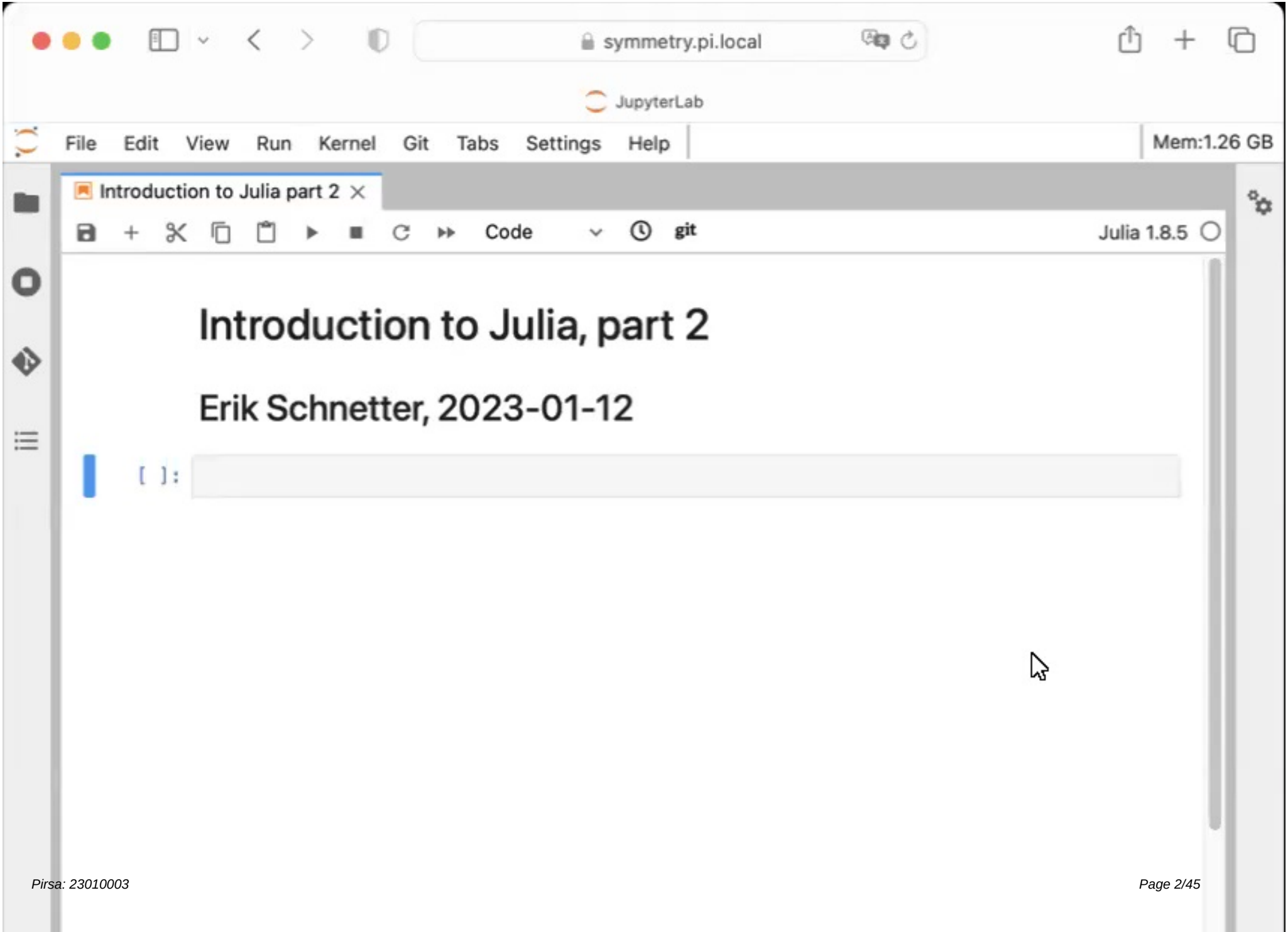
Title: Numerical Methods Lecture - 230112

Speakers: Erik Schnetter

Collection: Numerical Methods (2022/2023)

Date: January 12, 2023 - 9:15 AM

URL: https://pirsa.org/23010003


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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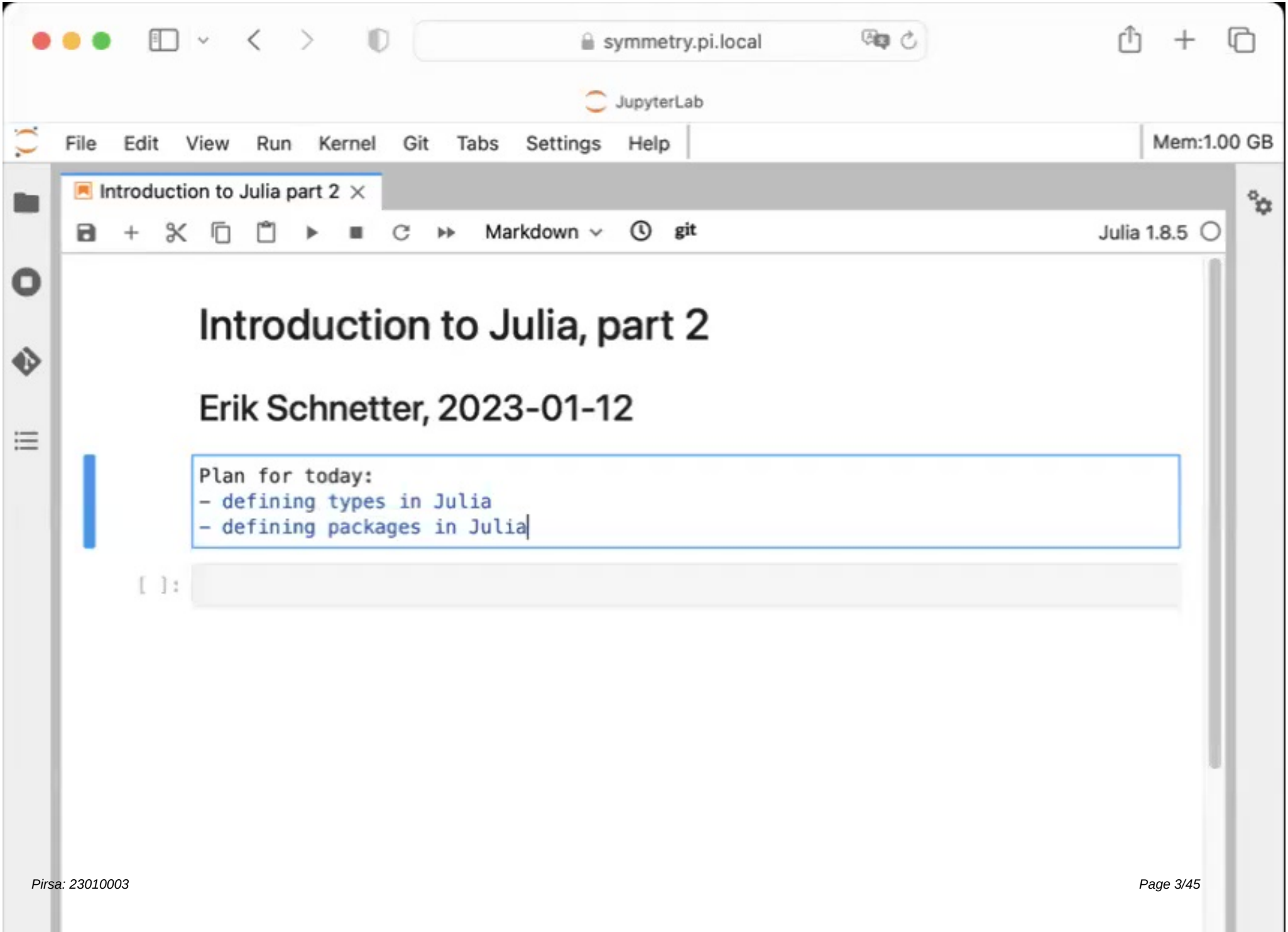
Introduction to Julia part 2
Code
git
Julia 1.8.5
Introduction to Julia, part 2
Erik Schnetter, 2023-01-12
[ ]: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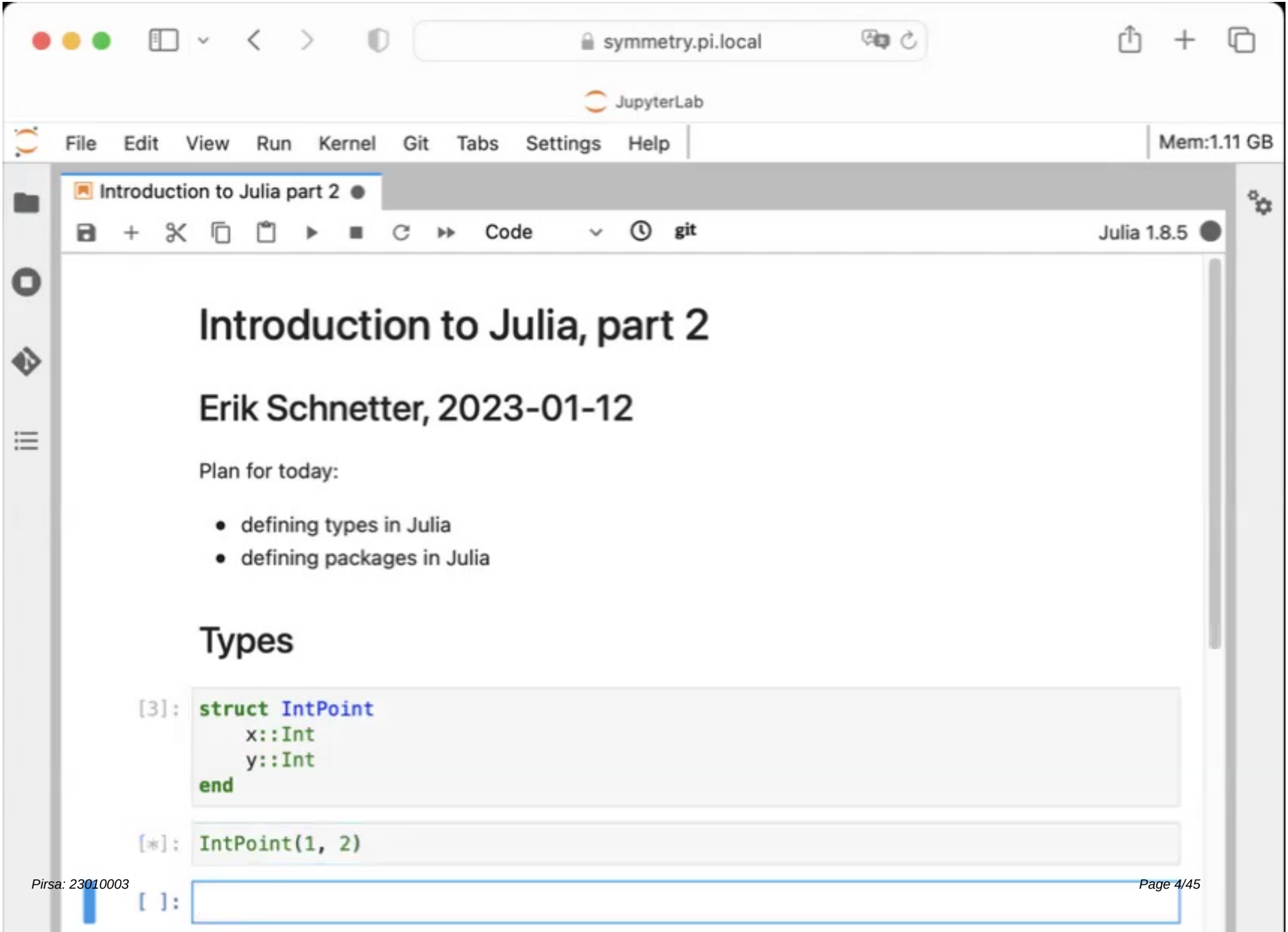
Introduction to Julia part 2
Markdown
git
Julia 1.8.5
Introduction to Julia, part 2
Erik Schnetter, 2023-01-12
Plan for today:
- defining types in Julia
- defining packages in Julia
[ ]: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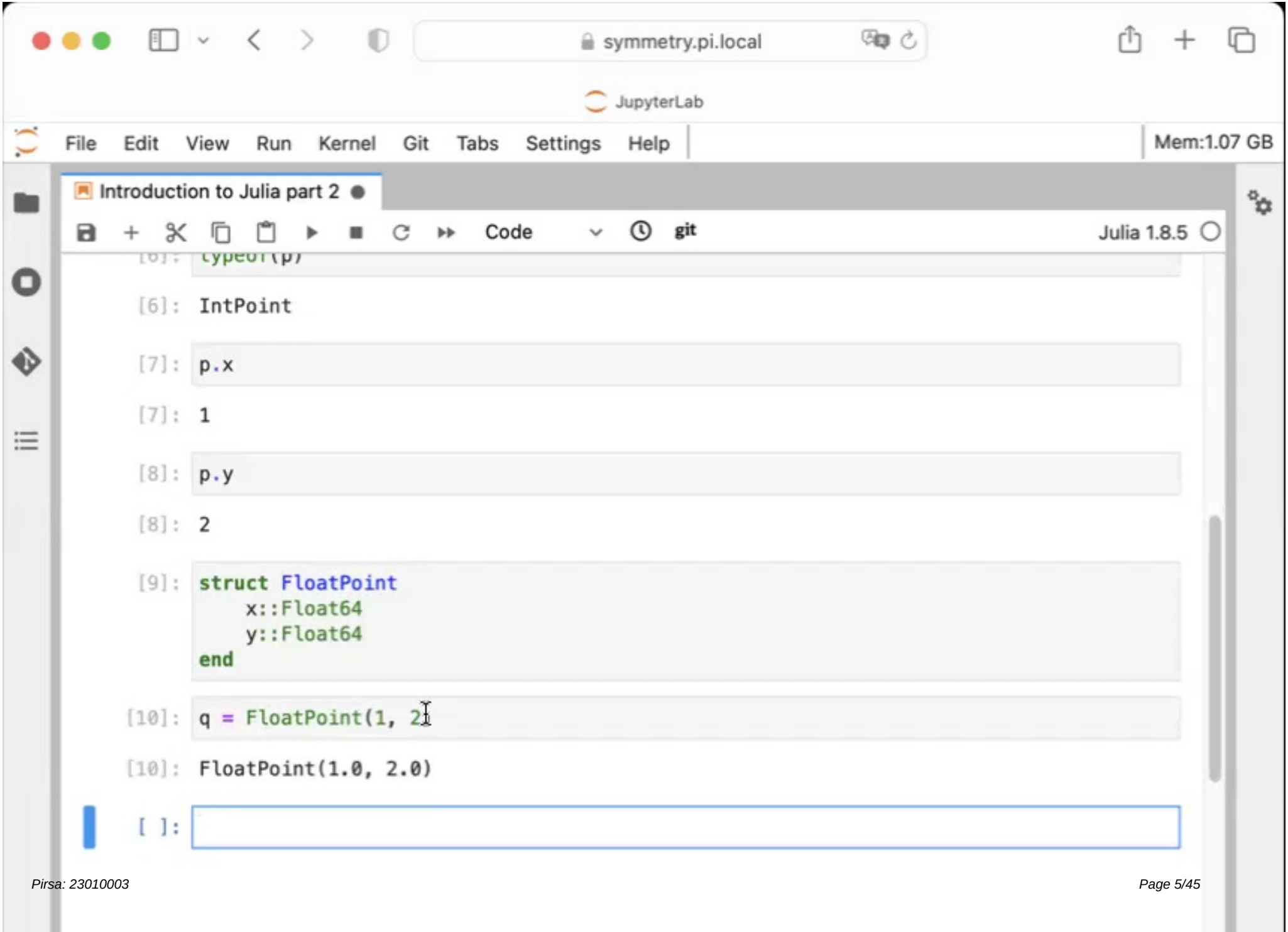
Introduction to Julia part 2
Code
git
Julia 1.8.5
Introduction to Julia, part 2
Erik Schnetter, 2023-01-12
Plan for today:
defining types in Julia
defining packages in Julia
Types
[3]:
struct IntPoint
x::Int
y::Int
end
[*]:
IntPoint(1, 2)
[ ]: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JupyterLab
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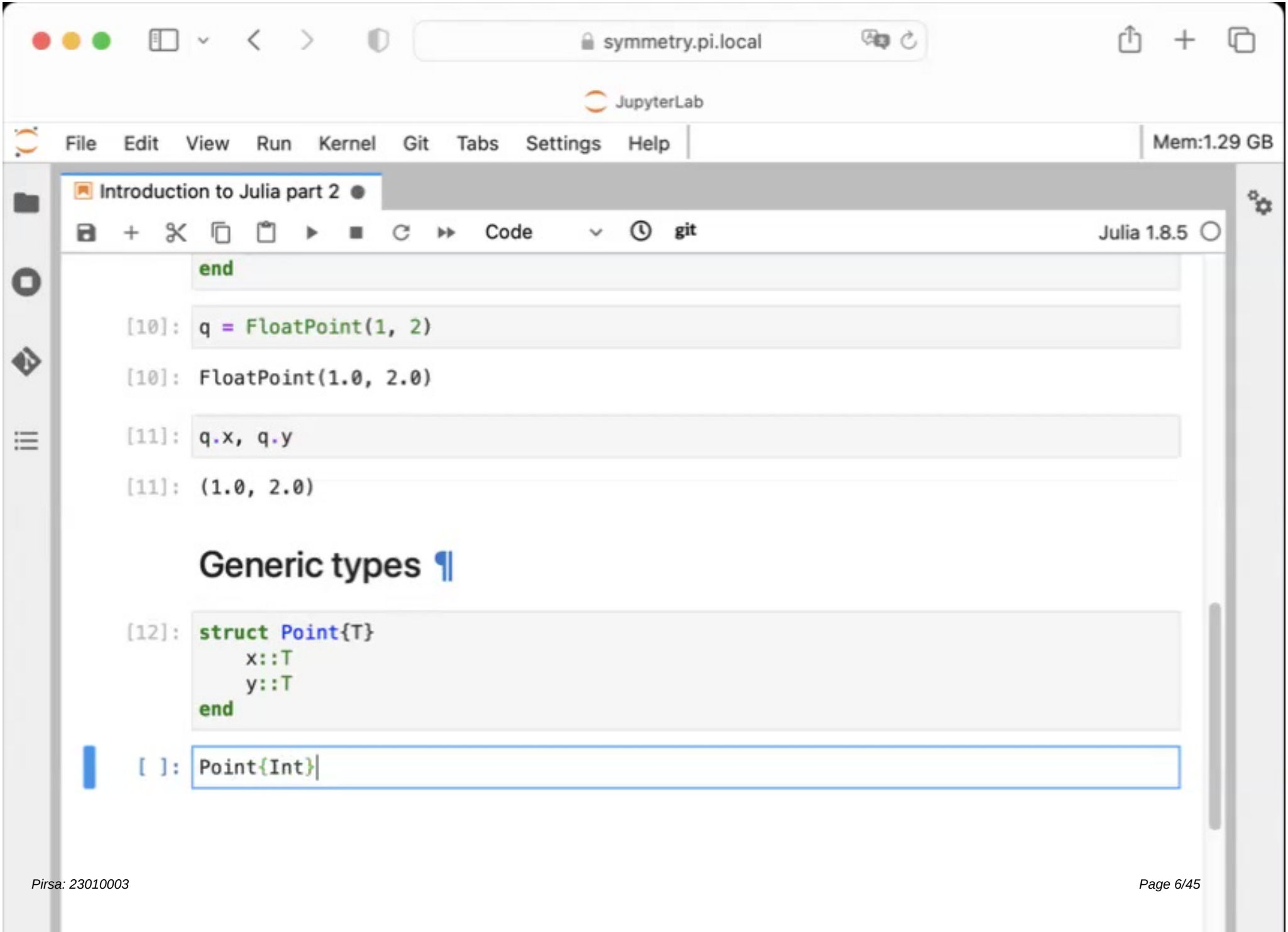
Introduction to Julia part 2
Code
git
Julia 1.8.5
[6]: typeof(p)
[6]: IntPoint
[7]: p.x
[7]: 1
[8]: p.y
[8]: 2
[9]: struct FloatPoint
x::Float64
y::Float64
end
[10]: q = FloatPoint(1, 2
[10]: FloatPoint(1.0, 2.0)
[ ]:


