

# Una introducción a la caja de herramientas DUNE Numerics para la solución de modelos matemáticos



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# Presentación del libro



## Las matemáticas en la vida real Introducción básica al modelamiento matemático

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Dirección de Investigación y Extensión  
Vicerrectoría  
Sede Palmira



### CAPÍTULOS:

1. Introducción a los números reales  $\mathbb{R}$ .
2. Introducción a las funciones.
3. La derivada.
4. Modelamiento matemático.
5. Anexos.

Serie CIENCIAS BÁSICAS

# Presentación del libro

## 4.3 Situaciones cotidianas

En primer lugar, se muestran “expresiones” de situaciones cotidianas con sus respectivas representaciones como funciones y sus derivadas.

### 4.3.1 Encender la luz



Figura 4.3.  
Encender la luz

La acción de encender la luz, como en la figura 4.3, se puede escribir matemáticamente como el cambio en la posición del switch  $P$  como variable independiente o causa del fenómeno, y el efecto se puede ver en el cambio de la intensidad lumínica  $I$ . Esto quiere decir que la intensidad lumínica es una función de la posición del switch  $I(P)$ . La variación se puede escribir como:

$$\frac{dI}{dP}$$

4.1



# DUNE Numerics Project

## Introducción

### Distributed and Unified Numerics Environment (DUNE)

- ▶ Software de código abierto bajo la licencia GNU General Public Licence 2  Free as in Freedom.
- ▶ Disponible en macOS, Debian , Ubuntu , openSUSE , Arch Linux  y FreeBSD .
- ▶ Conjunto de bibliotecas C++ con enlaces a Python.
- ▶ Utilizado en la resolución de ecuaciones diferenciales parciales e implementación de métodos basados en mallas, por ejemplo diferencias finitas, elementos finitos o volúmenes finitos.



**Figura:** Tomado de <https://dune-project.org>.

### Proyectos que emplean DUNE

- ▶ <https://dune-project.org/about/dune>
- ▶ <https://dumux.org>
- ▶ <https://opm-project.org>
- ▶ <https://precice.org>
- ▶ <https://www.zib.de/projects/kaskade7-finite-element-toolbox>



**Figura:** Tomado de <https://dune-project.org>.

# EI DUNE verso: módulos

<https://dune-project.org/groups/core>



**Figura:** Tomado de

<https://gitlab.com/dune-archiso/repository/dune-archiso-repository-pdelab-git/-/pipelines>

**dune-common** Clases fundamentales e infraestructura para la construcción del sistema.

**dune-geometry** Elementos de referencia, métodos de cuadraturas y transformaciones geométricas.

**dune-grid** Interfaces con las mallas (ALUGrid, UGGrid, AlbertaGrid, YaspGrid), construcción y visualización.

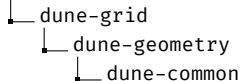
**dune-istl** Biblioteca de solucionadores iterativas de plantillas, clases genéricas de matrices/vectores dispersos, solucionadores

**dune-localfunctions** Interface genérica para funciones de elementos finitos.

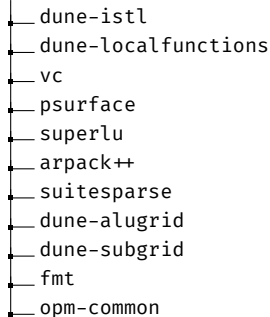
# El DUNE verso: módulos

## Dependencias de algunos módulos

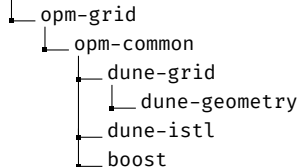
dune-fem



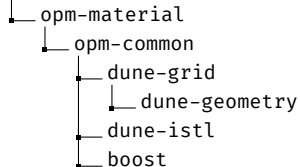
dumux



opm-upscaling




opm-models



# Curso de DUNE/PDELab 2021

<https://dune-pdelab-course.readthedocs.io>

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[Edit on GitHub](#)

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- Introduction
  - About Dune
  - About this Course
  - How to study with the Material
  - Setting up the exercise environment
- Lectures
  - C++ for Scientific Computing
  - Introduction to Finite Elements
  - The Dune Grid Interface
  - Simulation Workflow
  - Elliptic Problems
  - Instationary Problems
  - Finite Volumes
  - Systems of PDEs
  - Adaptivity
  - Parallelization
  - Code Generation with Python
- Questions and Answers
- Licensing and Copyright

Next

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# Snippet en C++

## Listado: Programa dune-basics.cc.

```
#ifndef HAVE_CONFIG_H
#include "config.h"
#endif
#include <iostream>
#include <dune/common/parallel/mpihelper.hh> // An initializer of MPI
#include <dune/common/exceptions.hh>       // We use exceptions

int main(int argc, char **argv)
{
    try
    {
        // Maybe initialize MPI
        Dune::MPIHelper &helper = Dune::MPIHelper::instance(argc, argv);
        std::cout << "Hello World! This is dune-basics." << std::endl;
        if (Dune::MPIHelper::isFake)
            std::cout << "This is a sequential program." << std::endl;
        else
            std::cout << "I am rank " << helper.rank() << " of " << helper.size()
                      << " processes!" << std::endl;
        return 0;
    }
    catch (Dune::Exception &e)
    {
        std::cerr << "Dune reported error: " << e << std::endl;
    }
    catch (...)
    {
        std::cerr << "Unknown exception thrown!" << std::endl;
    }
}
```



## Pipeline Browser

builtin:  
solution\_navier\_stokes-00\*

## Properties

## Information

## Properties

Apply Reset Delete ?

