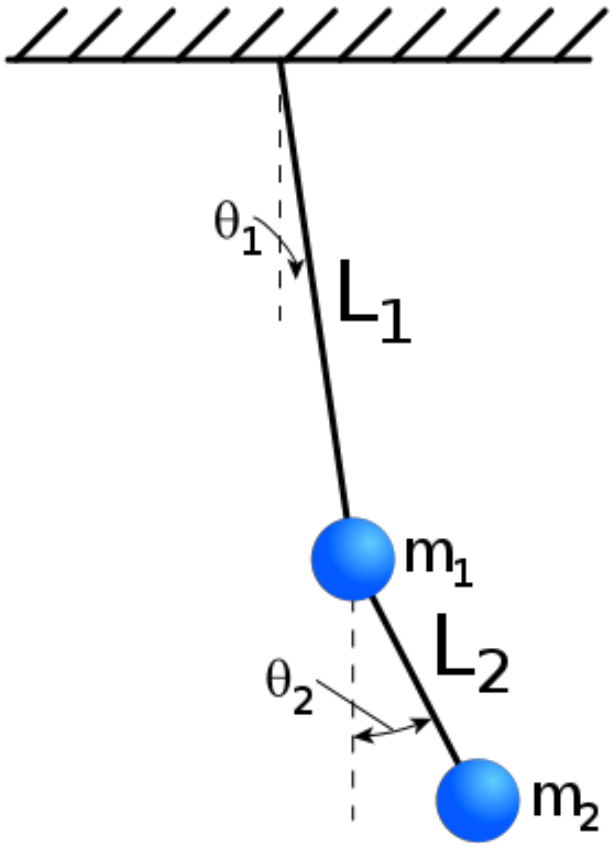




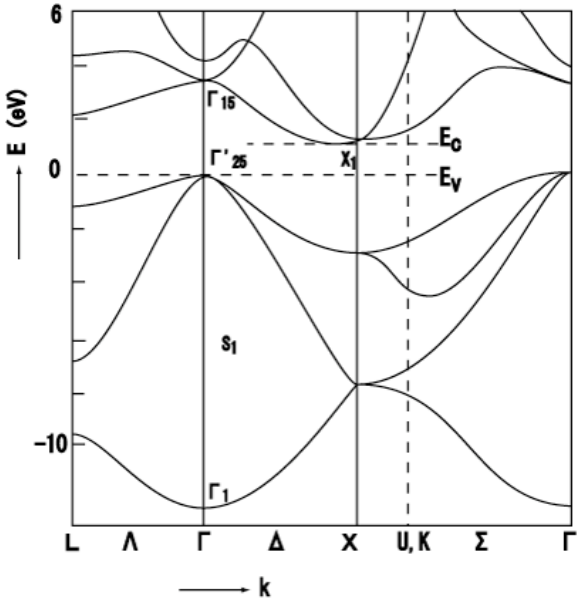
$$\frac{d^2\theta}{dt^2} + \frac{g}{\ell}\theta = 0$$

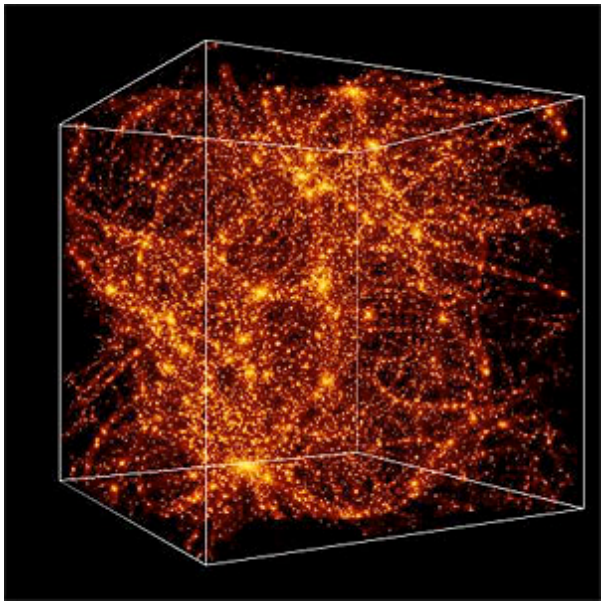
- Analytical solution (harmonic oscillator): compare with previous results