symmetry.pi.local
JupyterLab
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Introduction to Julia part 2
Code
git
Julia 1.8.5
end
[10]: q = FloatPoint(1, 2)
[10]: FloatPoint(1.0, 2.0)
[11]: q.x, q.y
[11]: (1.0, 2.0)
Generic types ¶
[12]: struct Point{T}
x::T
y::T
end
[ ]: Point{Int}

symmetry.pi.local

JupyterLab

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Introduction to Julia part 2 ●

Code git Julia 1.8.5

[10]: FloatPoint(1.0, 2.0)

[11]:
```
q.x, q.y
```

[11]:
```
(1.0, 2.0)
```

Generic types

[12]:
```
struct Point{T}
    x::T
    y::T
end
```

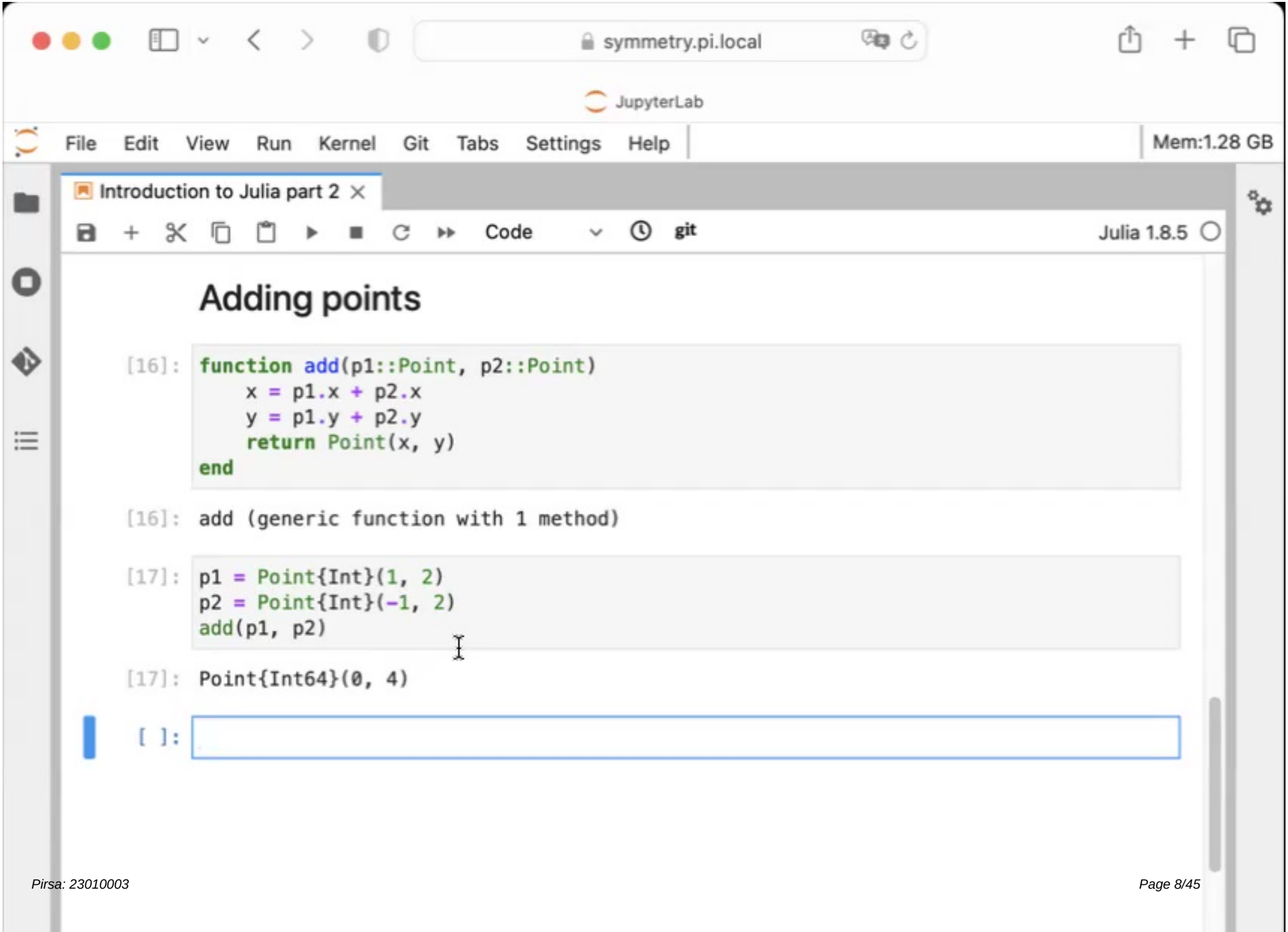
[13]:
```
Point{Int}(1, 2)
```

[13]:
```
Point{Int64}(1, 2)
```

[14]:
```
Point{Float64}(1, 2)
```

[14]:
```
Point{Float64}(1.0, 2.0)
```

[ ]: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JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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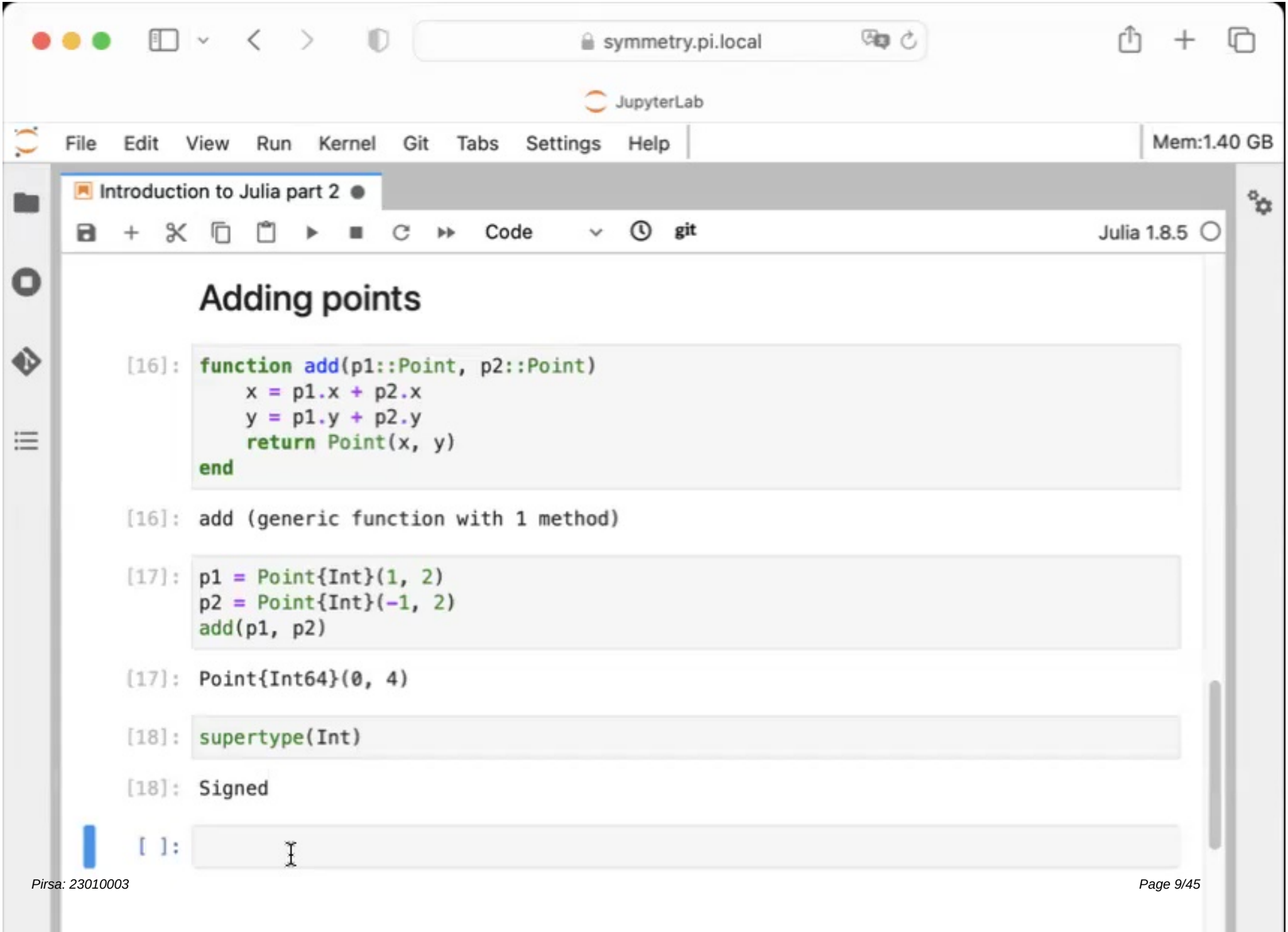
Introduction to Julia part 2
Code
git
Julia 1.8.5
Adding points
[16]:
function add(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[16]:
add (generic function with 1 method)
[17]:
p1 = Point{Int}(1, 2)
p2 = Point{Int}(-1, 2)
add(p1, p2)
[17]:
Point{Int64}(0, 4)
[ ]: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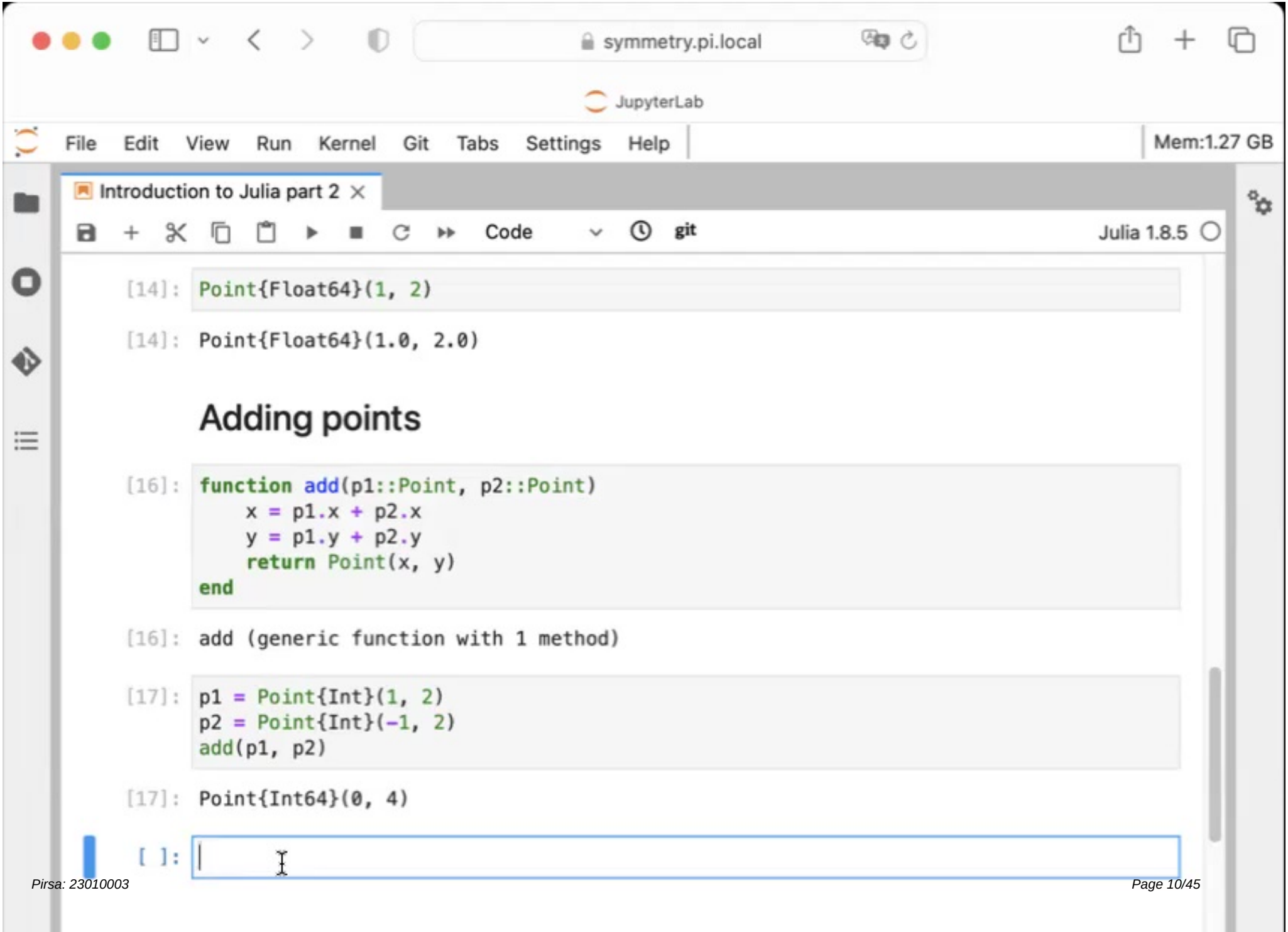
Introduction to Julia part 2
Code
git
Julia 1.8.5
Adding points
[16]:
function add(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[16]:
add (generic function with 1 method)
[17]:
p1 = Point{Int}(1, 2)
p2 = Point{Int}(-1, 2)
add(p1, p2)
[17]:
Point{Int64}(0, 4)
[18]:
supertype(Int)
[18]:
Signed
[ ]: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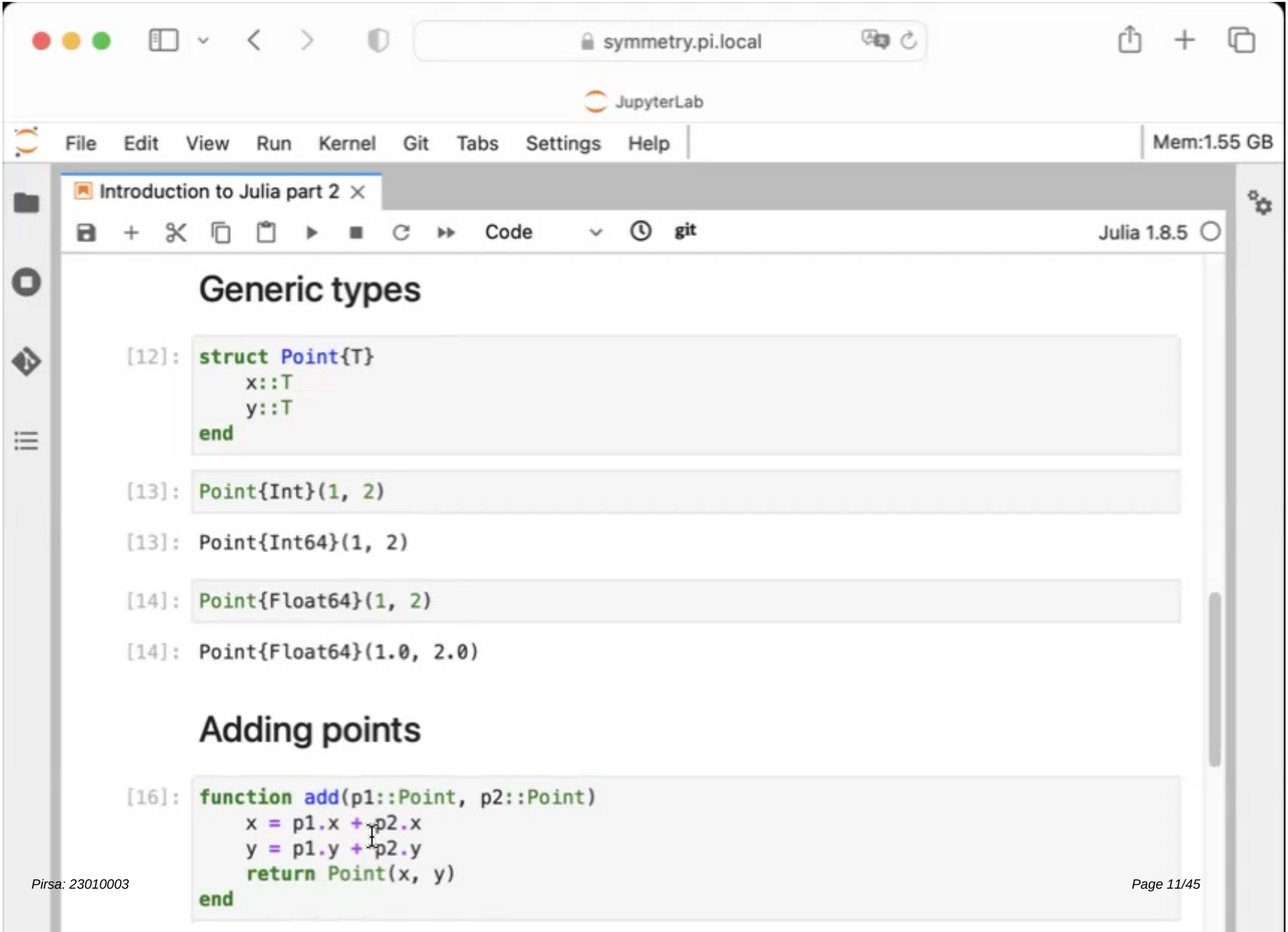
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.27 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
[14]: Point{Float64}(1, 2)
[14]: Point{Float64}(1.0, 2.0)
Adding points
[16]: function add(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[16]: add (generic function with 1 method)
[17]: p1 = Point{Int}(1, 2)
p2 = Point{Int}(-1, 2)
add(p1, p2)
[17]: Point{Int64}(0, 4)
[ ]:


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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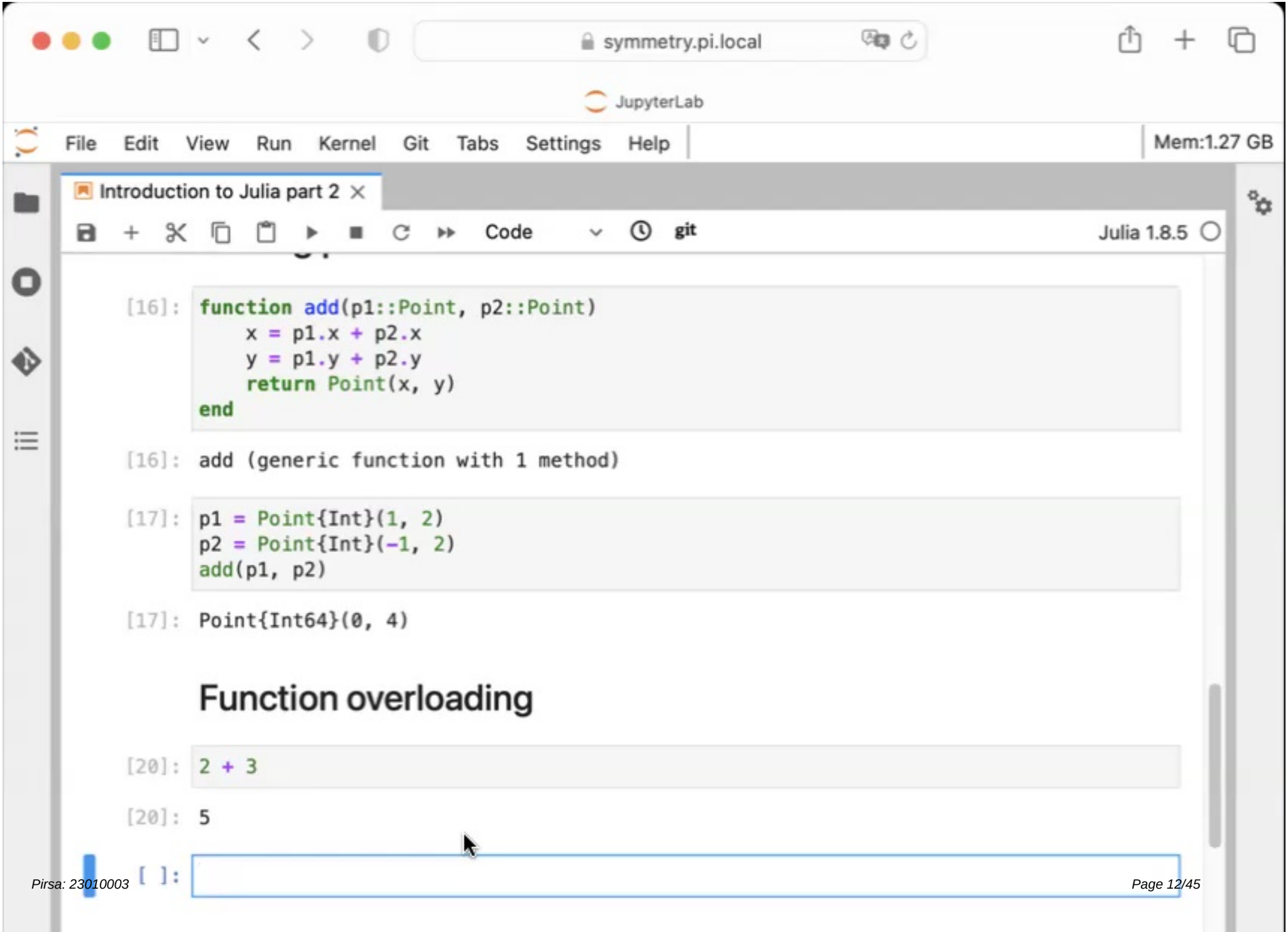
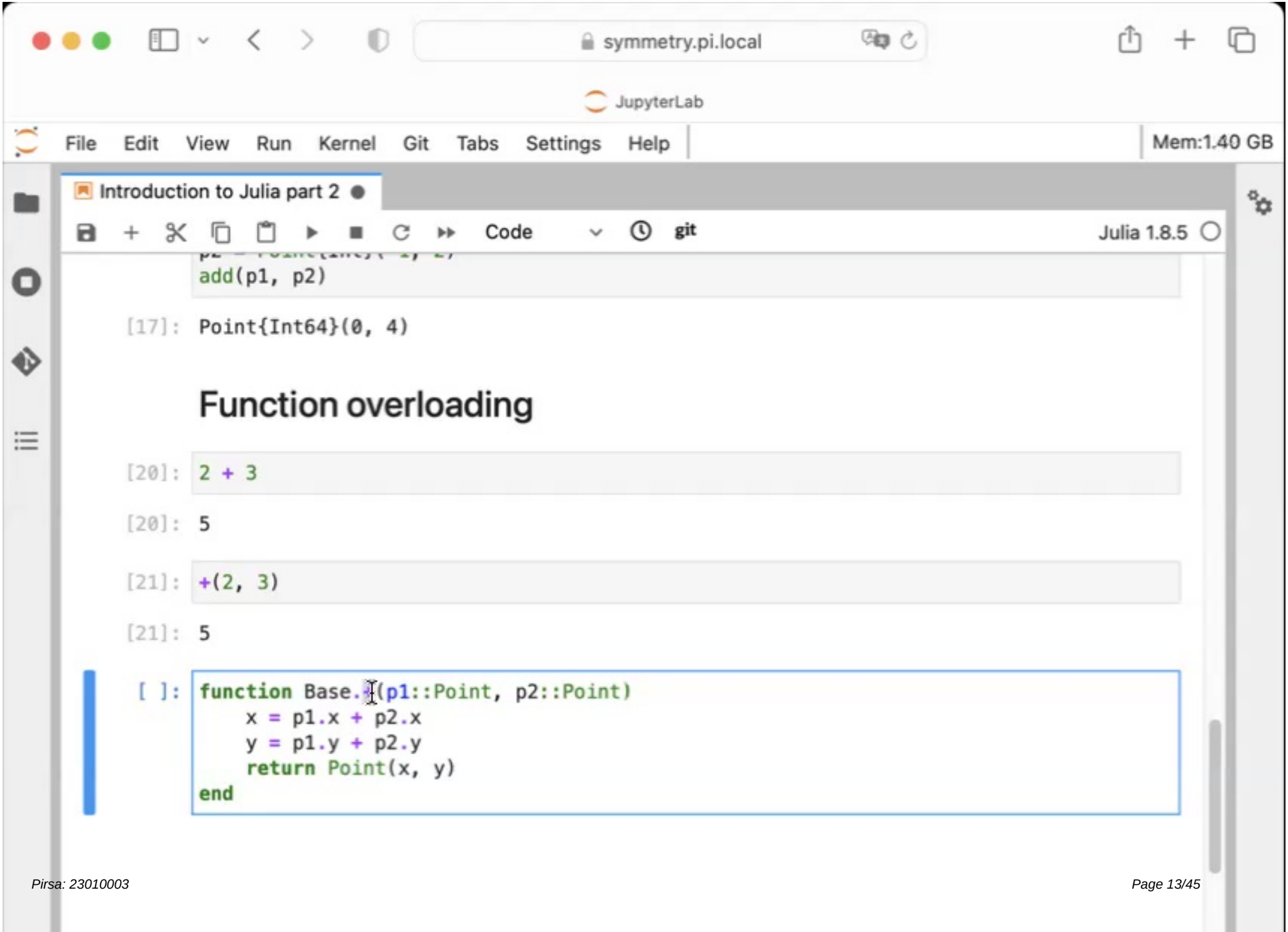
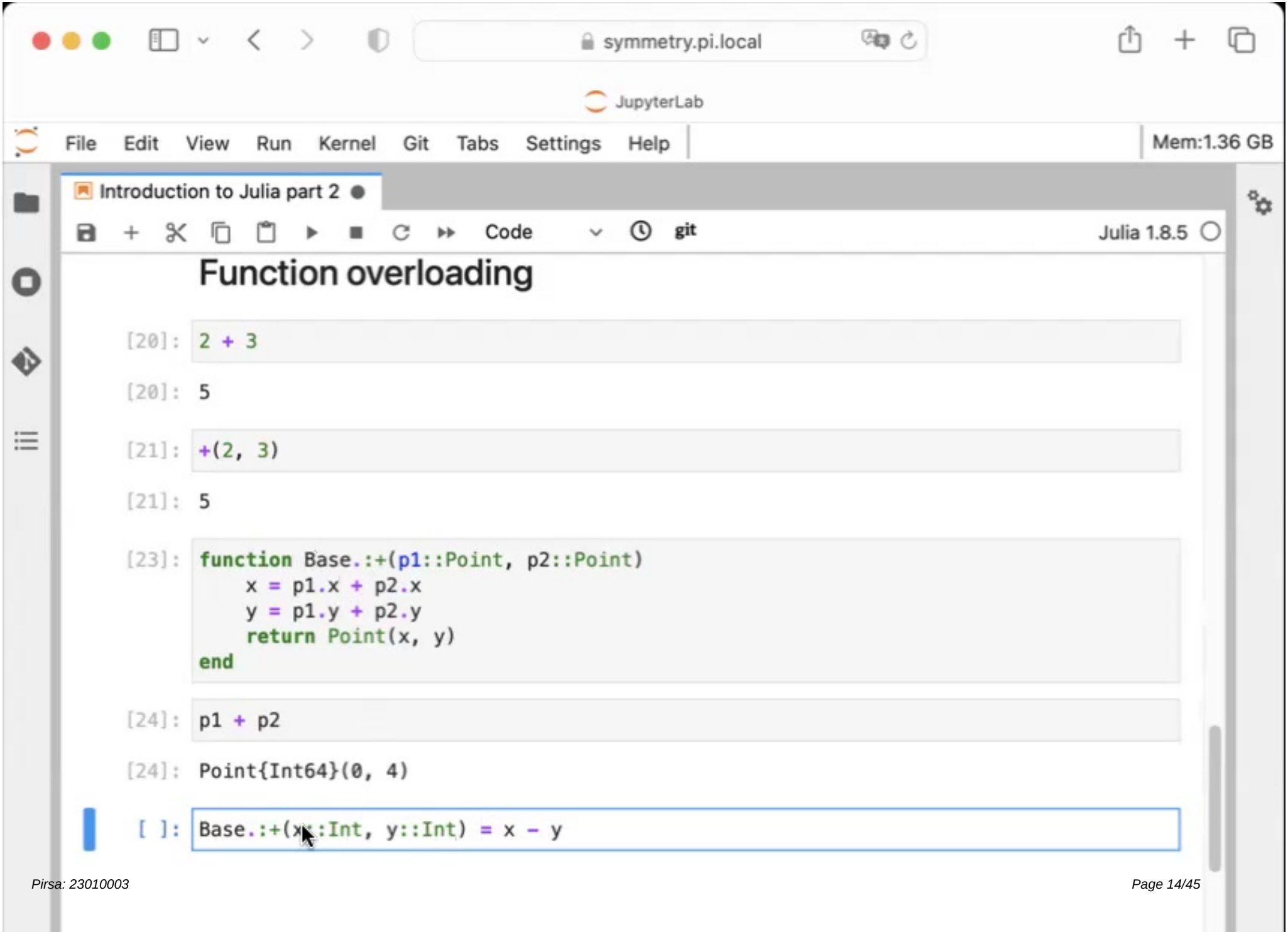
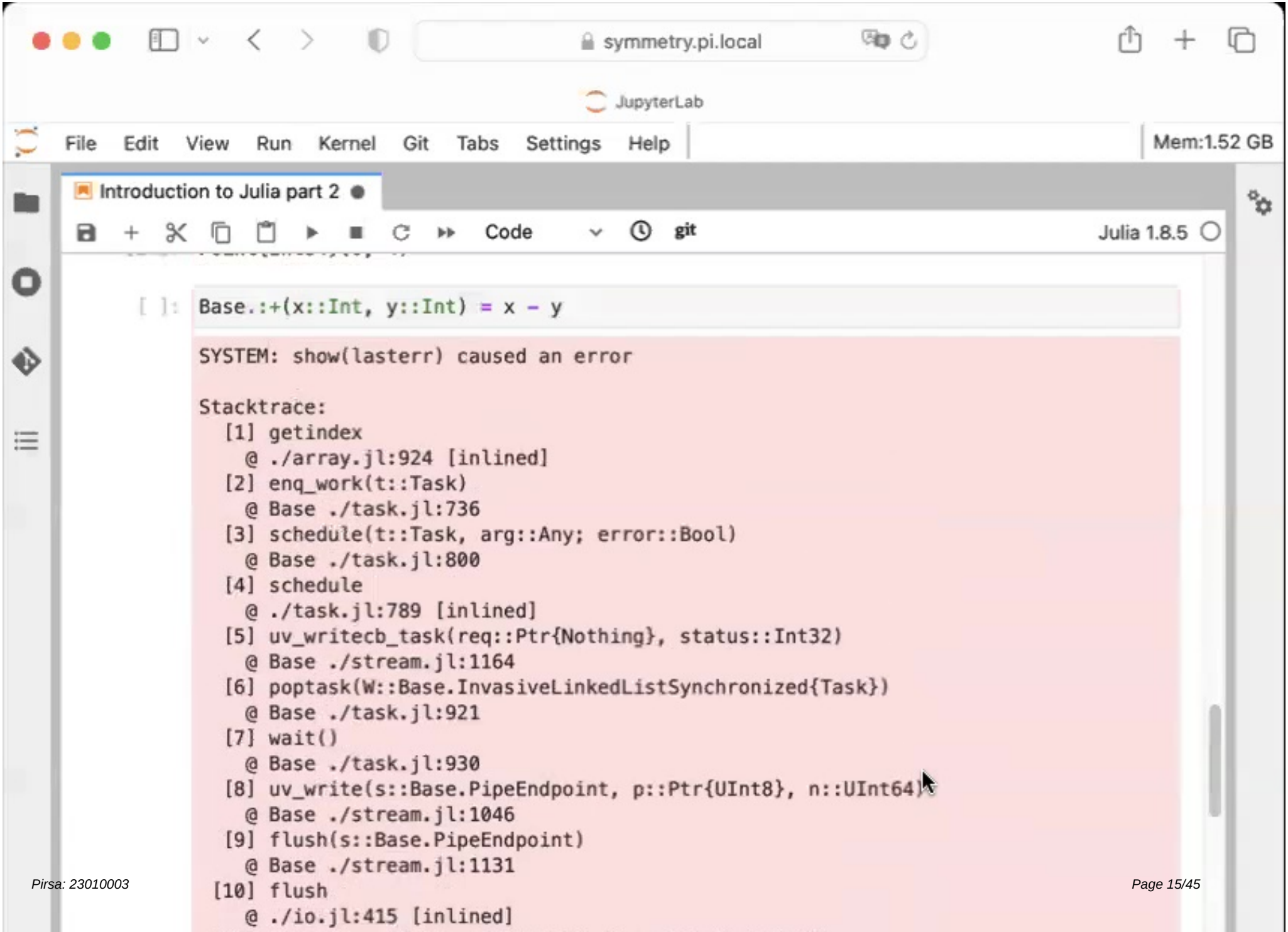
Introduction to Julia part 2
Code
git
Julia 1.8.5
Generic types
[12]:
struct Point{T}
x::T
y::T
end
[13]:
Point{Int}(1, 2)
[13]:
Point{Int64}(1, 2)
[14]:
Point{Float64}(1, 2)
[14]:
Point{Float64}(1.0, 2.0)
Adding points
[16]:
function add(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.27 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
[16]:
function add(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[16]:
add (generic function with 1 method)
[17]:
p1 = Point{Int}(1, 2)
p2 = Point{Int}(-1, 2)
add(p1, p2)
[17]:
Point{Int64}(0, 4)
Function overloading
[20]:
2 + 3
[20]:
5
[ ]:


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.40 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
add(p1, p2)
[17]: Point{Int64}(0, 4)
Function overloading
[20]: 2 + 3
[20]: 5
[21]: +(2, 3)
[21]: 5
[ ]: function Base.+(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.36 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
Function overloading
[20]: 2 + 3
[20]: 5
[21]: +(2, 3)
[21]: 5
[23]: function Base.:+(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[24]: p1 + p2
[24]: Point{Int64}(0, 4)
[ ]: Base.:+(x::Int, y::Int) = x - y


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.52 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
[ ]:
Base.:+(x::Int, y::Int) = x - y
SYSTEM: show(lasterr) caused an error
Stacktrace:
[1] getindex
@ ./array.jl:924 [inlined]
[2] enq_work(t::Task)
@ Base ./task.jl:736
[3] schedule(t::Task, arg::Any; error::Bool)
@ Base ./task.jl:800
[4] schedule
@ ./task.jl:789 [inlined]
[5] uv_writecb_task(req::Ptr{Nothing}, status::Int32)
@ Base ./stream.jl:1164
[6] poptask(W::Base.InvasiveLinkedListSynchronized{Task})
@ Base ./task.jl:921
[7] wait()
@ Base ./task.jl:930
[8] uv_write(s::Base.PipeEndpoint, p::Ptr{UInt8}, n::UInt64)
@ Base ./stream.jl:1046
[9] flush(s::Base.PipeEndpoint)
@ Base ./stream.jl:1131
[10] flush
@ ./io.jl:415 [inlined]

symmetry.pi.local

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Introduction to Julia part 2 ●

Code git Julia 1.8.5

[5]:
```
p.y
```

[5]:
```
2
```

[6]:
```
struct FloatPoint
    x::Float64
    y::Float64
end
```

[7]:
```
q = FloatPoint(1, 2)
```

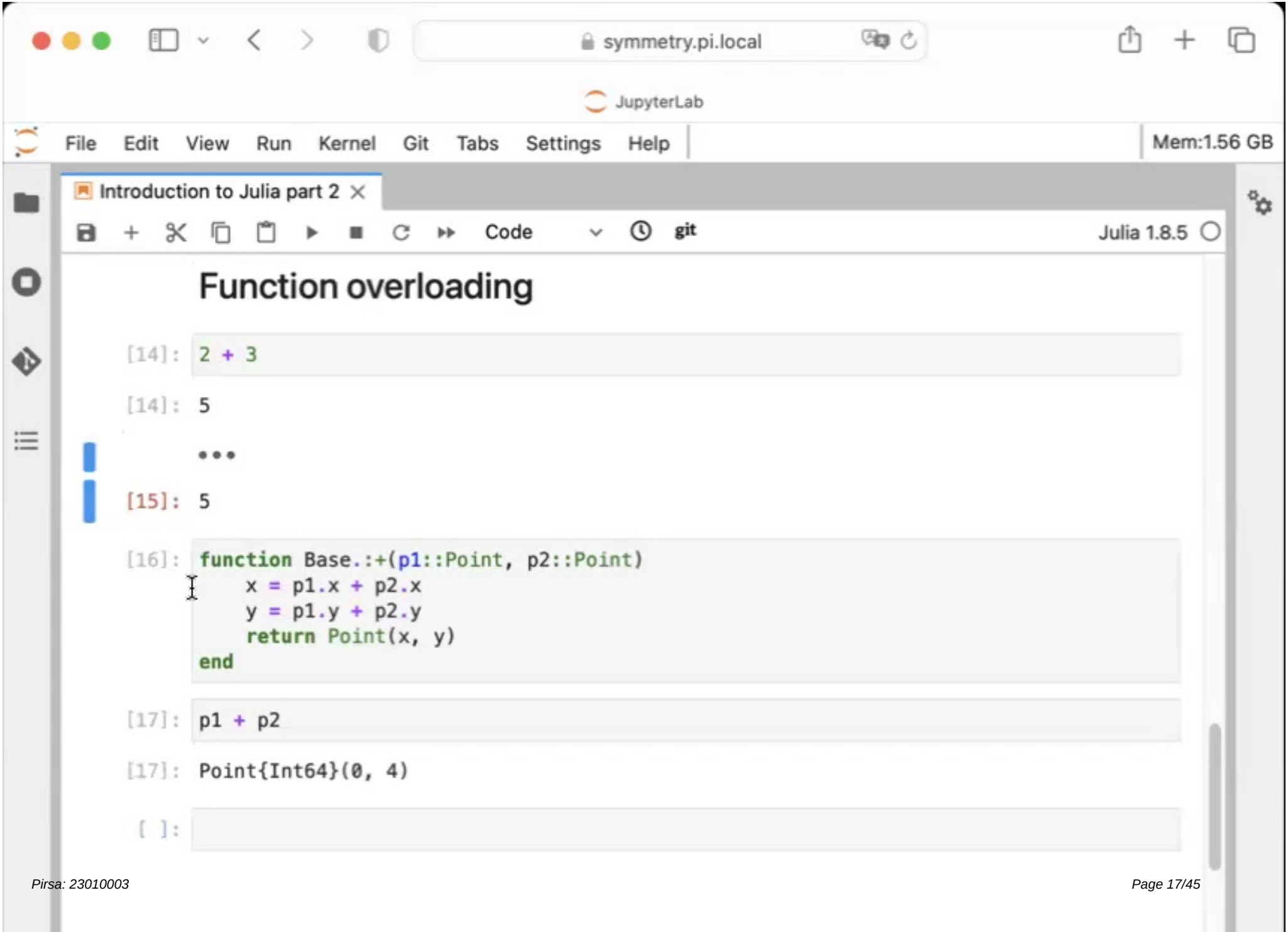
[7]:
```
FloatPoint(1.0, 2.0)
```

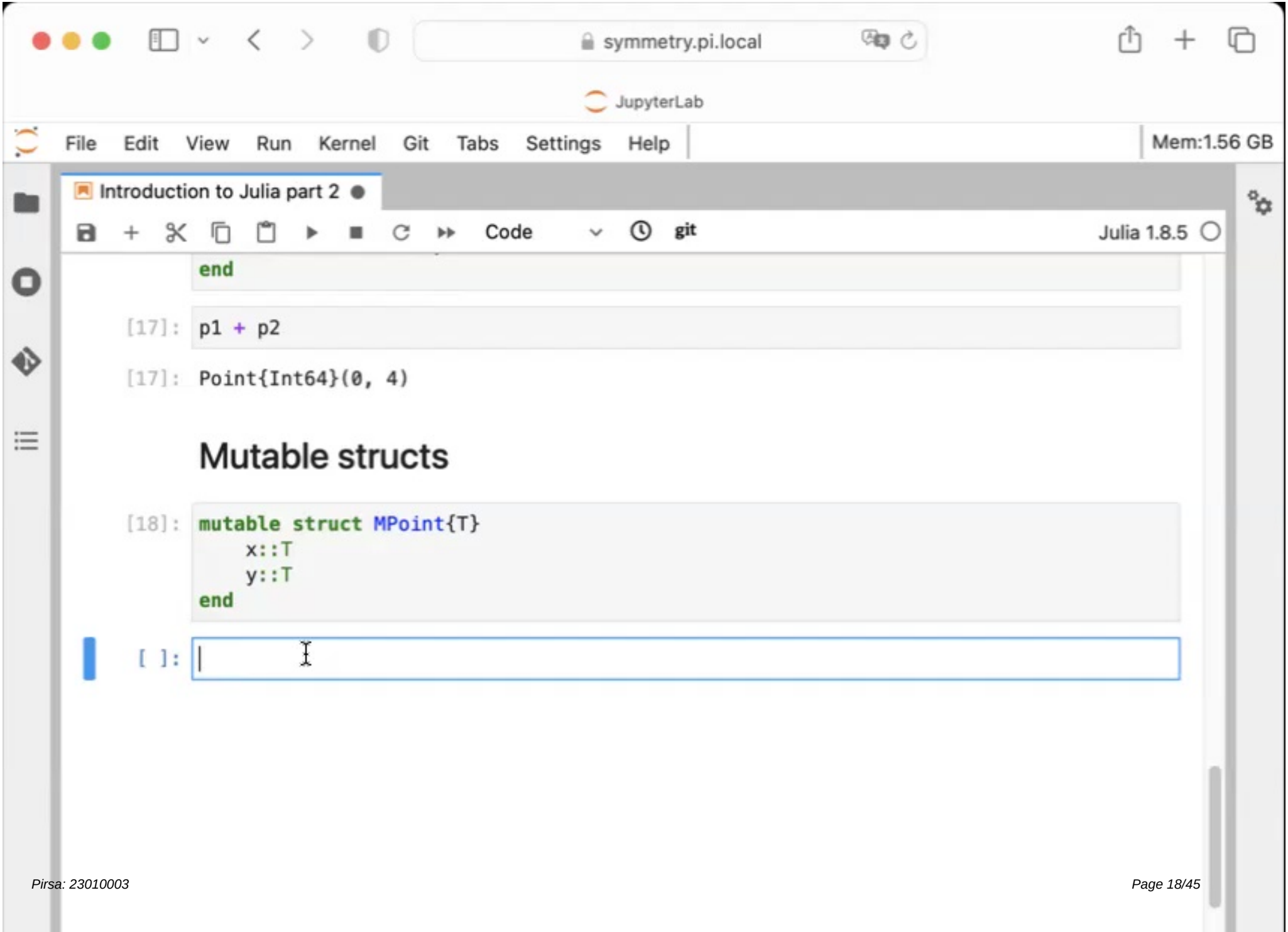
[8]:
```
q.x, q.y
```

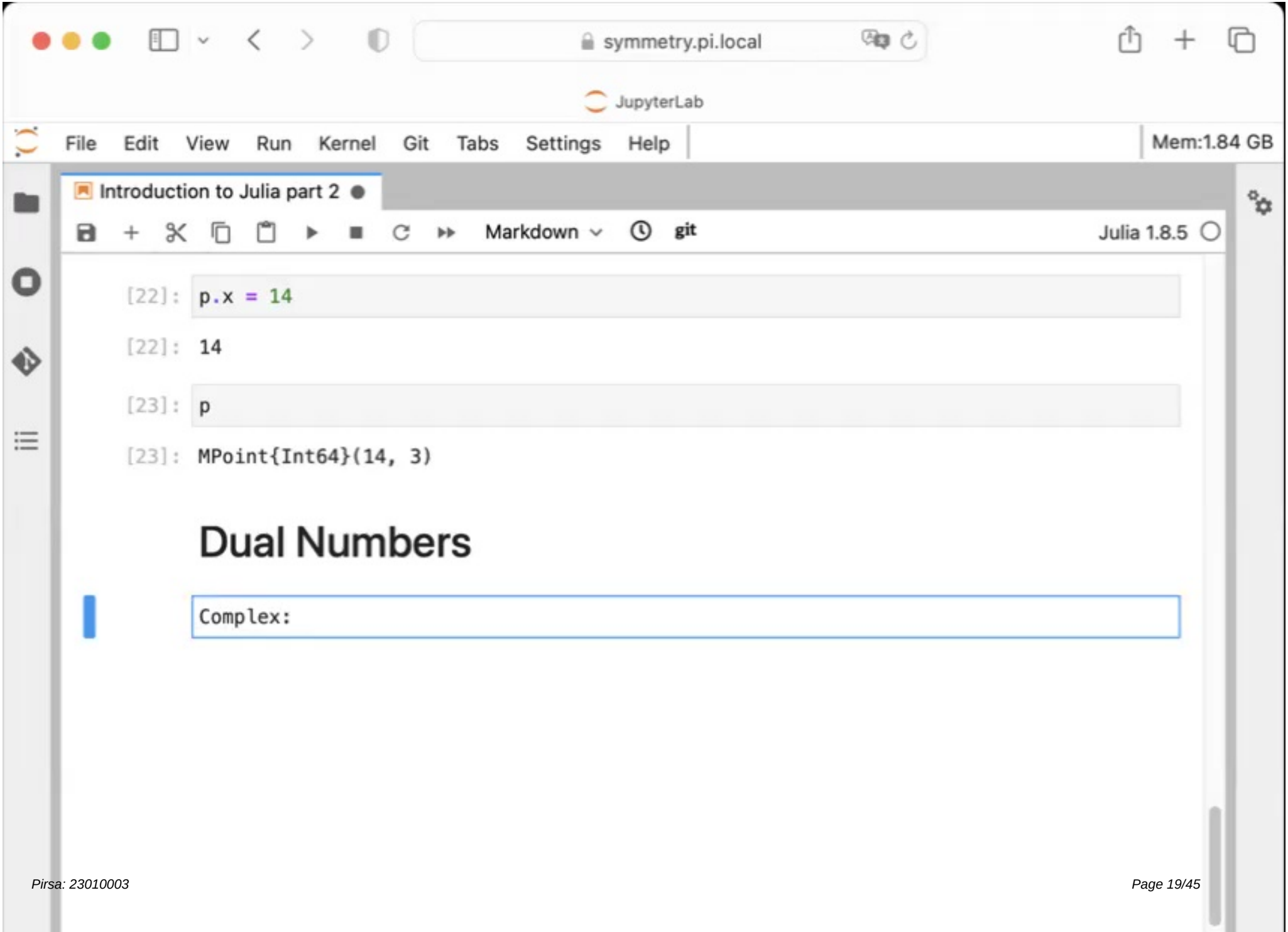
[8]:
```
(1.0, 2.0)
```

Generic types

[9]:
```
struct Point{T}
    x::T
    y::T
end
```


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.56 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
Function overloading
[14]: 2 + 3
[14]: 5
[15]: 5
[16]: function Base.:+(p1::Point, p2::Point)
x = p1.x + p2.x
y = p1.y + p2.y
return Point(x, y)
end
[17]: p1 + p2
[17]: Point{Int64}(0, 4)
[ ]:


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.56 GB
Introduction to Julia part 2
Code
git
Julia 1.8.5
end
[17]: p1 + p2
[17]: Point{Int64}(0, 4)
Mutable structs
[18]: mutable struct MPoint{T}
x::T
y::T
end
[ ]: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JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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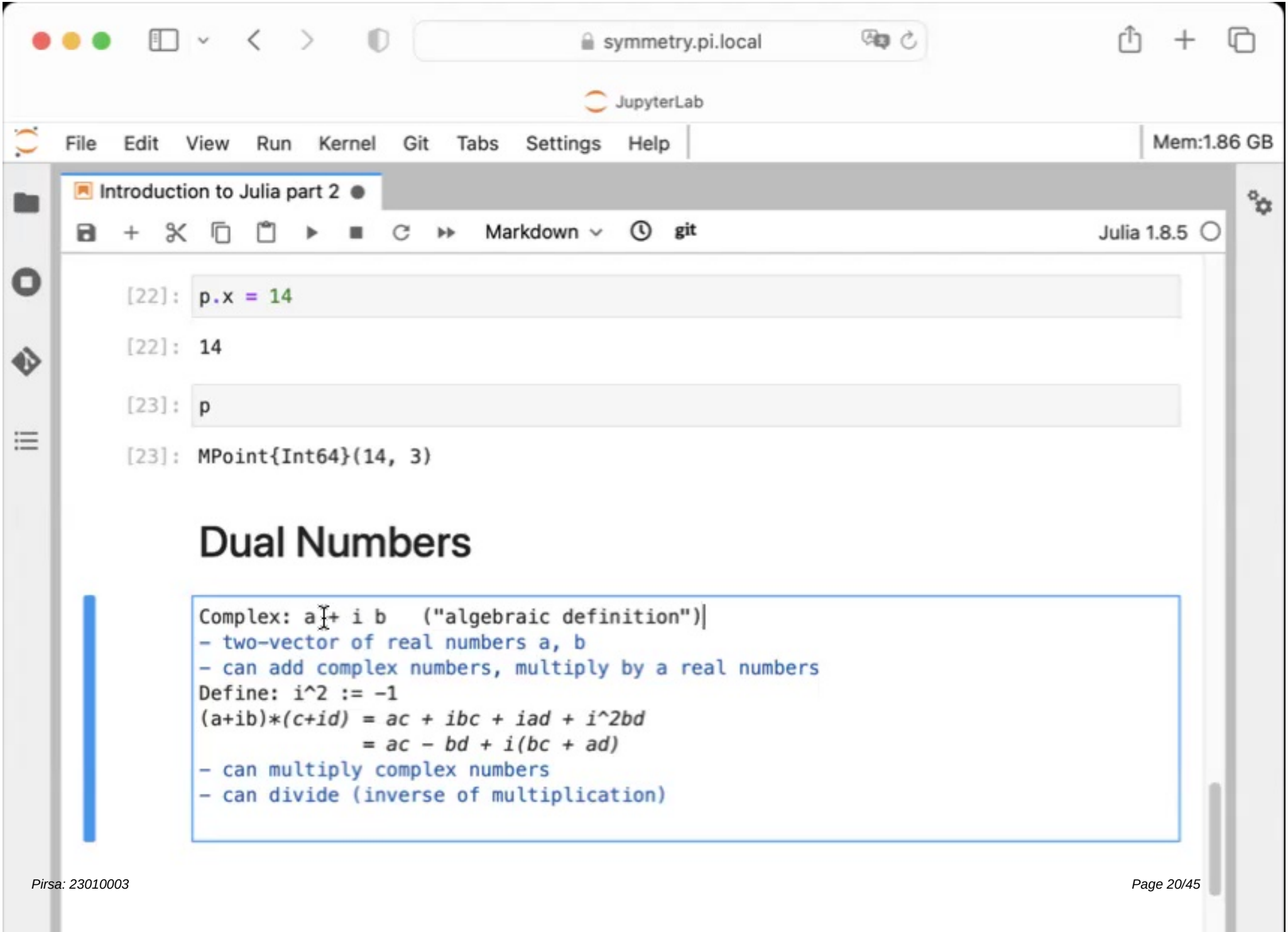
Introduction to Julia part 2
Markdown
git
Julia 1.8.5
[22]: p.x = 14
[22]: 14
[23]: p
[23]: MPoint{Int64}(14, 3)
Dual Numbers
Complex: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JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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Introduction to Julia part 2
Markdown
git
Julia 1.8.5
[22]: p.x = 14
[22]: 14
[23]: p
[23]: MPoint{Int64}(14, 3)
Dual Numbers
Complex: a + i b ("algebraic definition")
- two-vector of real numbers a, b
- can add complex numbers, multiply by a real numbers
Define: i^2 := -1
(a+ib)*(c+id) = ac + ibc + iad + i^2bd
= ac - bd + i(bc + ad)
- can multiply complex numbers
- can divide (inverse of multiplication)

