

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



Webinar 13 de Julio de 2021

Elaborado por:  
John Jairo Leal Gómez  
Universidad Nacional de Colombia  
Carlos Alonso Aznarán Laos  
Universidad Nacional de Ingeniería, Perú

# Presentación del libro



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

John Jairo Leal Gómez / Juan Pablo Cardona Guío



Dirección de Investigación y Extensión  
Vicerrectoría  
Sede Palmira



UNIVERSIDAD  
NACIONAL  
DE COLOMBIA

## 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:

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

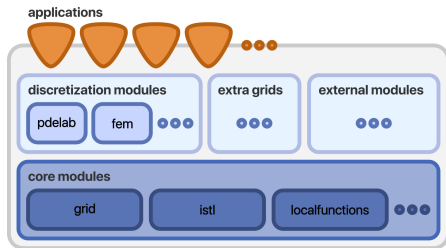
4.1



# DUNE Numerics Project

## 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.



**Origen:** [dune-project.org/about/dune](https://dune-project.org/about/dune).

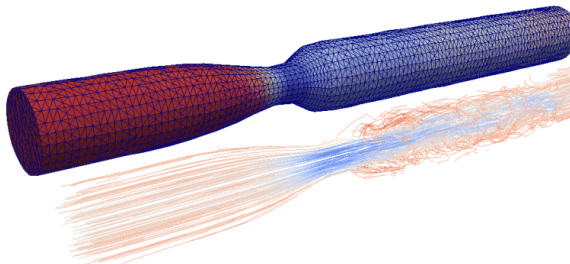


**Figura:** Los binarios están disponible en el repositorio **Arch Linux for Education** (Jingbei Li, Carlos Aznarán y otros, octubre 2022).

# DUNE Numerics Project

## Proyectos que emplean DUNE

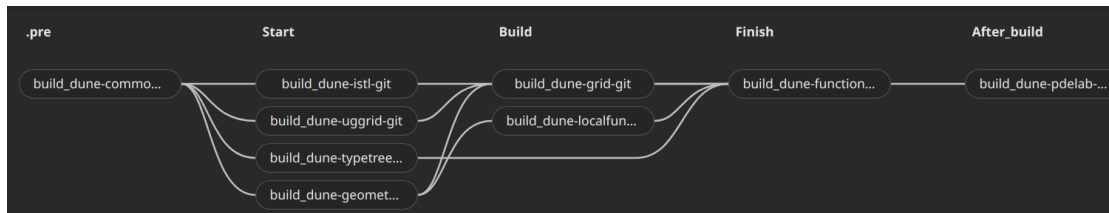
- ▶ <https://dumux.org>
- ▶ <https://opm-project.org>
- ▶ <https://precice.org>
- ▶ <https://www.zib.de/projects/kaskade7-finite-element-toolbox>



**Origen:** [dune-project.org/gallery](https://dune-project.org/gallery).

# 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).

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

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

# EI DUNE verso: módulos

## Dependencias de algunos módulos

### dune-fem

- dune-alugrid
- dune-istl
- dune-localfunctions
- suitesparse
- superlu
- dune-polygongrid (opcional)
- dune-spgrid (opcional)
- eigen (opcional)

### opm-models

- dune-alugrid
- dune-istl
- dune-localfunctions
- opm-material
  - opm-common
    - boost
    - fmt
- suitesparse

### dumux

- dune-grid
- dune-istl
- dune-localfunctions
- dune-alugrid (opcional)
- dune-foamgrid (opcional)
- dune-functions (opcional)
- dune-mmesh (opcional)
- dune-spgrid (opcional)
- dune-subgrid (opcional)
- opm-grid (opcional)

### dune-pdelab

- arpack++
- dune-alugrid
- dune-functions
- suitesparse
- superlu
- dune-multidomaingrid (opcional)

# Curso de DUNE/PDELab 2021

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

 DUNE/PDELab Course Material

latest

Search docs

Introduction

Lectures

Questions and Answers

Licensing and Copyright

 Read the Docs

v: latest

 » Dune/PDELab Course

[Edit on GitHub](#)

## Dune/PDELab Course

- [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

© Copyright 2021, Dune Course Team. Revision 73f0edae.  
Built with [Sphinx](#) using a [theme](#) provided by [Read the Docs](#).



# Snippet en C++

## Listado: Programa dune-basics.cc.

```
#ifdef 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)

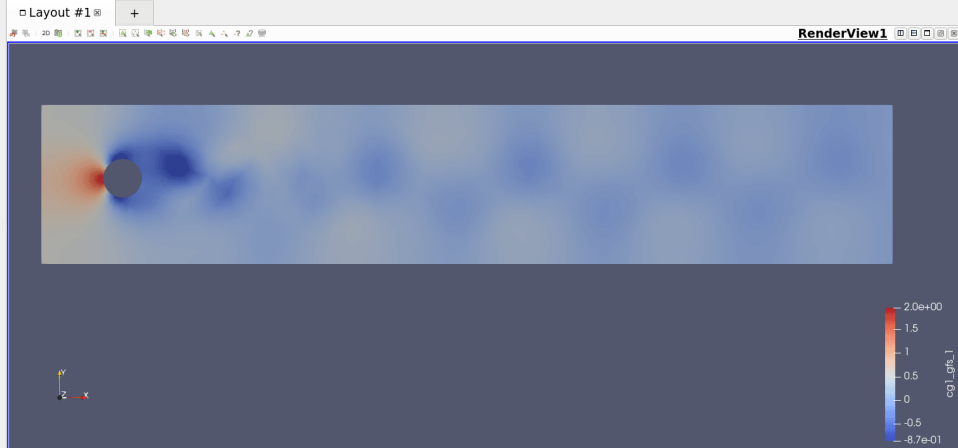
Properties ( Copy Paste Refresh )

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

Display (Un) Copy Paste Refresh

Representation Surface

## Coloring



# 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**[Get Updates](#)[Share This](#)

Linux

[Summary](#)[Files](#)[Reviews](#)[Support](#)[Blog](#)[Discussion](#)[Admin](#)[Add New...](#)

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 et al. “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).



# Agradecimientos

¡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>

Dudas, sugerencias o preguntas a:

[jlealgom@unal.edu.co](mailto:jlealgom@unal.edu.co)  
[caznaranl@uni.pe](mailto:caznaranl@uni.pe)