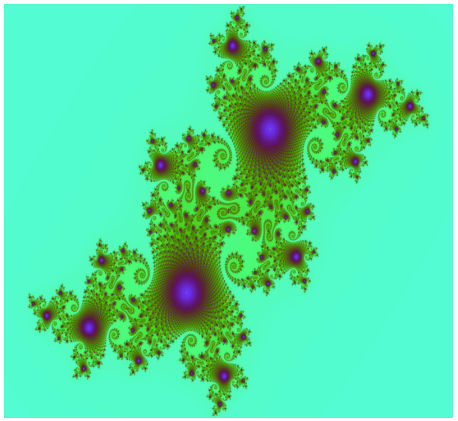
Double pendulum

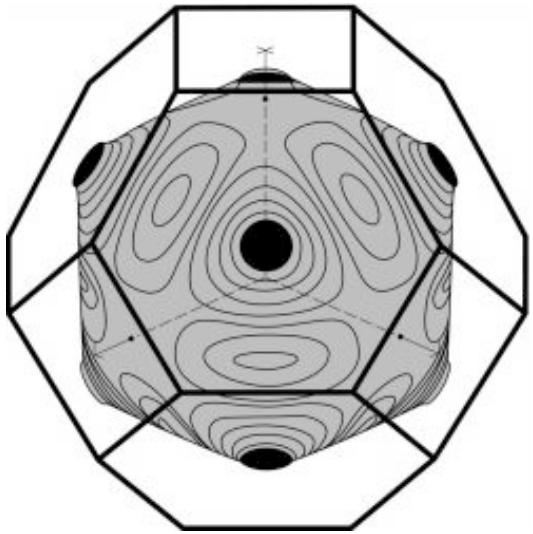