symmetry.pi.local

JupyterLab

File Edit View Run Kernel Git Tabs Settings Help Mem:1.68 GB

Introduction to Julia part 2 ●

Markdown git Julia 1.8.5

[22]: 14

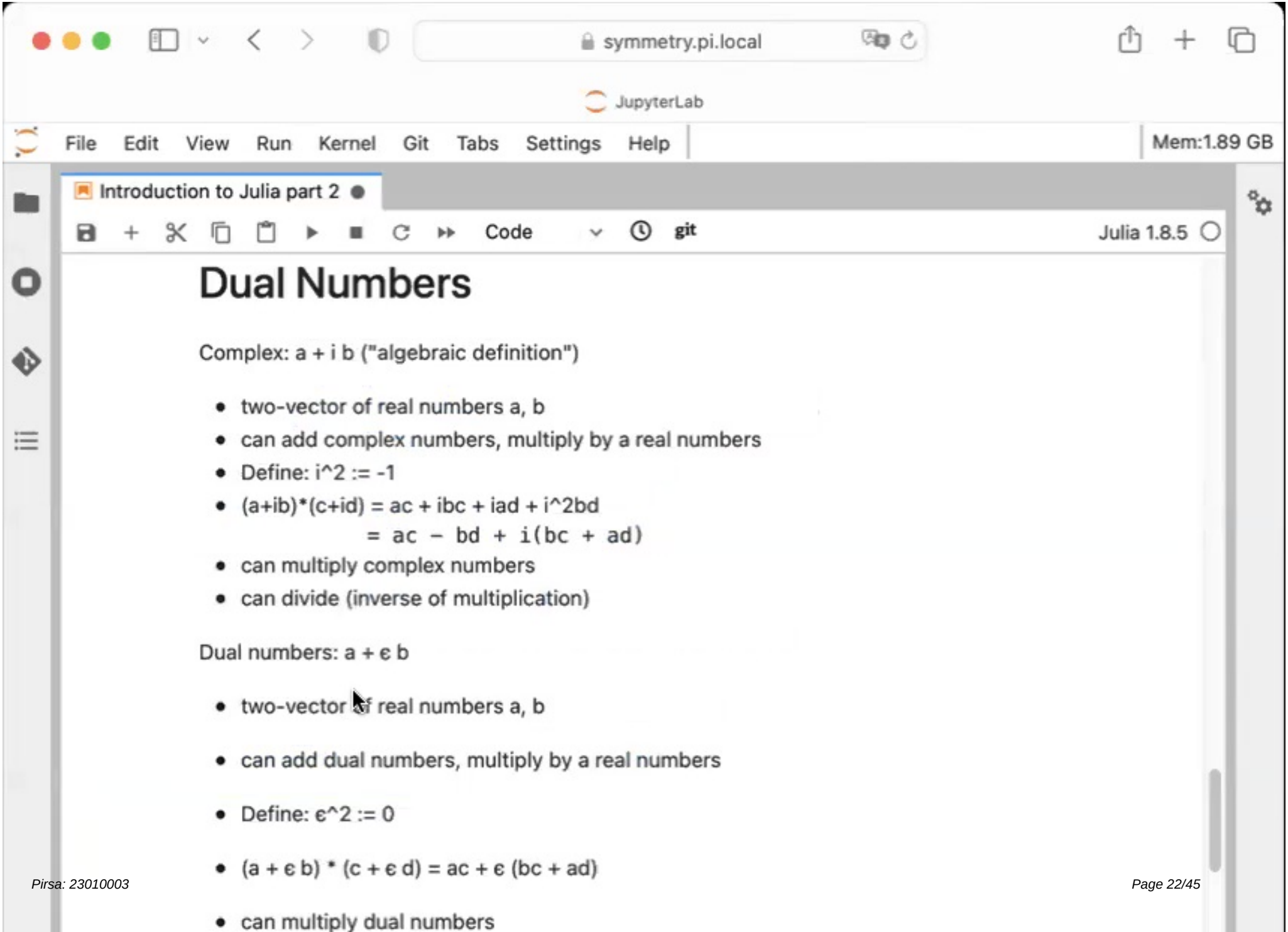
[23]: p

[23]: MPoint{Int64}(14, 3)

Dual Numbers

```
Complex: a + i b   ("algebraic definition")
- two-vector of real numbers a, b
- can add complex numbers, multiply by a real numbers
Define: i^2 := -1
(a+ib)*(c+id) = ac + ibc + iad + i^2bd
              = ac - bd + i(bc + ad)
- can multiply complex numbers
- can divide (inverse of multiplication)

Dual numbers: a + ϵ b
- two-vector of real numbers a, b
- can add dual numbers, multiply by a real numbers
Define: ϵ^2 := 0
(a + ϵ b) * (c + ϵ d) = ac + ϵ (bc + ad
```


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
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Introduction to Julia part 2
Code
git
Julia 1.8.5
Dual Numbers
Complex: a + i b ("algebraic definition")
two-vector of real numbers a, b
can add complex numbers, multiply by a real numbers
Define: i^2 := -1
(a+ib)*(c+id) = ac + ibc + iad + i^2bd
= ac − bd + i(bc + ad)
can multiply complex numbers
can divide (inverse of multiplication)
Dual numbers: a + ϵ b
two-vector of real numbers a, b
can add dual numbers, multiply by a real numbers
Define: ϵ^2 := 0
(a + ϵ b) * (c + ϵ d) = ac + ϵ (bc + ad)
can multiply dual numbers

symmetry.pi.local

JupyterLab

File Edit View Run Kernel Git Tabs Settings Help Mem:1.99 GB

Introduction to Julia part 2 ●

Code git Julia 1.8.5

Complex: a + i b ("algebraic definition")

- two-vector of real numbers a, b
- can add complex numbers, multiply by a real numbers
- Define: i^2 := -1
- (a+ib)*(c+id) = ac + ibc + iad + i^2bd
  = ac − bd + i(bc + ad)
- can multiply complex numbers
- can divide (inverse of multiplication)

Dual numbers: a + ϵ b

- two-vector of real numbers a, b
- can add dual numbers, multiply by a real numbers
- Define: ϵ^2 := 0
- (a + ϵ b) * (c + ϵ d) = ac + ϵ (bc + ad)
- can multiply dual numbers
- can divide (inverse of multiplication)

symmetry.pi.local

JupyterLab

File Edit View Run Kernel Git Tabs Settings Help Mem:2.13 GB

Introduction to Julia part 2 ●

Code git Julia 1.8.5

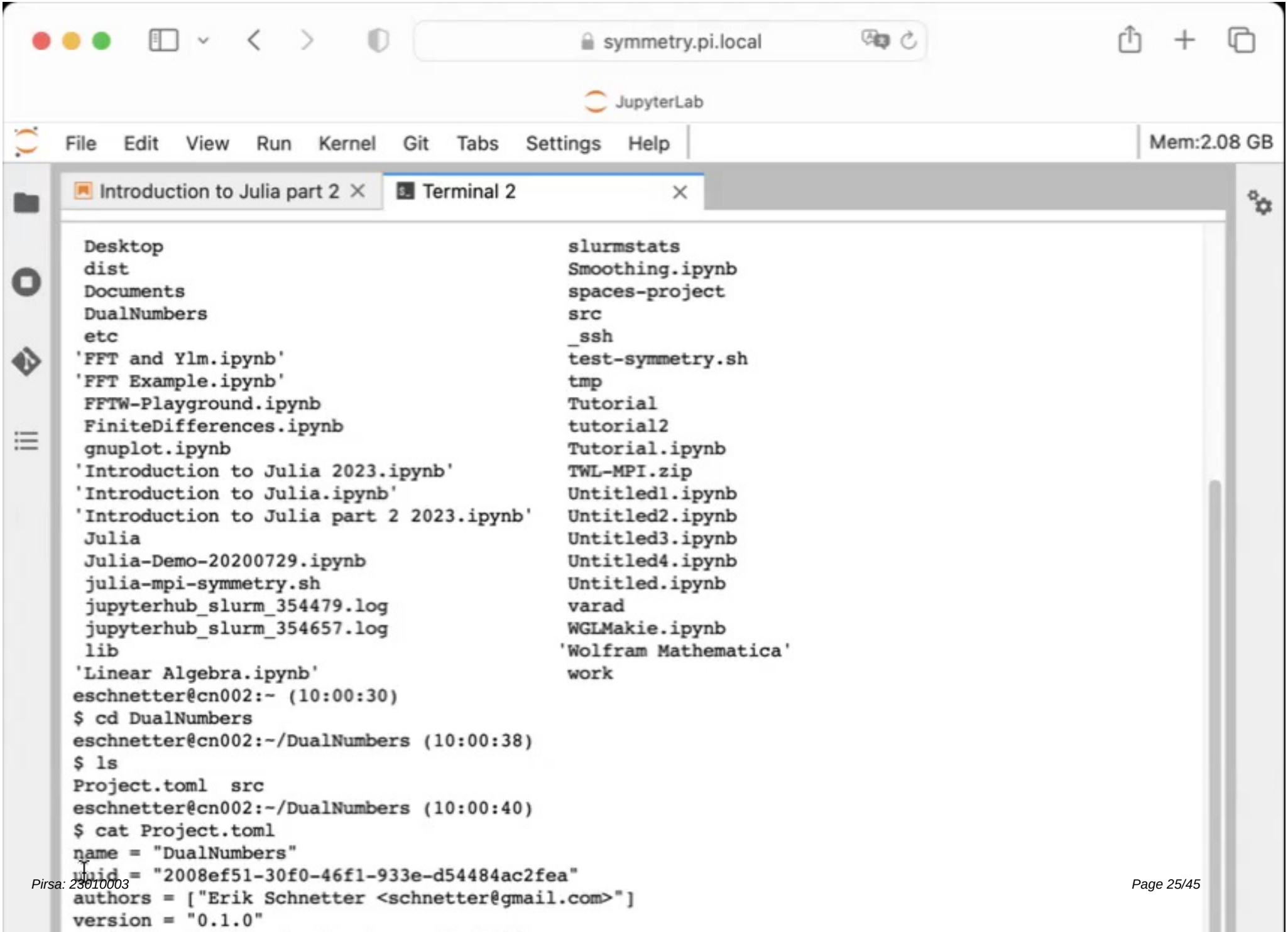
- (a+ib)*(c+id) = ac + ibc + iad + i^2bd
  = ac − bd + i(bc + ad)
- can multiply complex numbers
- can divide (inverse of multiplication)

Dual numbers: a + ϵ b

- two-vector of real numbers a, b
- can add dual numbers, multiply by a real numbers
- Define: ϵ^2 := 0
- (a + ϵ b) * (c + ϵ d) = ac + ϵ (bc + ad)
- can multiply dual numbers
- can divide (inverse of multiplication)

(x + ϵ)^n = x^n + ϵ n x^(n-1)

[ ]:


symmetry.pi.local
JupyterLab
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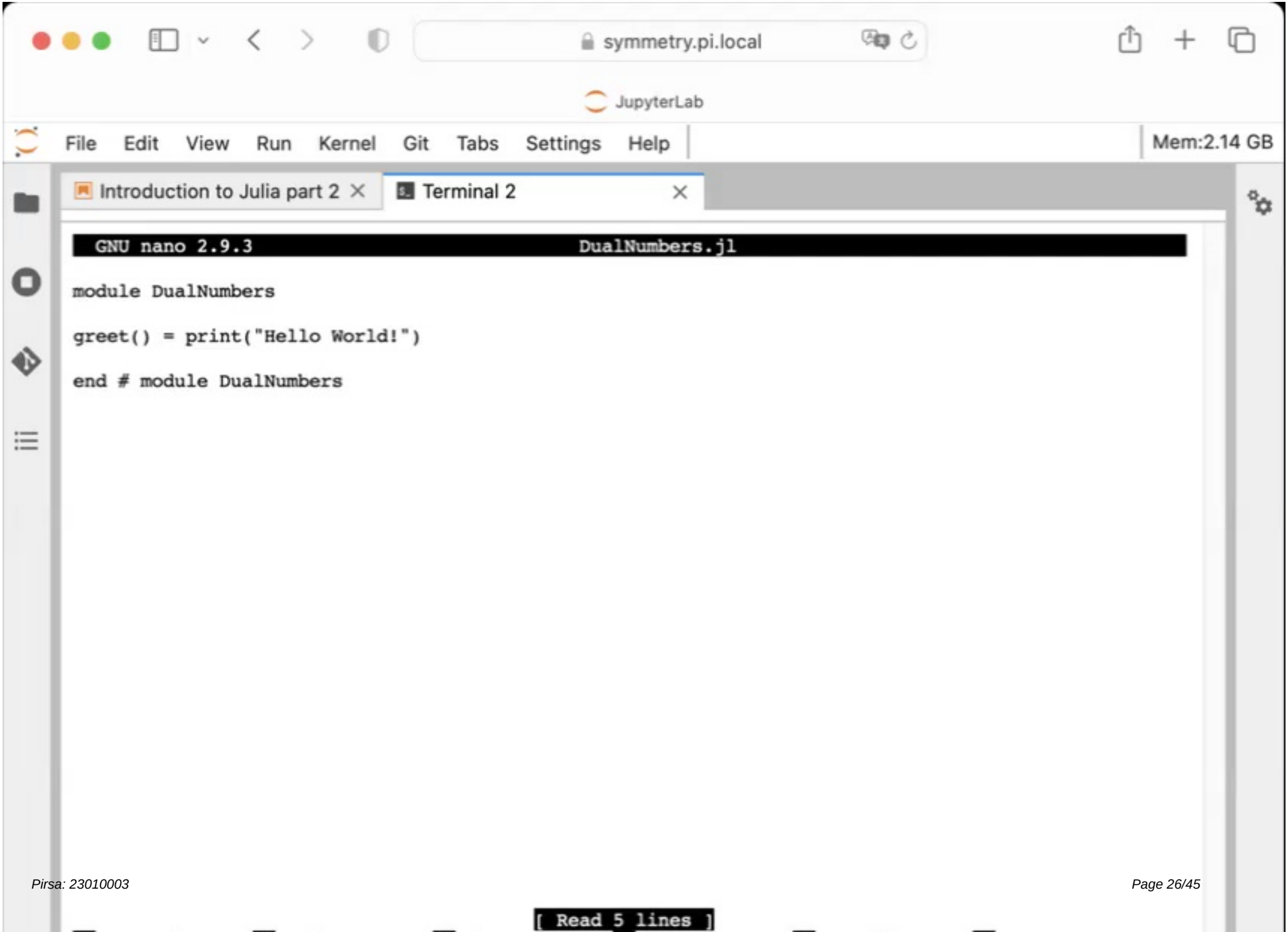
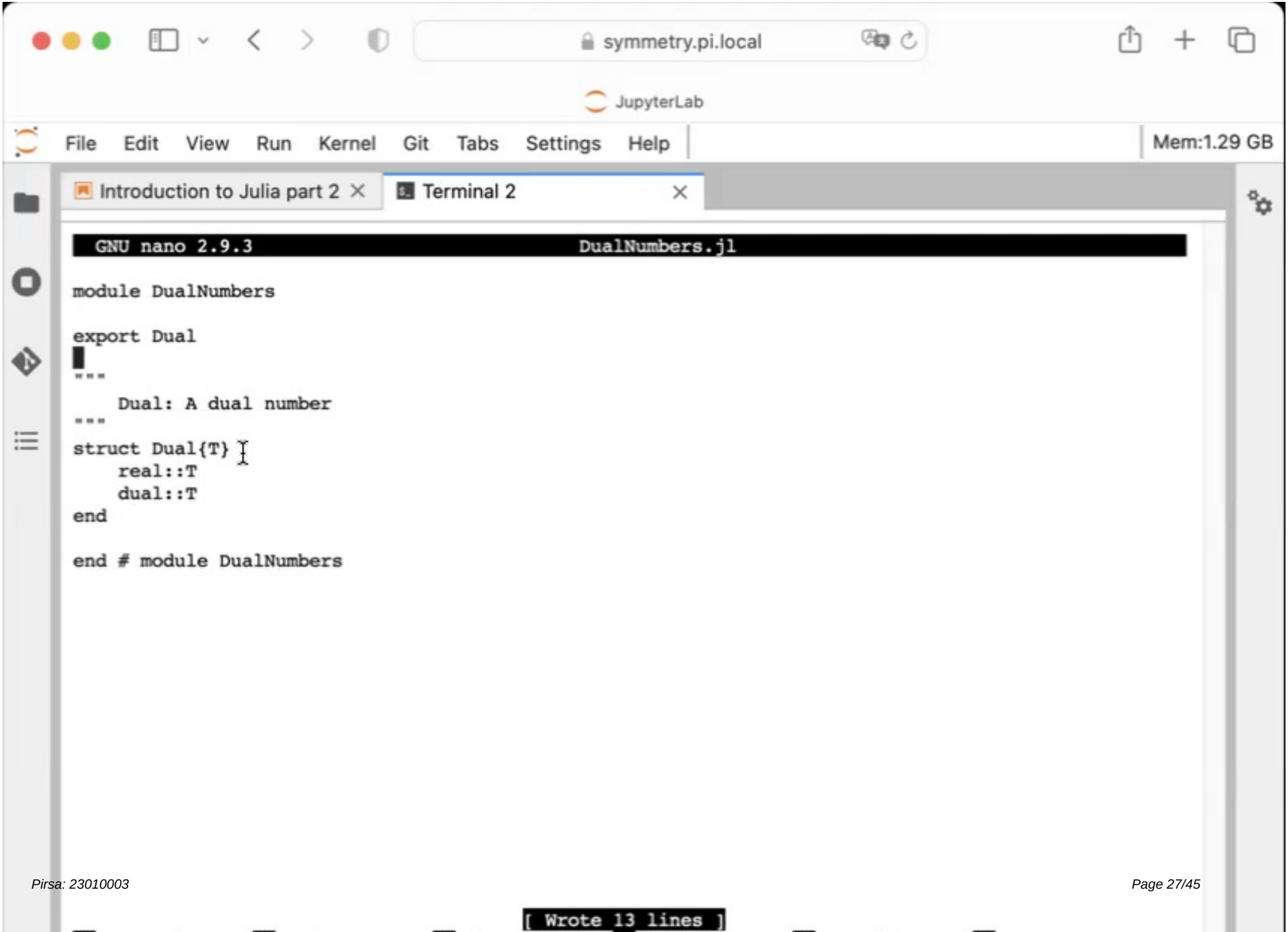
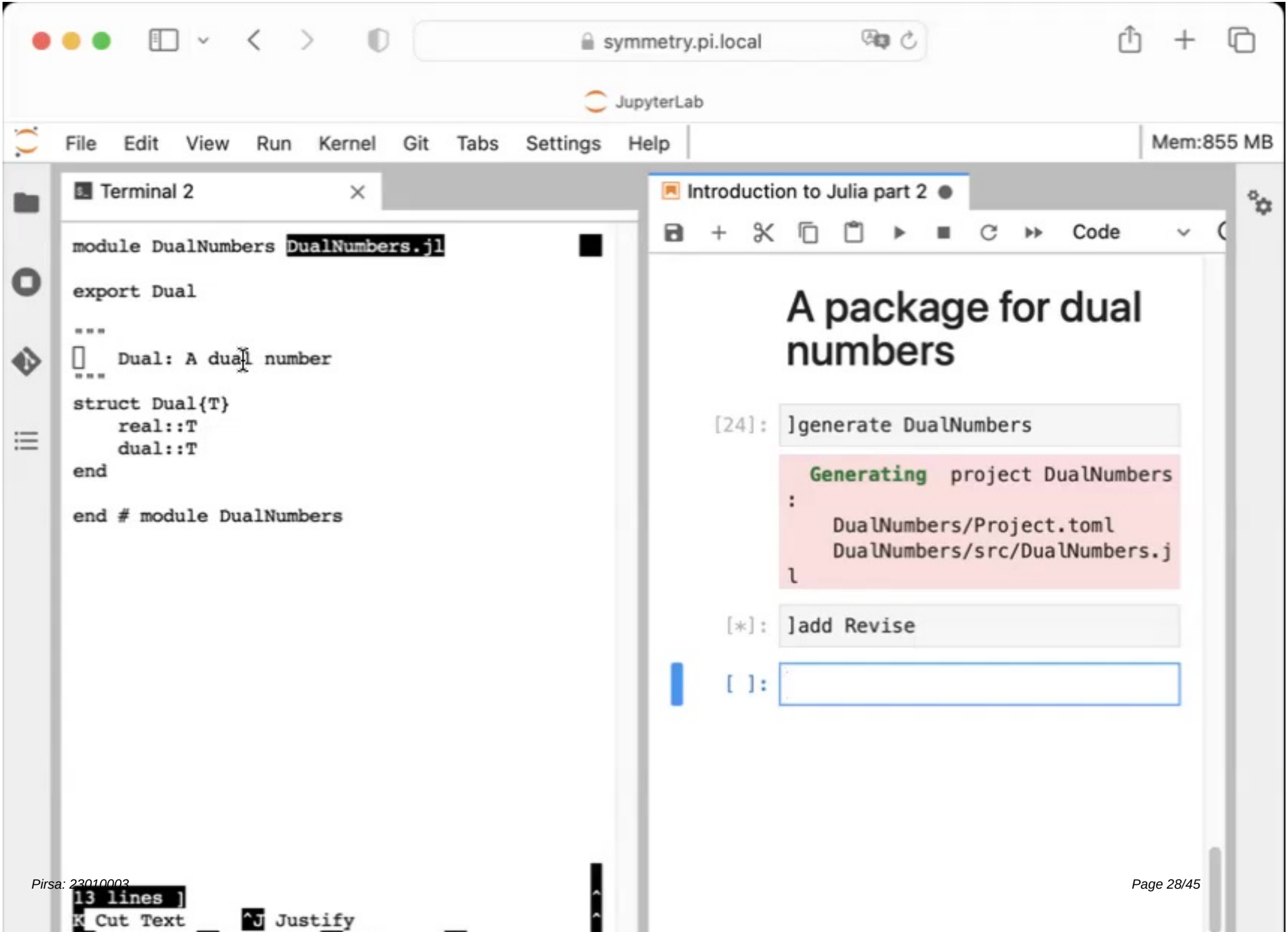
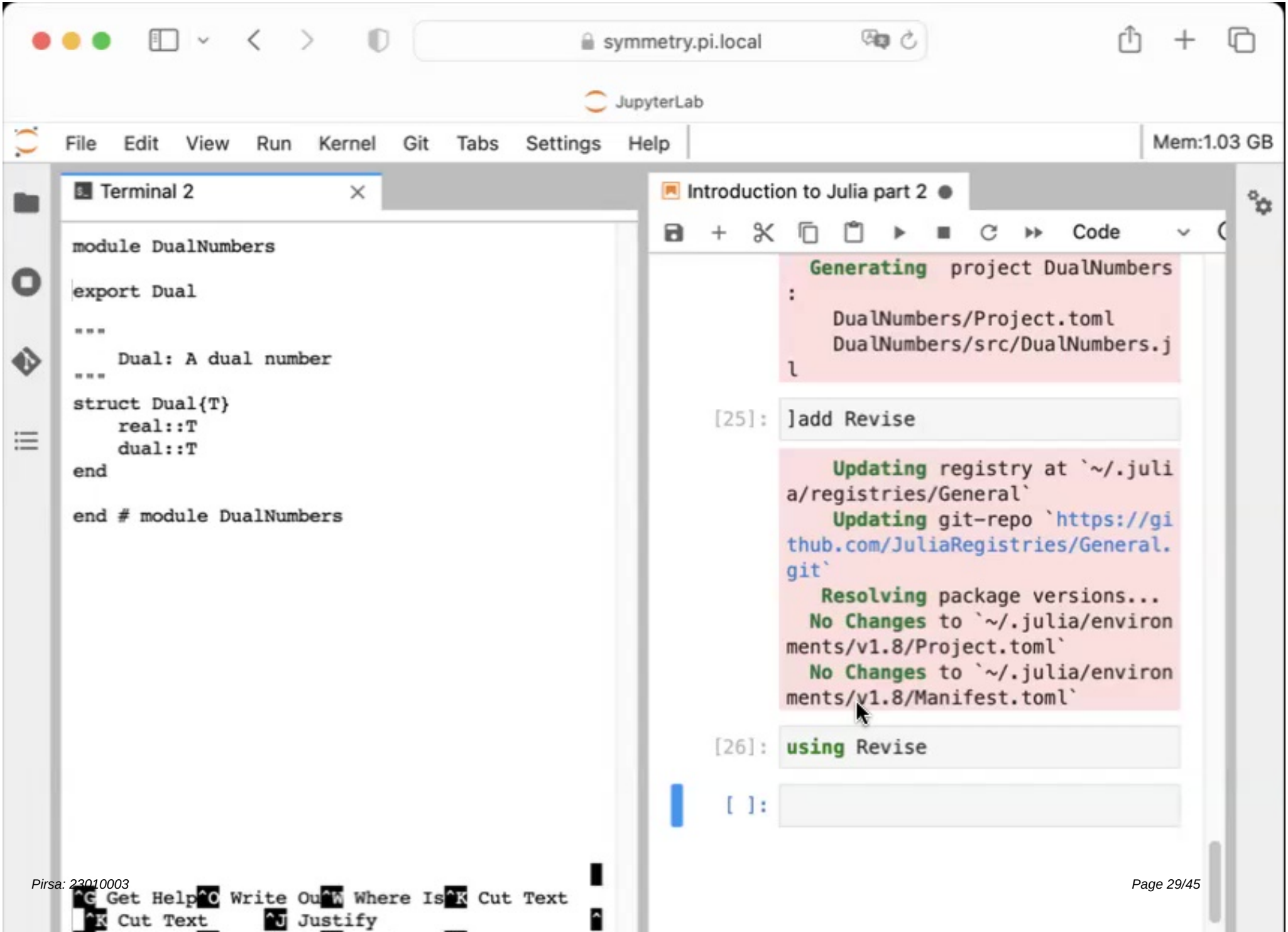
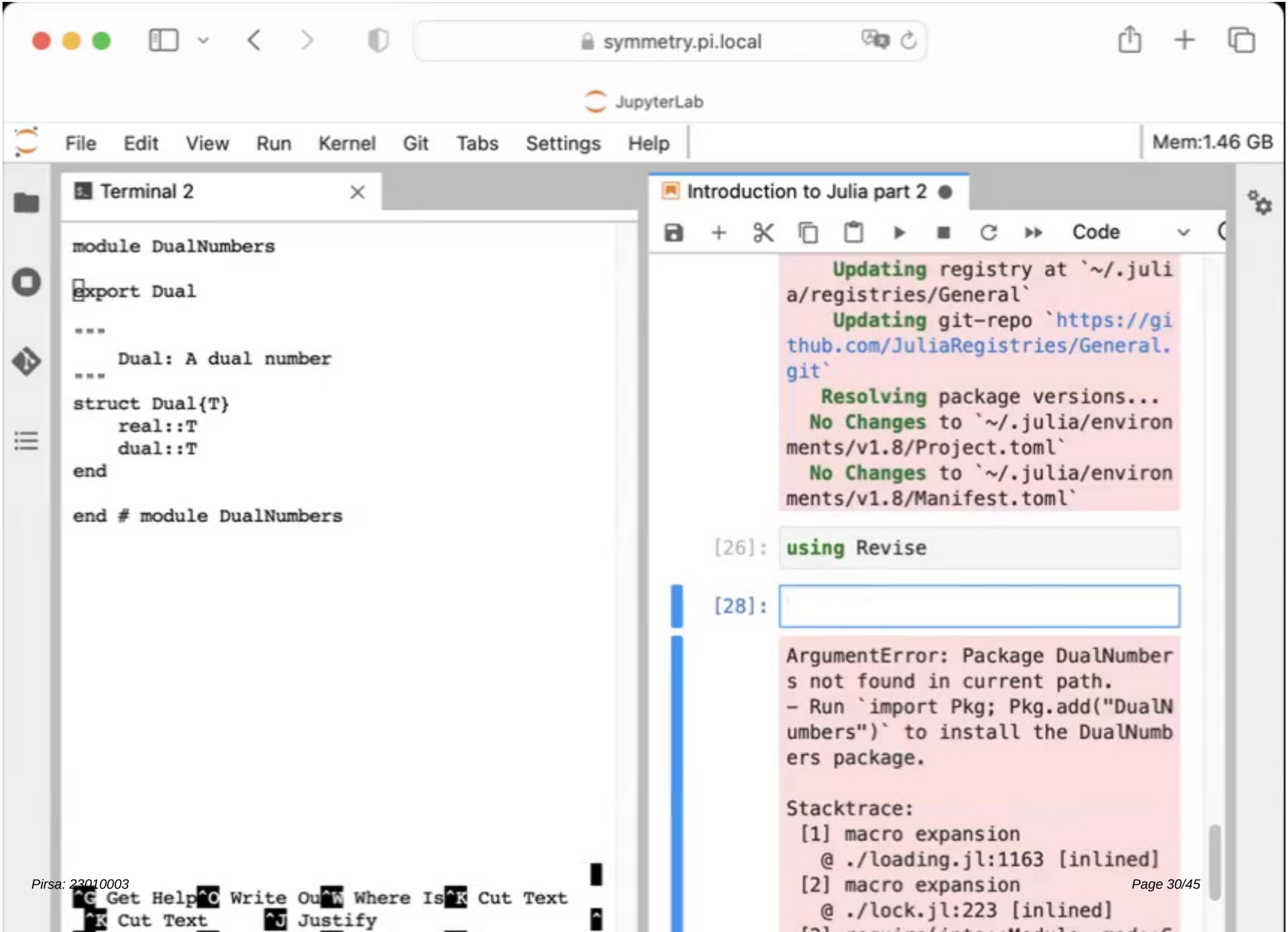
Introduction to Julia part 2
Terminal 2
Desktop
dist
Documents
DualNumbers
etc
'FFT and Ylm.ipynb'
'FFT Example.ipynb'
FFTW-Playground.ipynb
FiniteDifferences.ipynb
gnuplot.ipynb
'Introduction to Julia 2023.ipynb'
'Introduction to Julia.ipynb'
'Introduction to Julia part 2 2023.ipynb'
Julia
Julia-Demo-20200729.ipynb
julia-mpi-symmetry.sh
jupyterhub_slurm_354479.log
jupyterhub_slurm_354657.log
lib
'Linear Algebra.ipynb'
slurmstats
Smoothing.ipynb
spaces-project
src
_ssh
test-symmetry.sh
tmp
Tutorial
tutorial2
Tutorial.ipynb
TWL-MPI.zip
Untitled1.ipynb
Untitled2.ipynb
Untitled3.ipynb
Untitled4.ipynb
Untitled.ipynb
varad
WGLMakie.ipynb
'Wolfram Mathematica'
work
eschnetter@cn002:~ (10:00:30)
$ cd DualNumbers
eschnetter@cn002:~/DualNumbers (10:00:38)
$ ls
Project.toml src
eschnetter@cn002:~/DualNumbers (10:00:40)
$ cat Project.toml
name = "DualNumbers"
uuid = "2008ef51-30f0-46f1-933e-d54484ac2fea"
authors = ["Erik Schnetter <schnetter@gmail.com>"]
version = "0.1.0"

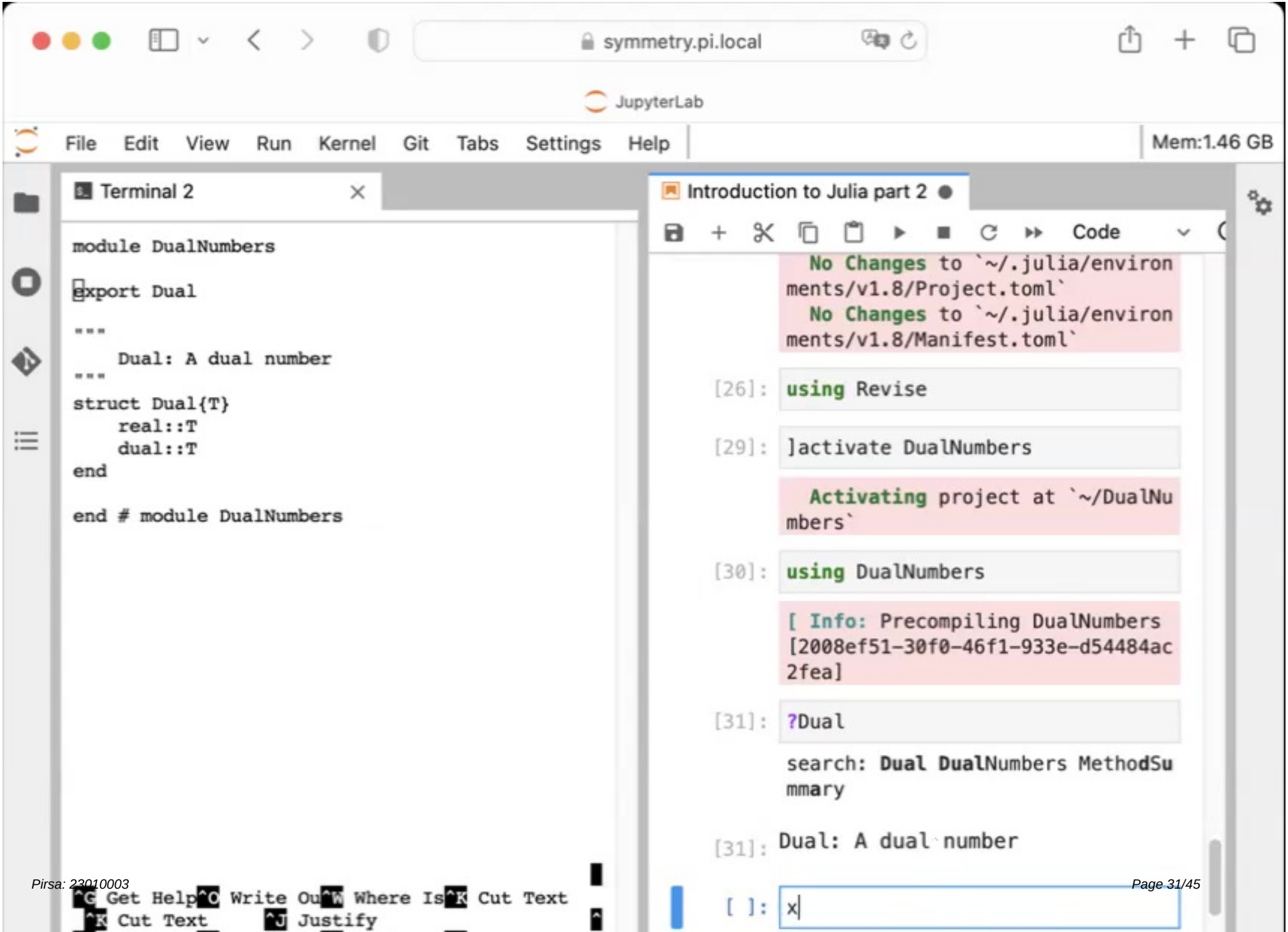

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:2.14 GB
Introduction to Julia part 2
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
module DualNumbers
greet() = print("Hello World!")
end # module DualNumbers
[Read 5 lines]

