

A virtual laboratory for blended-learning: Numerical Methods using WIRIS

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TIME 2010



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Keywords:

Blended learning, Maths, Moodle, quizzes, maths web-tools

- Moodle is one of the most extended Learning Management Systems.
- Problems with Moodle arise in our scientific context:
 - Representation of math formulas.
 - Mathematical computation via web.

We present a tool to solve these problems:

WIRIS: A powerful editor and calculator via web



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In 2004-05 the Málaga University choosed Moodle as LMS, so MetNum was developed in Moodle.



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Moodle was born in...

- In 2002, Martin Dougiamas presented the first version of Moodle.
(<http://dougiamas.com>)
- Born in August of 2002, until July of 2008, there existed more than 21 millions of registered users, spread over 46000 places and it is translated to more than 75 languages.
- The design of Moodle is based on socio-constructivist pedagogy.
- A set of tools that support an inquiry- and discovery-based approach to online learning.
- An environment that allows for collaborative interaction among students.

The key is the continuous process of interaction between students and teachers. The collaboration in the design of learning units provide the best method to compile the knowledge of the subject.



The key of the success...

- Compatible, flexible and easy to modify.
- It has been written using the popular and powerful PHP language.
- Moodle is built in a highly modular fashion and uses common technologies such as shared libraries, abstraction.
- Cascading Style Sheets to define the interfaces.
- Moodle is a GNU multi-platform environment used without problems in Linux, Mac, Windows, etc.



Some interesting characteristics...

- Identification of students
- Observing their work
- Forums
- Quizzes
- Glossaries
- Lessons
- Wikis

E-learning units in MetNum



The screenshot shows the Moodle interface for the 'MetNum' course. The main content area displays the course title 'Métodos numéricos (ITI Sistemas grupos ABC e ITI Gestión grupos AB, 2009-10)' and a banner for 'Métodos Numéricos—Curso 2009/2010' with the SCILAB logo and the text 'SCILAB: Hacia el software libre'. Below the banner, there is a section titled 'PIZARRA' (Blackboard) with a list of activities and resources, including 'Revisión de exámenes febrero', 'LISTADO DE ALUMNOS QUE ESTÁN EN BOLONIA', 'Notas convocatoria diciembre', 'Notas control práctico', 'Examen Diciembre', 'Recetario que os daremos para examen final', and 'Rutinas 5 primeras prácticas y 2 ficheros de ejemplo para práctica 5'. The right sidebar contains a calendar for May 2010, a list of events, and a section for 'Actividad reciente' (Recent activity) showing the last activity from Saturday, May 1, 2010.

E-learning units in MetNum

Búsqueda avanzada

Administración

- Crear asignatura
- Copiar asignatura
- Activar edición
- Configuración
- Editar información
- Profesores
- Alumnos
- Grupos
- Borrar asignatura
- Copia de seguridad
- Restaurar
- Importar
- Restablecer
- Informes
- Preguntas
- Niveles
- Calificaciones
- Archivos
- Ayuda
- Foro de profesores

HERRAMIENTAS DE METNUM + Material anterior

- Foro de Noticias
- Foro de sugerencias 2006-2007
- Bienvenida a MetNum
- Chat de MetNum
- Correo Interno
- Material Cursos anteriores
- Exámenes Anteriores
- Relaciones de problemas
- F.A.Q. definiciones de teoría
- Encuesta MetNum
- Problema 1 a resolver - PLAZO FINALIZADO NO ENVIAR MAS
- Problema 2 a resolver - PLAZO FINALIZADO NO ENVIAR MAS
- Problema 3 a resolver - PLAZO FINALIZADO NO ENVIAR MAS
- Problema 4 a resolver- plazo finalizado no enviar mas
- Problema 5 a resolver

- Reserva de Laboratorio Sistemas A
- Reserva Laboratorio Sistemas B
- Reserva de Laboratorio Gestión A
- Reserva de Laboratorios Gestión B

Viernes 3 de Noviembre: Listas provisionales de turnos de prácticas.
 NOTA 1: Sistemas B, en teoría esta lleno y no debería haber ningún alumno sin puesto. Si algún alumno de Sistemas B, todavía no se ha apuntado que me mande un correo.



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E-learning units in MetNum

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0 INTRODUCCION A MATLAB

- En la semana del 16 al 20 de octubre, se impartirán 2 horas de Introducción a Matlab en horario **normal** de clase. Consultar en calendario la fecha concreta en la que se impartirá esta clase.
- En la semana del 23 a 27 de octubre, se realizará la primera práctica virtual. Es importante vuestra participación y obligatoria para el plan de Bolonia.