Search ... (use Esc to clear text)

Properties ( )

- ☒ Cell/Point Array Status
- ☒ cg2\_dirichlet\_gfs\_0\_0\_pow2gf
- ☒ cg2\_dirichlet\_gfs\_0\_0\_pow2gf
- ☒ cg1\_gfs\_1

Display (Un) ( ) ( ) ( )

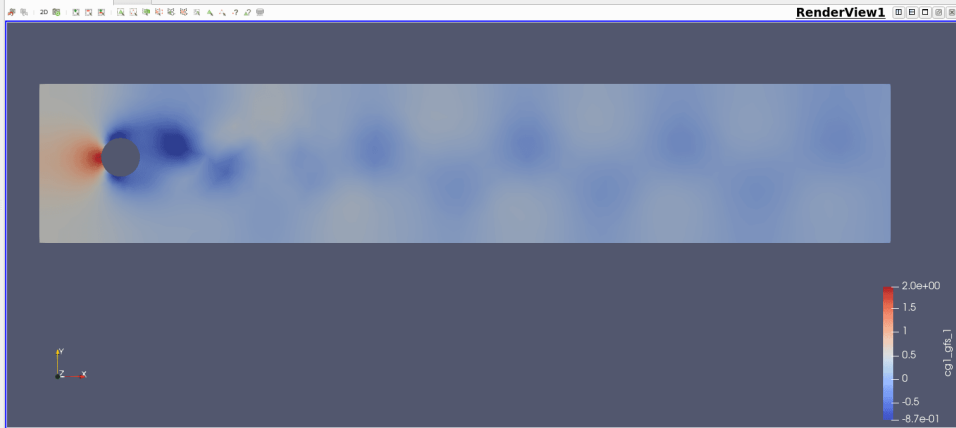
Representation Surface

## Coloring

Coloring ( ) ( ) ( )

## Layout #1

+



# Snippet en Python

## Grid Views: Adaptivity and Moving Domains

### Dynamic Local Grid Refinement and Coarsening

### Evolving Domains

Mean Curvature Flow

### Using C++ Code Snippets

### Discontinuous Galerkin Methods: DUNE-FEM-DG Module

## USER PROJECTS

### HP adaptive DG scheme for twophase flow problem

### Virtual Finite Elements: the DUNE-VEM module

## INFORMATION AND RESOURCES

Information for C++ Developers

How to showcase your own project

Notebooks and Scripts

Mesh Files used in the Examples

Citing this project

List of things that need doing...

```
[1]: import matplotlib
matplotlib.rc( 'image', cmap='jet' )
import math

from ufl import *
from dune.ufl import Constant, DirichletBC
import dune.ufl
import dune.geometry as geometry
import dune.fem as fem
from dune.fem.plotting import plotPointData as plot
import matplotlib.pyplot as pyplot
```

set up polynomial order and radius of reference surface

```
[2]: order = 2
R0 = 2.
```

We begin by setting up reference domain  $\Gamma_0$  (`grid`), and the space on  $\Gamma_0$  that describes  $\Gamma(t)$  (`space`). From this we interpolate the non-spherical initial surface `positions`, and, then reconstruct `space` for the discrete solution on  $\Gamma(t)$ .

grid construction; dune grid format file

```
[3]: from dune.fem.view import geometryGridView
from dune.fem.space import lagrange as solutionSpace
from dune.alugrid import aluConformGrid as leafGridView
```



## Finite Elements

As another example we solve the poisson equation

$$\begin{aligned} -\Delta u &= f && \text{in } \Omega, \\ u &= 0 && \text{auf } \partial\Omega \end{aligned}$$

in Python based on a simplicial Dune grid: `ALUConformGrid`.

```
In [2]: import time
import numpy
import math
```

Como primer paso construimos la grilla

```
In [3]: from dune.grid import cartesianDomain, gridFunction
from dune.alugrid import aluConformGrid
vertices = numpy.array([(0,0), (1,0), (1,1), (0,1), (-1,1), (-1,0), (-1,-1), (0,-1)])
triangles = numpy.array([(2,0,1), (0,2,3), (4,0,3), (0,4,5), (6,0,5), (0,6,7)])
aluView = aluConformGrid({"vertices": vertices, "simplices": triangles})
aluView.hierarchicalGrid.globalRefine(7)
```

[Pull requests](#) [Issues](#) [Trending](#) [Explore](#)

## C++ review DUNE

Una organización donde compartir notas acerca de C++ con pdfs escritos en LaTeX.