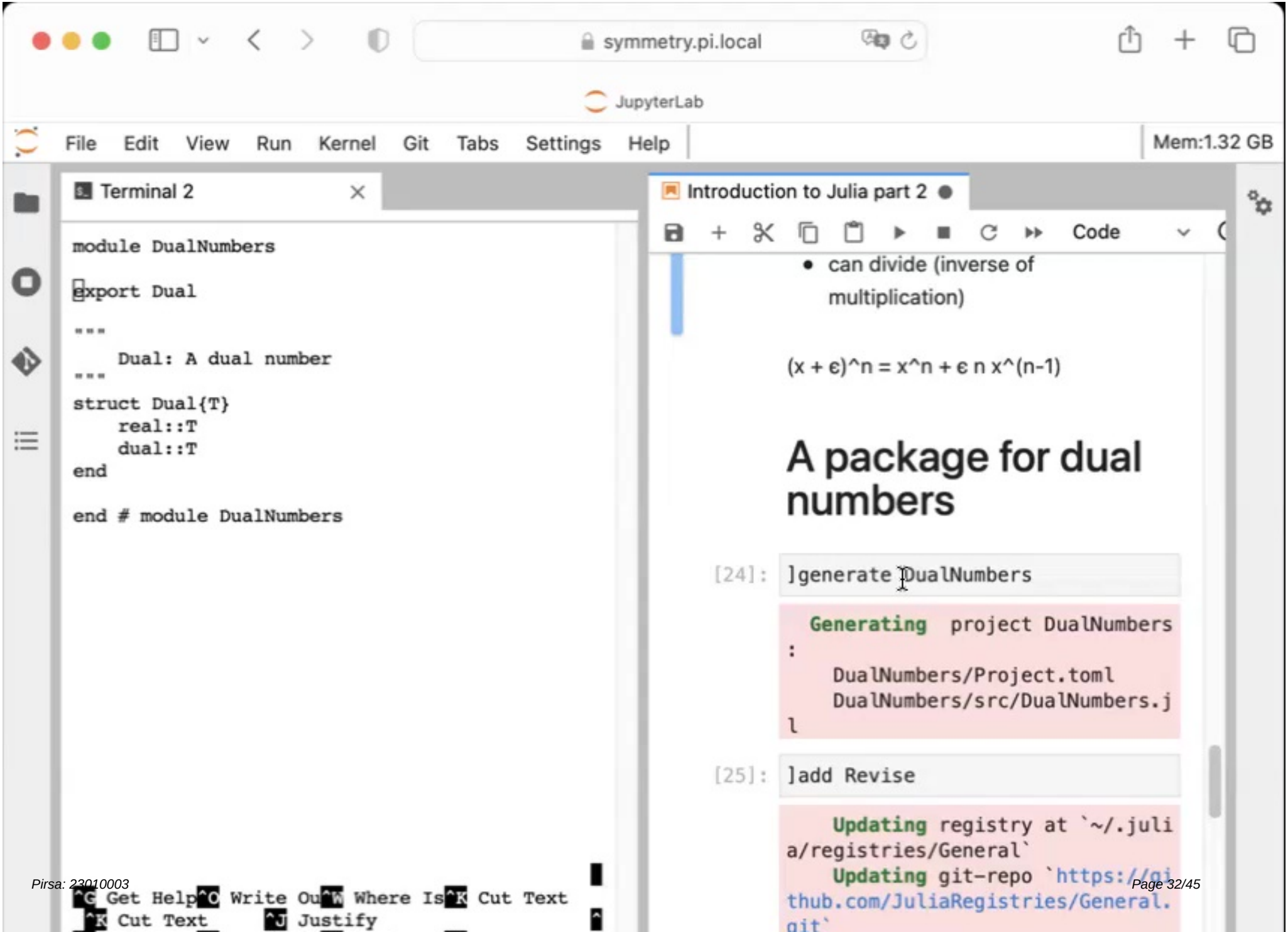

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.29 GB
Introduction to Julia part 2
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
[Wrote 13 lines]

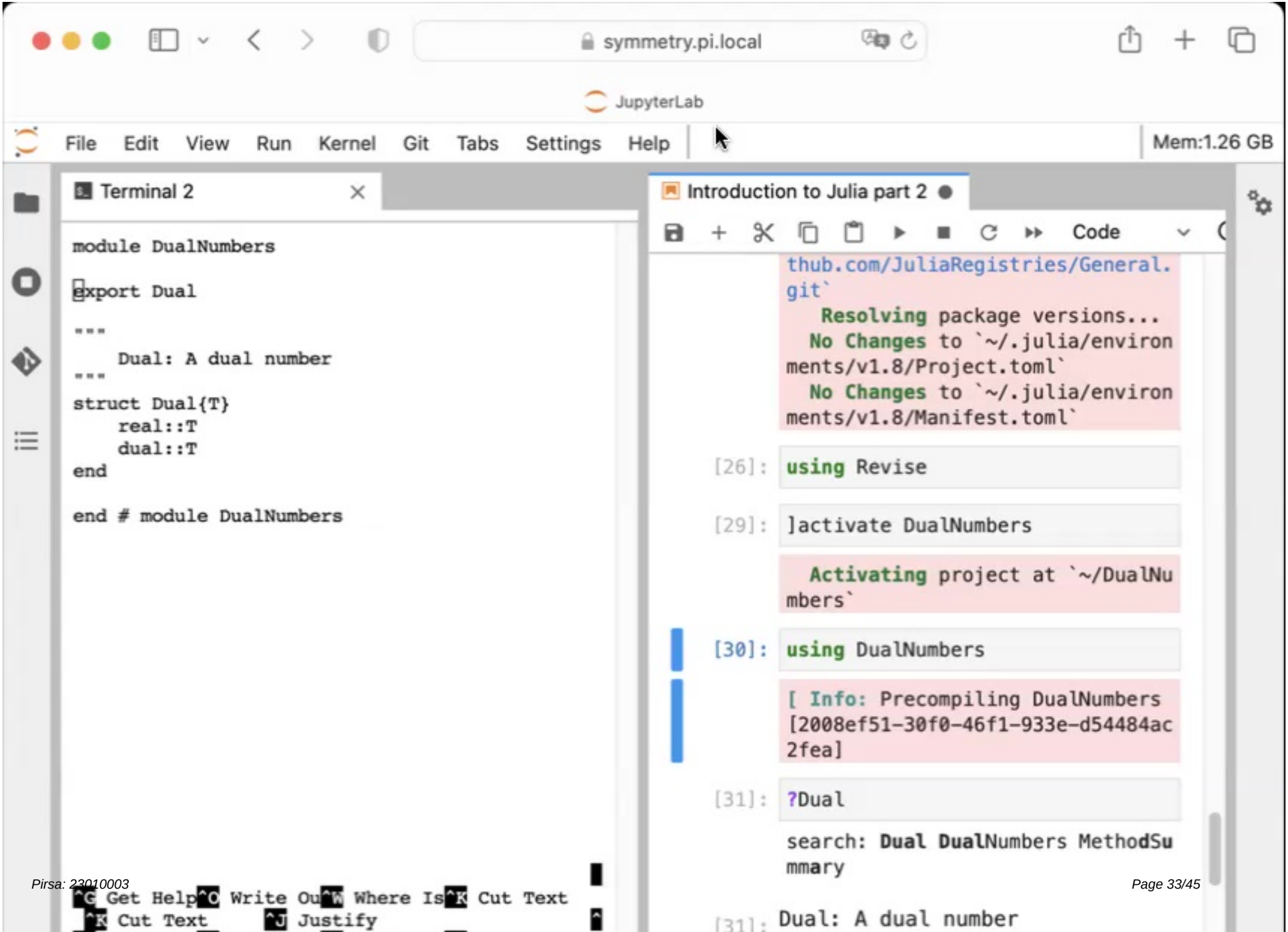

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:855 MB
Terminal 2
module DualNumbers DualNumbers.jl
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
13 lines]
^K Cut Text
^J Justify
Introduction to Julia part 2
Code
A package for dual numbers
[24]:]generate DualNumbers
Generating project DualNumbers:
DualNumbers/Project.toml
DualNumbers/src/DualNumbers.jl
[*]:]add Revise
[ ]:

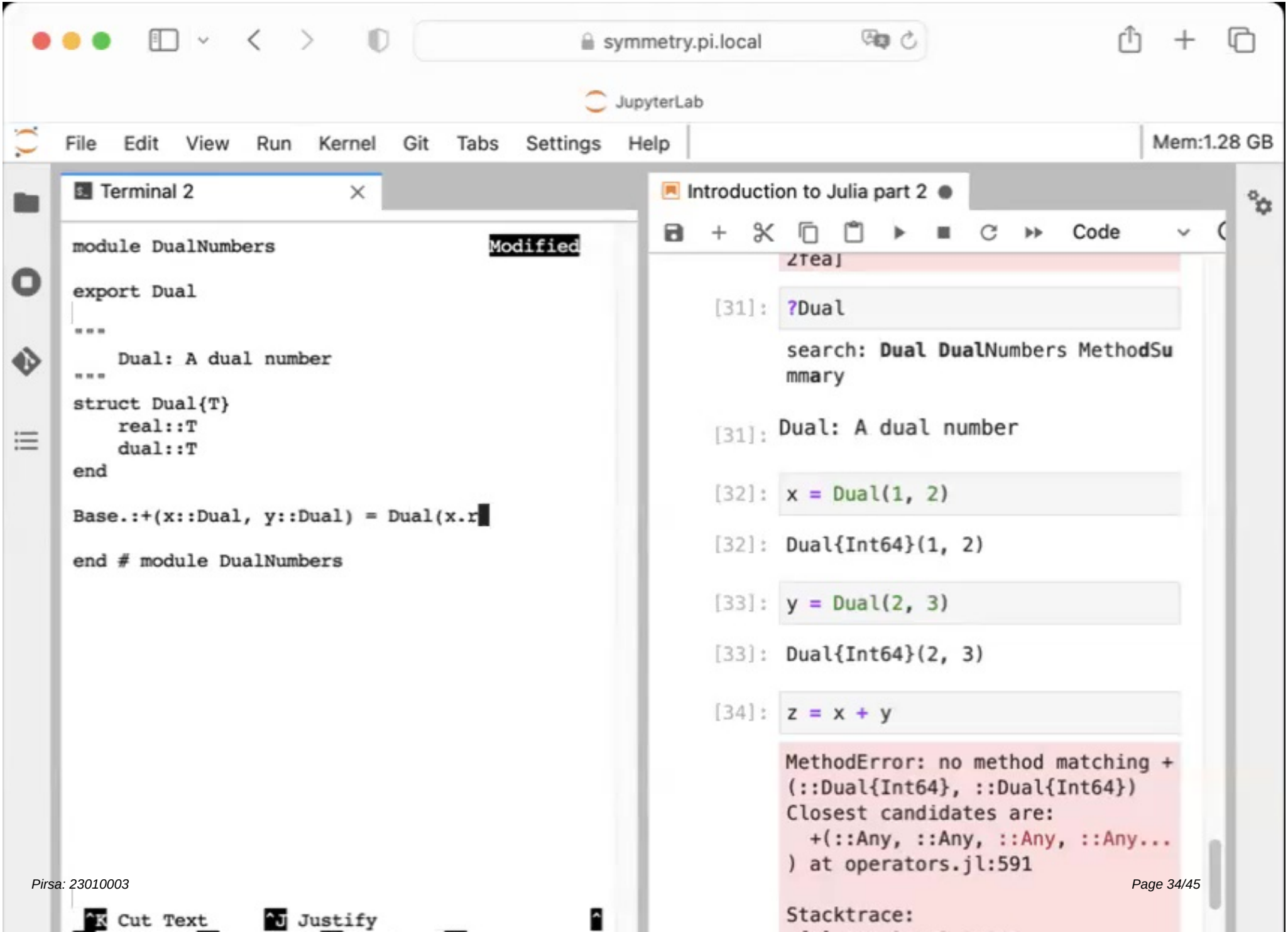

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.03 GB
Terminal 2
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
^G Get Help ^O Write Ou ^W Where Is ^K Cut Text
^K Cut Text ^J Justify
Introduction to Julia part 2
Code
Generating project DualNumbers
:
DualNumbers/Project.toml
DualNumbers/src/DualNumbers.j
l
[25]:]add Revise
Updating registry at `~/.juli
a/registries/General`
Updating git-repo `https://gi
thub.com/JuliaRegistries/General.
git`
Resolving package versions...
No Changes to `~/.julia/environ
ments/v1.8/Project.toml`
No Changes to `~/.julia/environ
ments/v1.8/Manifest.toml`
[26]: using Revise
[ ]:

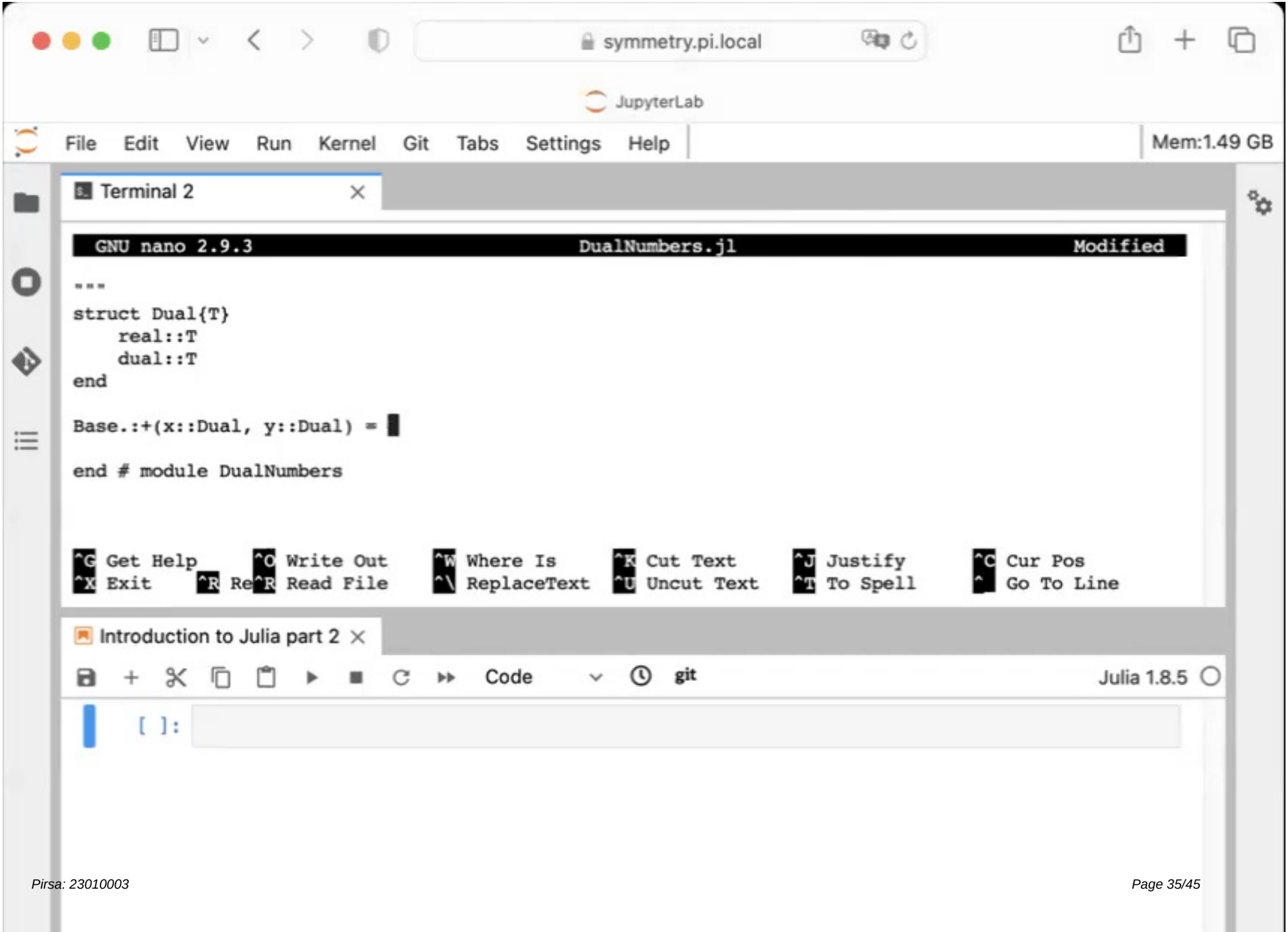

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.46 GB
Terminal 2
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
^G Get Help ^O Write Ou ^W Where Is ^K Cut Text
^K Cut Text ^J Justify
Introduction to Julia part 2
Code
Updating registry at `~/.julia/registries/General`
Updating git-repo `https://github.com/JuliaRegistries/General.git`
Resolving package versions...
No Changes to `~/.julia/environments/v1.8/Project.toml`
No Changes to `~/.julia/environments/v1.8/Manifest.toml`
[26]: using Revise
[28]:
ArgumentError: Package DualNumbers not found in current path.
- Run `import Pkg; Pkg.add("DualNumbers")` to install the DualNumbers package.
Stacktrace:
[1] macro expansion
@ ./loading.jl:1163 [inlined]
[2] macro expansion
@ ./lock.jl:223 [inlined]