- Introducción a Matlab (Tutorial clase) - ZIP
- Introducción a Matlab (para imprimir)
- Tutorial de Matlab
- Tutorial de Matlab - ZIP
- Manual de Tutorial
- Práctica 0
- Foro de Aprendizaje de Matlab 2005
- ¿Matlab es útil?
- Auto-Glosario de Matlab
- Foro de Aprendizaje de Matlab - Curso 2006/2007



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E-learning units in MetNum

2 ALGEBRA LINEAL NUMERICA

- Error en la solución de un sistema lineal.
- Métodos directos para sistemas de ecuaciones lineales: Métodos gaussianos.
- Métodos de factorización. Sistemas sobredeterminados.
- Métodos iterativos para sistemas lineales: Jacobi, Gauss-Seidel y SOR.
- Teoremas de convergencia.

MATERIAL PARA TEORIA

- Tema 2
- Tema 2 (para imprimir)
- Foro de Teoría - Tema 2. 2006-2007
- Foro Teoría Tema 2
- Relación de Problemas Tema 2
- Tema 2 Cuestionario 3
- Tema 2 Cuestionario 4

MATERIAL PARA PRACTICAS

- Práctica 1
- Foro Práctica 1
- Presentación clase Práctica 1
- ¿Has asistido a práctica 1? - solo bolonia
- Foro Práctica 1 / Curso 2006 - 2007
- ficheros M práctica 1 para versión 6 y 7 de matlab
- Ejercicios exámenes relativos a práctica 1



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E-learning units in MetNum

3. INTERPOLACIÓN Y APROXIMACIÓN

- Interpolación polinomial clásica. Fórmulas de Lagrange y en diferencias. Error.
- Interpolación osculadora: Método de Hermite y Hermite cúbica.
- Interpolación "spline".
- Aproximación mínimo-cuadrática.

MATERIAL PARA TEORIA

- Tema 3
- Tema 3 (para imprimir)
- Foro Teoría - Tema 3. 2006-07
- Foro Teoría Tema 3
- Relación de Problemas Tema 3
- Cuestionario 5

MATERIAL PARA PRACTICAS

- Práctica 2
- Foro Práctica 2
- Presentación clase Práctica 2
- ¿Has asistido a Práctica 2? solo bolonia
- Ejercicio Práctica 2
- Foro de práctica 2 / curso 2006-2007



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Our virtual course



- The subject Numerical Methods is taught in a blended-learning framework.
- Nowadays, it is the meeting and working point for the students of our subject.
- We check that our students "learn best when they are engaged in a social process of constructing knowledge through the act of constructing an artefact for others" (see Martin Dougiamas and Peter C. Taylor 2003).



Some lacks... math formulas

Teachers and students want to transmit math knowledge.

- In [Caprotti et al. 2008]: "mathematical instruction is a recognized key asset in our society and embracing technology in mathematics education is not only economically advantageous but also promotes better learning and understanding".
- In [Cohen 2008]: mathematics to the Web. Their group has developed MathDox.
- Moodle to make a direct preview of LaTeX code, which is usually used to present mathematical material. **LaTeX is very good for scientific teachers but hard for students.**



Some lacks... math computation

- The National Mathematics Advisory Panel has concluded that certain tools, in particular systems for automated testing and assessment, can improve the performance of students.
- It is possible to improve Moodle: creating new learning units that allow mathematical computation.



Some lacks... SOLUTION

- Representation of math formulas: **WIRIS**
- Math Computation via web: **WIRIS**



www.wiris.com

- It is currently being used with (high) success in educational environments in Spain, Luxemburg, Netherlands, Puerto Rico and Finland.
- Nowadays, WIRIS is a software family of products dedicated to mathematical calculation
- And the most interesting point, now this tool is integrated in the LMS Moodle using a WIRIS Plugin.



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www.wiris.com

The screenshot displays the WIRIS software interface. At the top, there is a menu bar with options: Edit, Operations, Symbols, Analysis, Matrix, Units, Combinatorics, Geometry, Greek, Programming, and Format. Below the menu bar is a toolbar with icons for various mathematical functions. The main workspace shows three mathematical operations: $\text{solve}(x^3 + 4x - 1) \rightarrow \{x = 0.24627\}$, $\int_0^2 (x+1) \rightarrow 4$, and $\text{plot}(\cos(x-1)) \rightarrow \text{plotter1}$. A window titled 'plotter1' is open, showing a 2D plot of the function $y = \cos(x-1)$ on a grid. The plot shows a periodic wave oscillating between -1 and 1. The window also includes a 'Refresh' button and a 'Java Applet Window' title bar.



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www.wiris.com

We have two tools integrated in Moodle:

- WIRIS Editor is a powerful tool used via web, and permits the graphical edition of mathematical formulas.
- WIRIS CAS is a Computer Algebra System (CAS) designed for mathematical computations.



www.wiris.com

- If Moodle integrates the WIRIS Plugin, we can edit maths expressions and compute an integral in an easy way.
- WIRIS incorporates libraries for Calculus, Algebra, and Statistics but not for numerical methods.
- Students can interact using WIRIS in Moodle to check if the result of an exercise is correct and develop new routines in WIRIS to solve other exercises.