[America](#)[stackoverflow.com/c/cpp-review-dune](https://stackoverflow.com/c/cpp-review-dune)[Repositories](#) 21[Packages](#)[People](#) 10[Teams](#) 1[Settings](#)

### Pinned repositories

[Customize pinned repositories](#)[introductory-review](#)

Un repositorio donde compartir notas acerca de C++ con pdfs escritos en LaTeX.

Dockerfile ☆ 1

[hdnum](#)[Template](#)

C++

[dune-basics](#)[Template](#)

An example module that says Hello World.

TeX

[github-starter-course](#)[Template](#)

github-starter-course created by GitHub Classroom

[cpp-examples](#)[Template](#)

Forked from igormcoelho-learning/autograding-example-cpp-catch

Example of C/C++ autograding with Catch2 library - GitHub Classroom

C++

[sandbox](#)[Template](#)

Forked from corneliusludmann/gitpod-playground

This repository intentionally left empty. It merely serves as an entry point for personal Gitpod experiments.

[Type](#)[Language](#)[Sort](#)[New](#)

6 results for repositories written in C++ sorted by last updated

[Clear filter](#)

### study-scientific-programming

Study of book Scientific Programming Advanced Concepts of Christian Engwer

#### Top languages

C++ TeX Python  
Jupyter Notebook Dockerfile



# dune-archiso

Archiso profile based on CyberOS with DUNE Numerics

Status: **Beta** Brought to you by: [carlosal1015](#)

Add a Review

Downloads: 11 This Week

Last Update: 2021-06-15

 **Download**

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This is a live USB containing a full operating system that can be booted, this means that you can use a USB stick to burn this image or virtualize it to Linux-KVM, QEMU, Virtualbox, VMWare, Hyper-V. We included the following repositories:

- Arch Linux Core [Official]
- Arch Linux Extra [Official]
- Arch Linux Community [Official]
- Arch Linux Multilib [Official]
- Arch4Edu [Third-party]
- Cyber [Third-party]
- Dune-archiso-repository-core [Third-party]
- Dune-archiso-repository-extra [Third-party]

In addition, we provide the packages of some modules of DUNE Numerics (version 2.7.1), DuMux (version 3.4) and the Open Porous Media (version 2021.04). The full list of packages is described in <https://dune-archiso.gitlab.io/packages>

Enjoy. I don't belong to dune-project. All the blame falls on me ([github.com/carlosal1015](https://github.com/carlosal1015)).

## Recommended Projects



**Arm Mbed OS**  
Platform operating system designed for the Internet of...



**Apache OpenOffice**  
The free and Open Source productivity suite



**KeePass**  
A lightweight and easy-to-use password manager



**Clonezilla**  
A partition and disk imaging/cloning program



**7-Zip**  
A free file archiver for extremely high compression

## Top Searches

[cyberos](#)

[cyber os](#)

[linux security](#)

# Referencias

## ► Libros



Oliver Sander. *DUNE — The Distributed and Unified Numerics Environment*. First. Lecture Notes in Computational Science and Engineering 140. Springer International Publishing, 2020. ISBN: 978-3-030-59701-6. DOI: 10.1007/978-3-030-59702-3.

## ► Artículos



Andreas Dedner, Robert Klöforn y Martin Nolte. “The DUNE-ALUGrid Module”. En: *CoRR* abs/1407.6954 (2014). URL: <http://arxiv.org/abs/1407.6954>.



Andreas Dedner y Martin Nolte. “The Dune Python Module”. En: *CoRR* abs/1807.05252 (2018). eprint: 1807.05252. URL: <http://arxiv.org/abs/1807.05252>.



Peter Bastian y col. “The Dune framework: Basic concepts and recent developments”. En: *Computers & Mathematics with Applications* 81.1 (1 de ene. de 2021). Development and Application of Open-source Software for Problems with Numerical PDEs, págs. 75-112. ISSN: 0898-1221. DOI: <https://doi.org/10.1016/j.camwa.2020.06.007>.

# Referencias

## ► Sitios web

-  Oliver Sander. *The Distributed and Unified Numerics Environment (DUNE)*. 12 de abr. de 2016. URL: <http://congress.cimne.com/icme2016/admin/files/filepaper/p72.pdf> (visitado 12-07-2021).
-  Alexander Jaust. *Coupling fluid flows with DuMuX, preCICE workshop 2020*. 19 de feb. de 2020. URL: <https://precice.org/precice-workshop-2020.html> (visitado 12-07-2021).
-  Simon Praetorius. *AMDiS Workshop 2021*. 12 de jul. de 2020. URL: <http://wwwpub.zih.tu-dresden.de/~praetori/amdis/workshop2021> (visitado 12-07-2021).
-  Dune Course Team. *Dune/PDELab Course*. 22 de oct. de 2020. URL: <https://dune-pdelab-course.readthedocs.io> (visitado 26-06-2021).



¡Muchas gracias!



Presentación disponible en:

[https://cpp-review-dune.github.io/webinar/  
slides.pdf](https://cpp-review-dune.github.io/webinar/slides.pdf)

Grabación disponible en:

<https://player.vimeo.com/video/572717824>

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