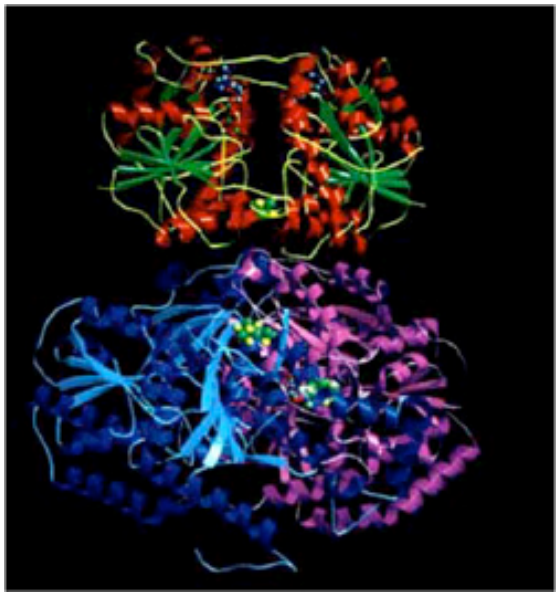
Advanced numerics

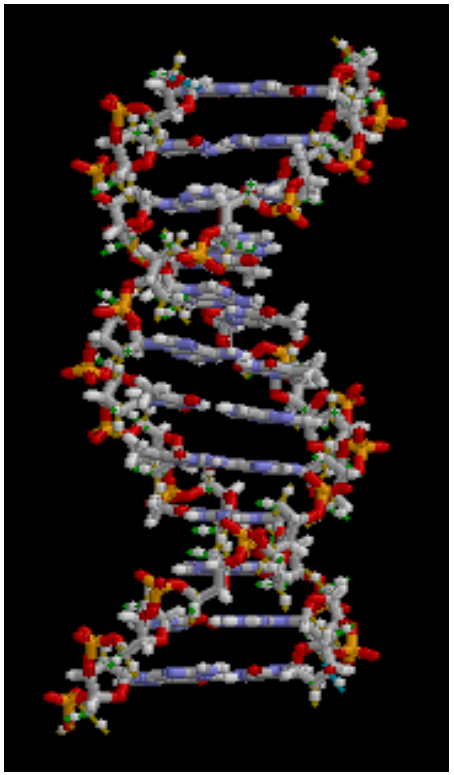