A new library for Numerical Methods



```

library Practice 1
cholesky(A,b,x,z,t) :=begin
    fa=n_rows(A)
    Ms=I_fa
    Mi=I_fa
    Tsup=Ts(A)
    Tinf=Ti(A)
    x=sustprog(Tinf,b,x)
    sustreg(Tsus, x ,z)
end

```

A new library for Numerical Methods

```

qr(A) inicio
    fa=n_rows(A)
    Q=I_fa
    k=1
    mientras k<=fa hacer
        w=matrix_constante(fa,1,0)
        j=k
        mientras j<=fa hacer
            w_kj=A_jk
            j=j+1
        fin
        p=0
        i=k
        mientras i<=fa hacer
            p=p+(A_i,k)^2
            w_ki=A_i,k
            i=i+1
        fin
        w_ki=A_k,k+signo(A_k,k)/sqrt(p)
        H=w-w^T
        M=H
        s=(w)^T*w
        c=1
        mientras c<=fa hacer
            d=1
            mientras d<=fa hacer
                H_c,d=2*M_c,d/x_ki,i
                d=d+1
            fin
            c=c+1
        fin
        H=I_fa+H
        T=H^T
        Q=Q*T
        A=H*A
        k=k+1
    fin
    R=A
    (Q,R)
fin

```

A new library for Numerical Methods

```

solqr(A,b):=inicio
    (Q,R)=qr(A)
    bb=QT·b
    x=sustreg(R,bb)
    [x]
fin

```



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A new library for Numerical Methods

```

-----
simpson(F,c,d,n):=inicio
    locales w,z,k
    w=(d-c)/n
    z=0
    k=1
    [ ]
    mientras k<=n hacer
        z=z+
        simpson1(F,c+(k-1)·w,c+k·w)
        k=k+1
    fin
    z
fin

```



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A new library for Numerical Methods

```

Práctica 3ª
Indica el número de decimales que salen por pantalla
precision(15)

Calcule una derivada
Formato será así deriv(F(x) = x^2, 3, 0.003)
deriv(F,x0,h) := inicio
    y = (F(x0+h) - F(x0-h))/(h/2)
fin

ghermis5(F) := inicio
    r = [2.0201828705,
        0.9585724848,
        0. -0.9585724848,
        -2.0201828705]
    p = [0.0198532421,
        0.3936193232,
        0.3453687205,
        0.3936193232,
        0.0198532421]
    k = 1
    ff = vector_constante(5,0)
    F2(x) := e^x
    mientras k <= 5 hacer
        ff_k = F(r_k) F2(r_k)
        k = k + 1
    fin
    y = p ff^T
fin

Esta rutina calcula int_-(a)^(inf) F(x)dx
por el método de Laguerre 5 puntos
F = función a integrar
a = límite inferior del intervalo de integración
Si t = 1 calcula int_-(inf)^(a) F(x)dx

```

A new library for Numerical Methods

```

glague5(F,a,t) := inicio
    pesos = [0.521755610583,
        0.398666811083,
        0.01759424496817,
        0.00361175867992,
        0.0000233699723858]
    r = [0.2663560319718,
        1.413403059107,
        3.596425771041,
        7.085810005859,
        12.640800844276]
    k = 1
    ff = vector_constante(5,0)
    F2(x) := e^x
    k = 1
    mientras k <= 5 hacer
        ff_k = F(r_k t + a) F2(r_k)
        k = k + 1
    fin
    y = pesos ff^T
fin

```

A new library for Numerical Methods

```

glegen4(F,a,b,n) := inicio
    h=(b-a)/n
    l=((b-a)/(h))+1
    x=vector_constante(l, 0)
    i=1
    k=a
    mientras i<=l hacer
        xi=k
        k=k+h
        i=i+1
    fin
    t=[0]
    p=1
    mientras p<=n hacer
        [t]=[t]+[glegen41(F, xp,xp+1)]
        p=p+1
    fin
    t
fin
  
```



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A new library for Numerical Methods

Algoritmo de la Práctica 4

Indica en número de decimales que salen por pantalla
precision(15)

Método de Euler para el problema de valores iniciales en EDO:
F: número del fichero con la función a integrar a la introducidos por el vector
x0= punto inicial
x1=punto final
n=número de intervalos
y0= vector con los puntos intermedios donde se evalúa
x=vector con los puntos intermedios donde se evalúa
p=matriz con los valores obtenidos en los puntos intermedios de x

```

euler1 ( x0, x1, y0, n) := inicio
    h=(x1-x0)/n
    l=(x1-x0)/h+1
    m=longitud(y0)
    k=1
    si l!=(n+1) entonces
        k=n+1
        [error,l,n]
    sino
        x=vector_constante(l, 0)
        i=1
        z=x0
        mientras i<=l hacer
            xi=z
            z=z+h
            i=i+1
        fin
        T=matriz_constante(l,m,0)
        k=1
        mientras k<=m hacer
            Ti,k=y0k
            k=k+1
        fin
        i=1
  
```



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A new library for Numerical Methods

```

Practica 5ª

F=funcion
a=extremo inferior del intervalo inicial
b=extremo superior del intervalo inicial
n=numero de iteraciones
x=solucion
e=condicion de error ( e=0 correcta, e!=0
Intervalo inicial incorrecto)
tol=cota de |x-x'| (x' solucion aproximada,
x solucion verdadera)

bipart(F,a,b,n) = Inicio
FA=F(a)
FB=F(b)
x=(a+b)/2
FX=F(x)
e=0
k=1
Al FA*FB>0 entonces
n=n+1
fin
si FA=0 entonces
x=a
k=n+1
fin
si FB=0 entonces
x=b
k=n+1
fin
mientras k<=n hacer
FX=F(x)
si FX=0 entonces
k=k+1
fin
si FA*FB<0 entonces
b=x
FB=F(b)
sino
a=x
FA=F(a)
fin

```



New self-evaluation material

Edición
Operaciones
Símbolos
Análisis
Matrices
Unidades
Combinatoria
Geometría
Griego
Programación
Formato

\lim_0 \lim_0 $\frac{d}{dx}$ \int_0^x \int_0^x
 \lim_0 \square' \int_0^x \int_0^x

WIRIS

▼|library Practice 1|▼

1. To solve the system $Ax=b$, by the Cholesky method, A must be a positive-definite matrix.

2. First, we check A is symmetric matrix, so we call the routine symmetric. If the output is 1, then it is symmetric.

$\text{symmetric}\left(\begin{pmatrix} 4 & 2 & -1 \\ 2 & 5 & 1 \\ -1 & 1 & 3 \end{pmatrix}\right) \Rightarrow 1$

3. Since it is symmetric, we call the function eig. This routine calculates the eigenvalues of a matrix. If all them are positive, then the matrix it is positive-definite.

$\text{eig}\left(\begin{pmatrix} 4 & 2 & -1 \\ 2 & 5 & 1 \\ -1 & 1 & 3 \end{pmatrix}\right) \Rightarrow \{\{\lambda=1.28552125561224\}, \{\lambda=4.14327732183542\}, \{\lambda=6.57120142254812\}\}$

4. Then, we can solve the system by Cholesky method.

$\text{cholesky}\left(\begin{pmatrix} 4 & 2 & -1 \\ 2 & 5 & 1 \\ -1 & 1 & 3 \end{pmatrix}, \begin{pmatrix} 11 \\ 11 \\ -2 \end{pmatrix}\right) \Rightarrow \begin{bmatrix} \frac{9}{5} \\ \frac{8}{5} \\ -\frac{3}{5} \end{bmatrix}$

A web portal



A web portal



A web portal

The screenshot shows a web portal titled "Métodos Numéricos con WIRIS". The left sidebar contains a menu with topics like "Temas 1º: Sistemas de Ecuaciones Lineales", "Temas 2º: Derivación y Aproximación Lineal", etc. The main content area is titled "Sistemas de Ecuaciones Lineales" and "Métodos Directos:". It includes a definition of a linear system $Ax=b$ and discusses methods for solving them, such as Gaussian elimination. There are buttons for "ejercicios" (exercises) and "ejercicios" (exercises). The right sidebar shows a calendar for "Domingo, 30-Mayo-2007" and a login section with fields for "Usuario:" and "Contraseña:".

A web portal

The screenshot shows the same web portal, but the main content area is titled "Interpolación y Aproximación" and "Interpolación Lineal:". It includes a definition of linear interpolation and discusses the method of Lagrange. There are buttons for "ejercicios" (exercises) and "ejercicios" (exercises). The right sidebar shows a calendar for "Domingo, 30-Mayo-2007" and a login section with fields for "Usuario:" and "Contraseña:".

Conclusions

- Students can represent mathematical formulas in an easy way with WIRIS.
- WIRIS allows developing new libraries of numerical methods using an easy programming language.
- Students can try to solve self-evaluation exercises, and have a powerful calculator.
- The only tool necessary is a web browser.



Conclusions

- The WIRIS package has been integrated into Moodle.
- Students have now the possibility to perform self-evaluation exercises with WIRIS CAS in Moodle.
- **Future work?:** Discrete Maths and Optimization libraries.





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