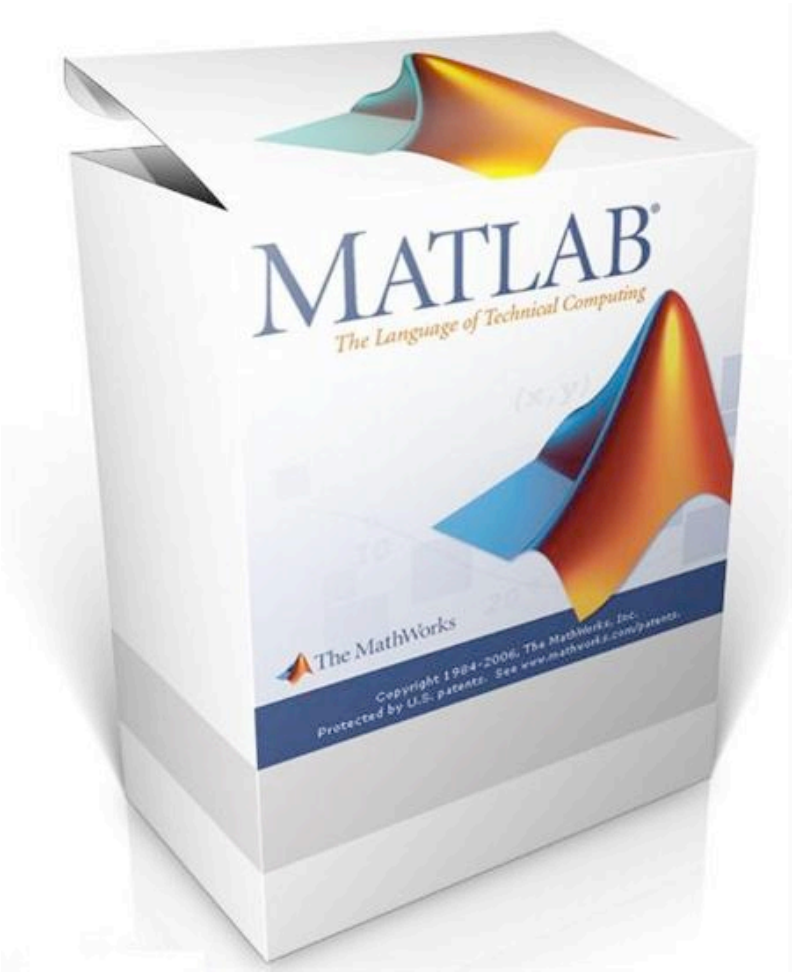








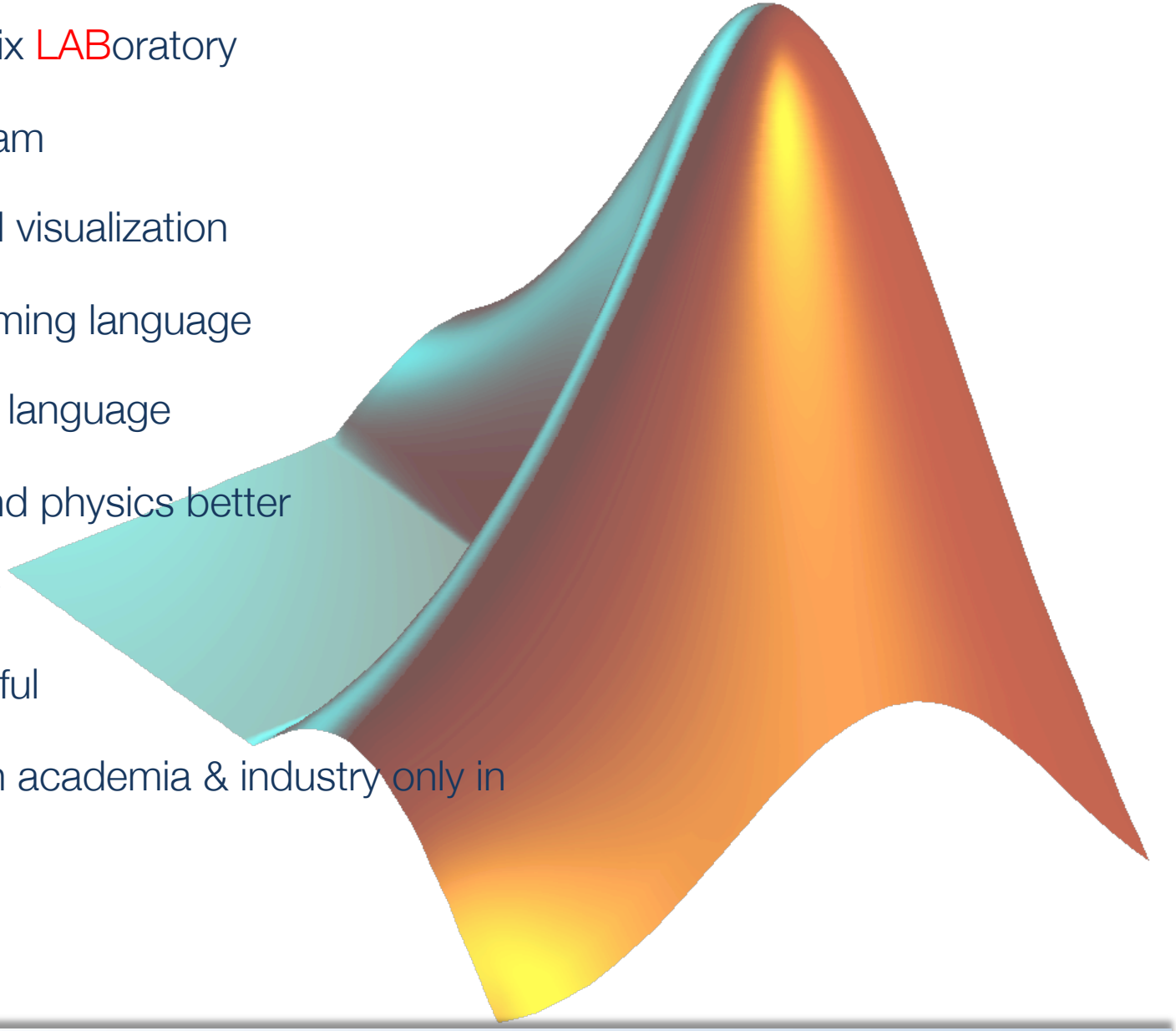
How?



Matlab

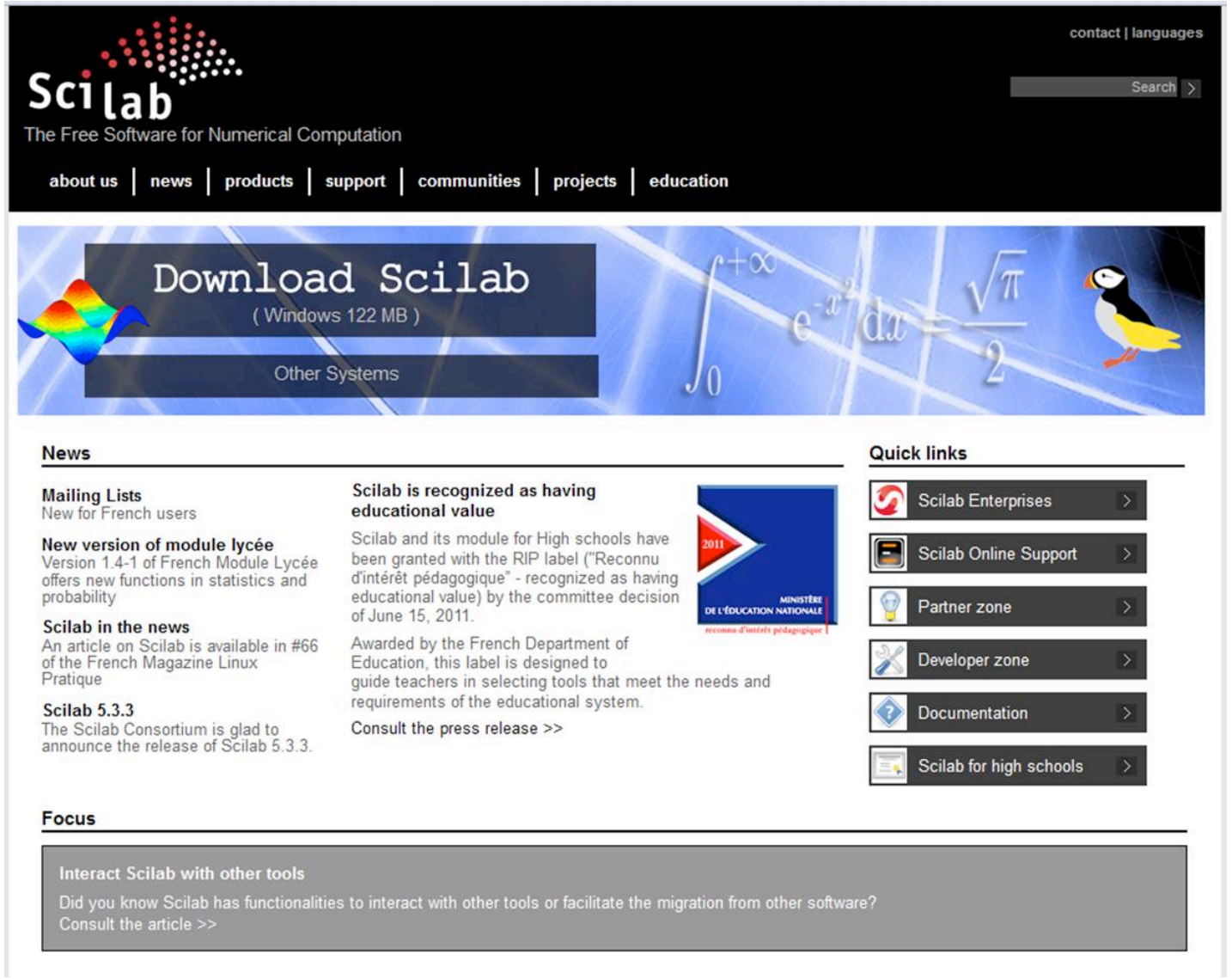
- MATLAB = MATrix LABoratory
- interactive program
- computation and visualization
- ...not a programming language
- array processing language
- tool to understand physics better
- very user friendly
- as well as powerful

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



Free alternative

- http://www.scilab.org



Example

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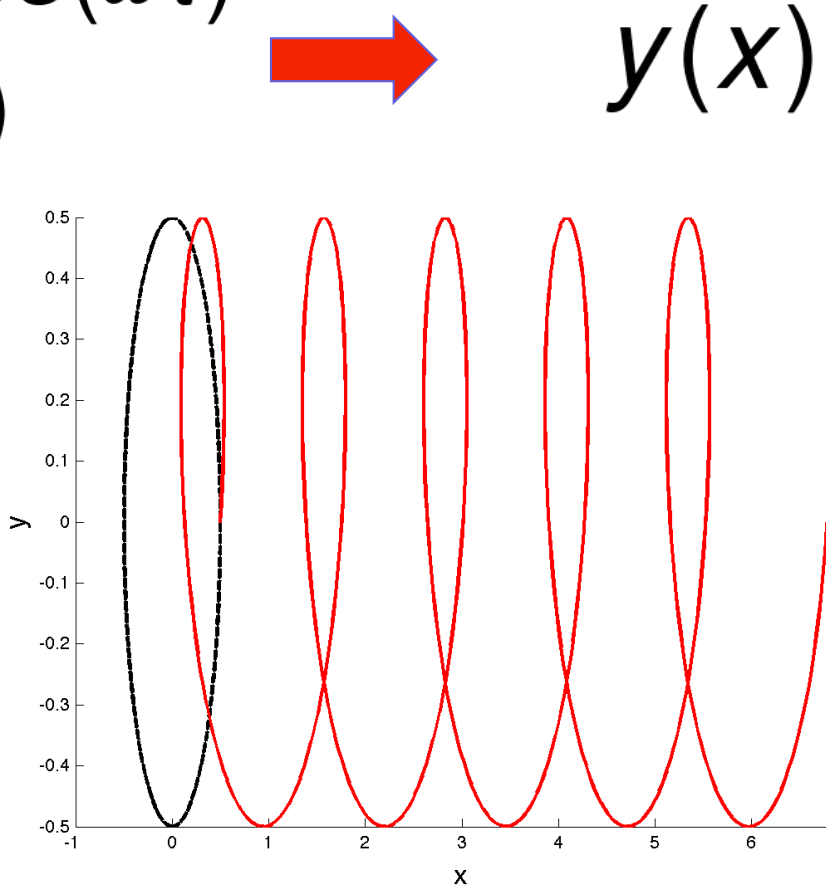


Example

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

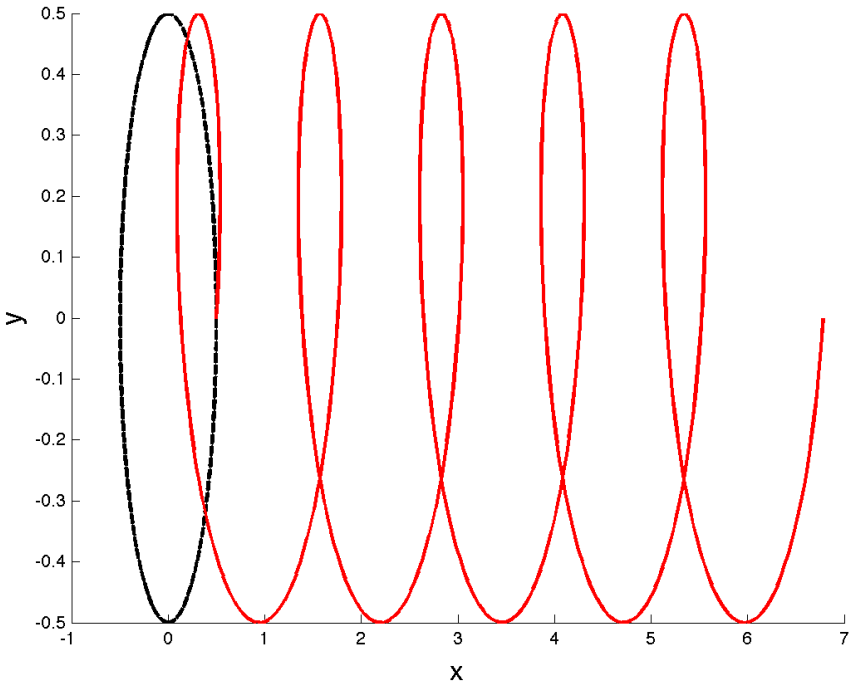
a=0; b=10*pi; M=500;
t=linspace(a,b,M);

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),ylal
hold off

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



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```

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