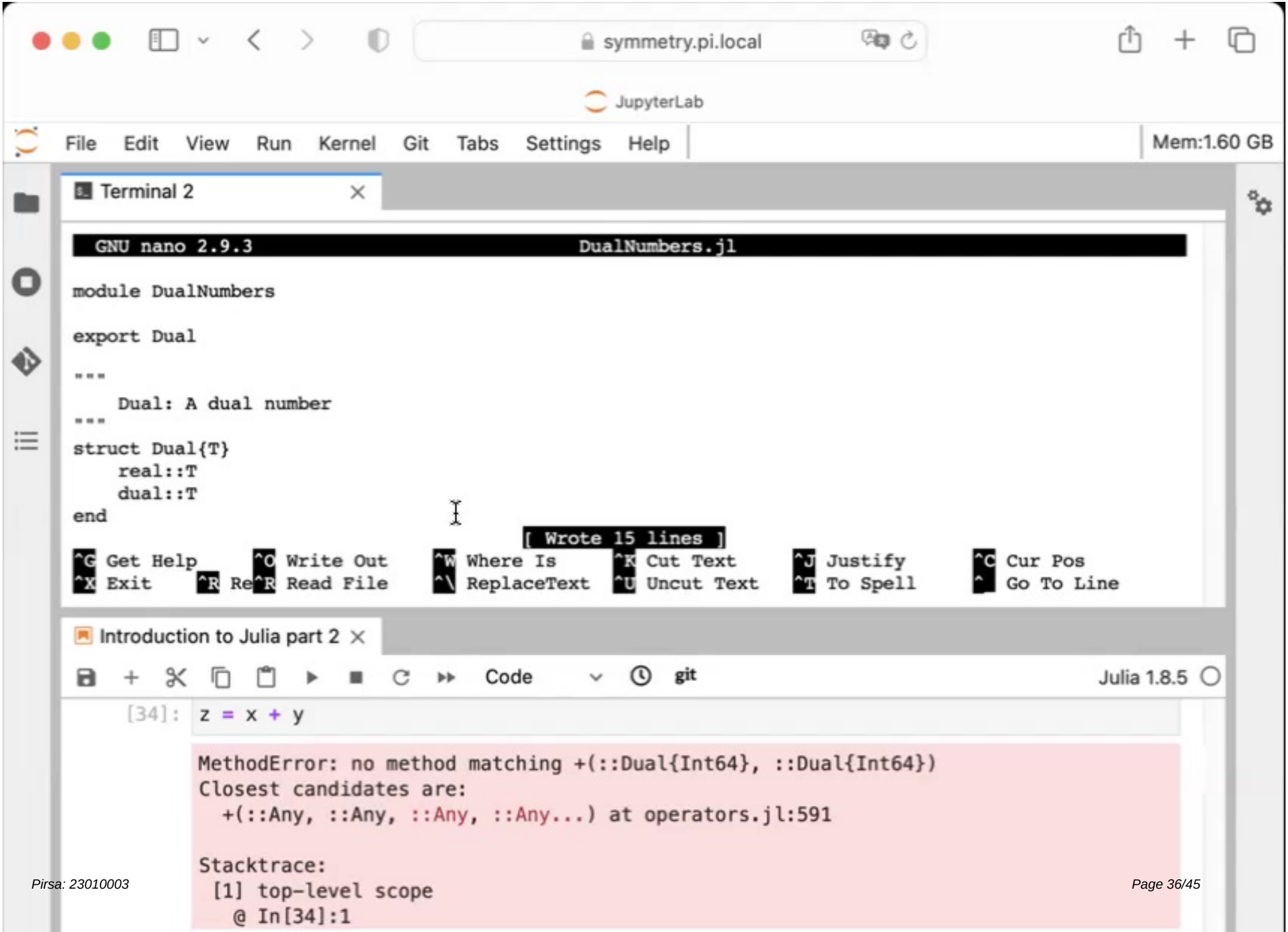

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.46 GB
Terminal 2
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
^G Get Help ^O Write Ou ^W Where Is ^K Cut Text
^K Cut Text ^J Justify
Introduction to Julia part 2
Code
No Changes to `~/.julia/environments/v1.8/Project.toml`
No Changes to `~/.julia/environments/v1.8/Manifest.toml`
[26]: using Revise
[29]:]activate DualNumbers
Activating project at `~/DualNumbers`
[30]: using DualNumbers
[Info: Precompiling DualNumbers [2008ef51-30f0-46f1-933e-d54484ac2fea]
[31]: ?Dual
search: Dual DualNumbers MethodSummary
[31]: Dual: A dual number
[ ]: x

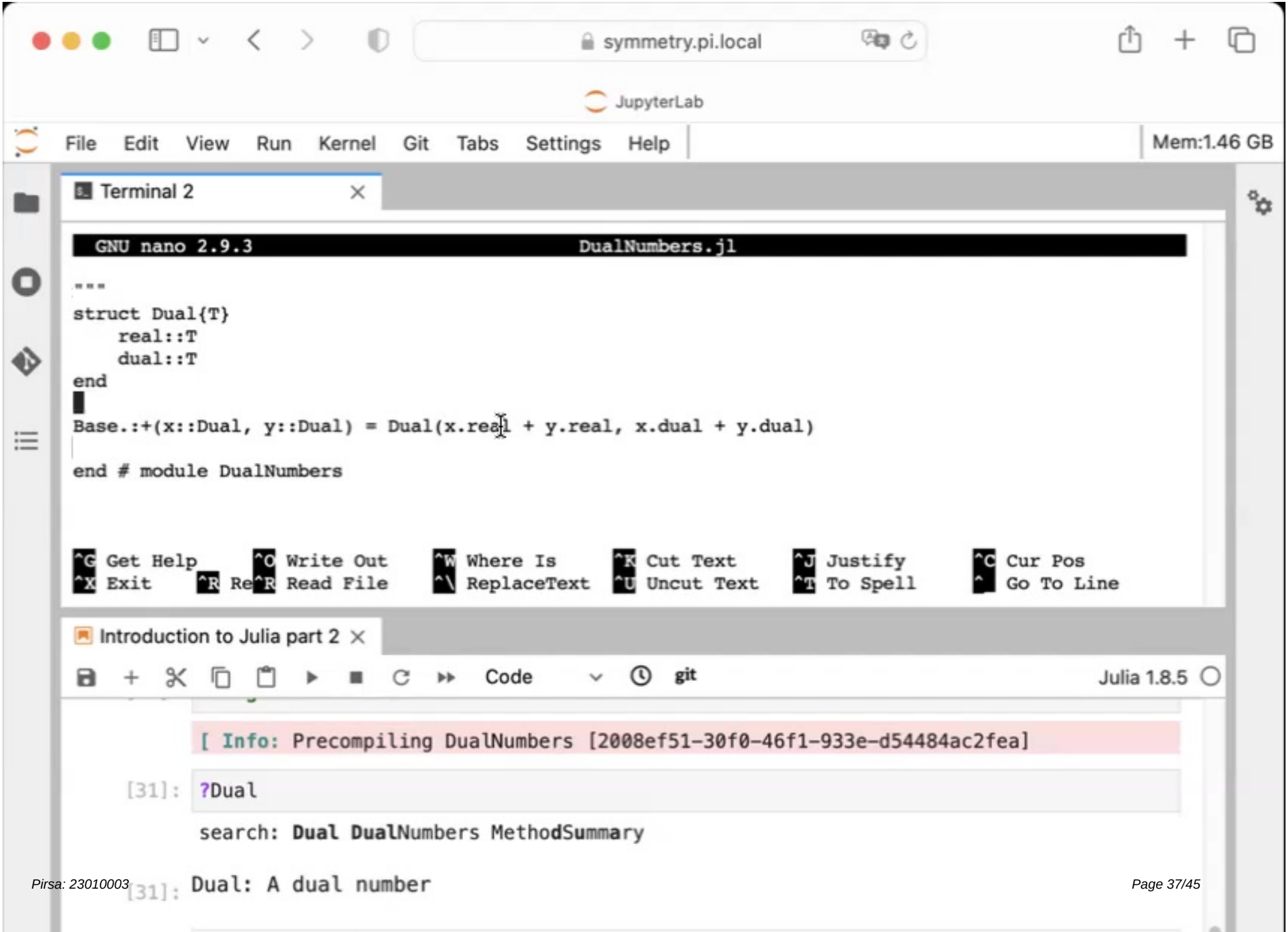

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.32 GB
Terminal 2
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
^G Get Help ^O Write Ou ^W Where Is ^K Cut Text
^K Cut Text ^J Justify
Introduction to Julia part 2
Code
• can divide (inverse of multiplication)
(x + ϵ)^n = x^n + ϵ n x^(n-1)
A package for dual numbers
[24]:]generate DualNumbers
Generating project DualNumbers:
DualNumbers/Project.toml
DualNumbers/src/DualNumbers.jl
[25]:]add Revise
Updating registry at `~/.julia/registries/General`
Updating git-repo `https://github.com/JuliaRegistries/General.git`

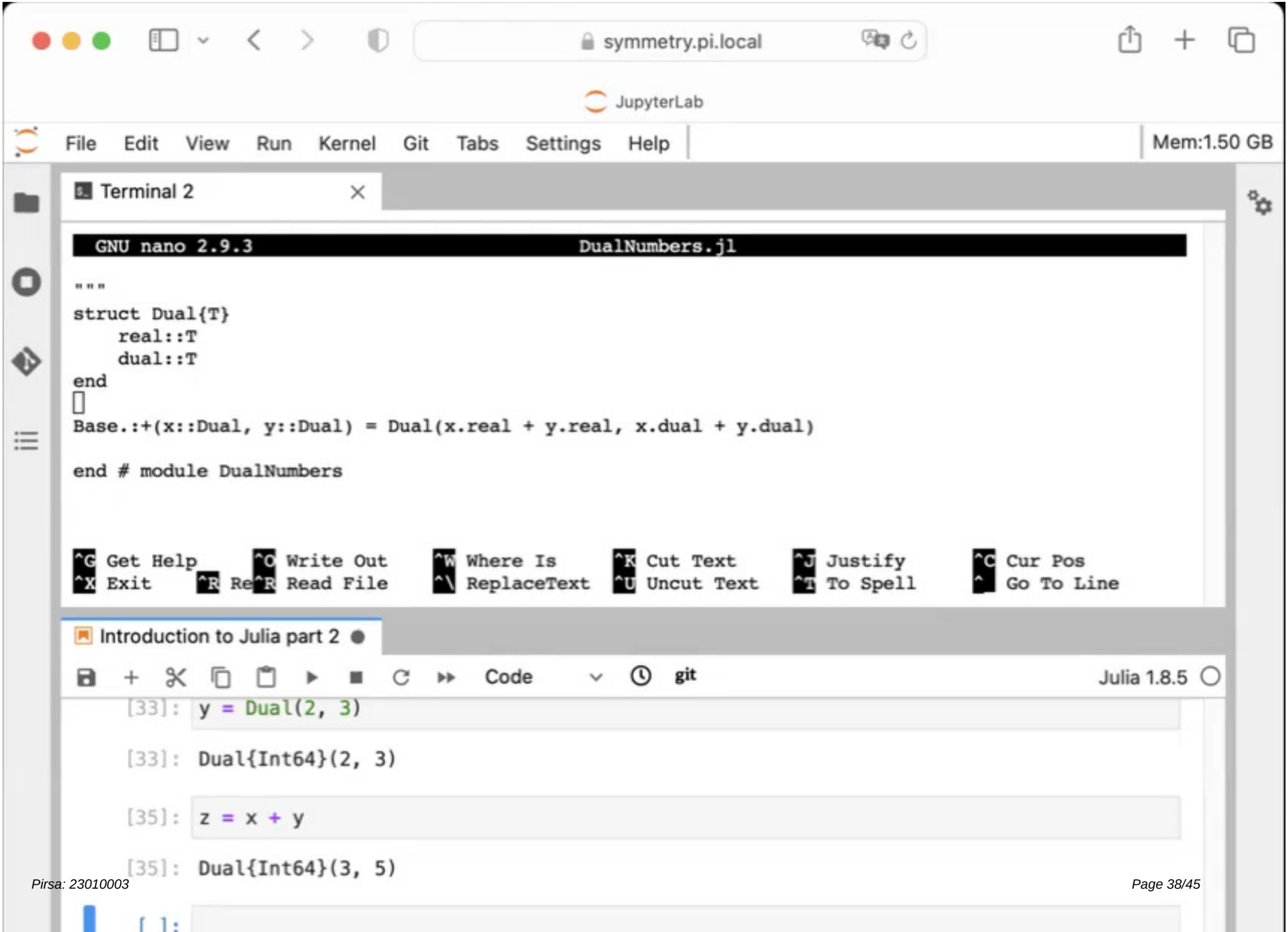

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.26 GB
Terminal 2
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
end # module DualNumbers
^G Get Help ^O Write Ou ^W Where Is ^K Cut Text
^K Cut Text ^J Justify
Introduction to Julia part 2
Code
thub.com/JuliaRegistries/General.git`
Resolving package versions...
No Changes to `~/.julia/environments/v1.8/Project.toml`
No Changes to `~/.julia/environments/v1.8/Manifest.toml`
[26]: using Revise
[29]:]activate DualNumbers
Activating project at `~/DualNumbers`
[30]: using DualNumbers
[Info: Precompiling DualNumbers [2008ef51-30f0-46f1-933e-d54484ac2fea]
[31]: ?Dual
search: Dual DualNumbers MethodSummary
[31]: Dual: A dual number

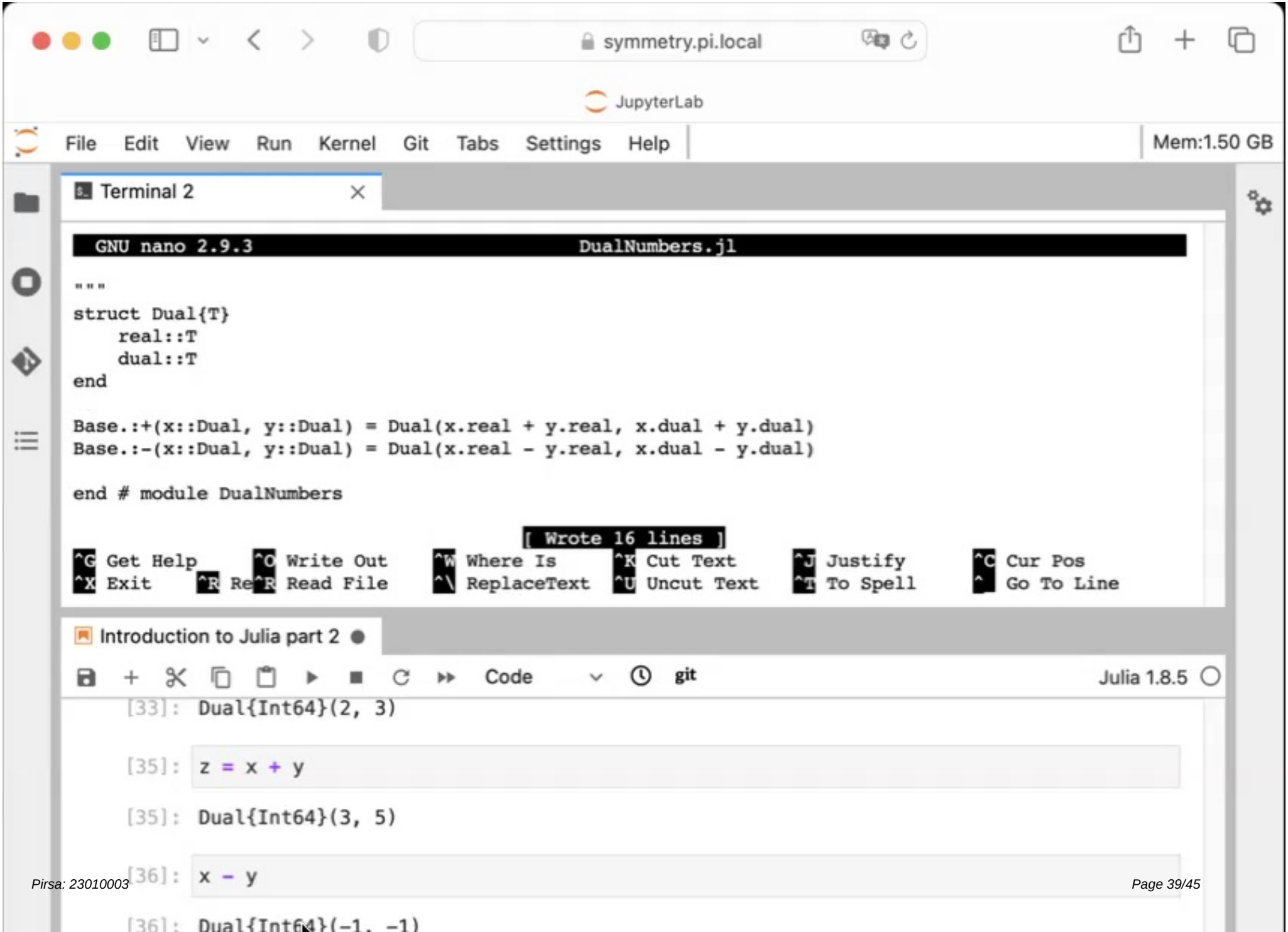

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.28 GB
Terminal 2
module DualNumbers
Modified
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
Base.:+(x::Dual, y::Dual) = Dual(x.r
end # module DualNumbers
Cut Text
Justify
Introduction to Julia part 2
Code
[31]: ?Dual
search: Dual DualNumbers MethodSummary
[31]: Dual: A dual number
[32]: x = Dual(1, 2)
[32]: Dual{Int64}(1, 2)
[33]: y = Dual(2, 3)
[33]: Dual{Int64}(2, 3)
[34]: z = x + y
MethodError: no method matching +(::Dual{Int64}, ::Dual{Int64})
Closest candidates are:
+(::Any, ::Any, ::Any, ::Any...) at operators.jl:591
Stacktrace:

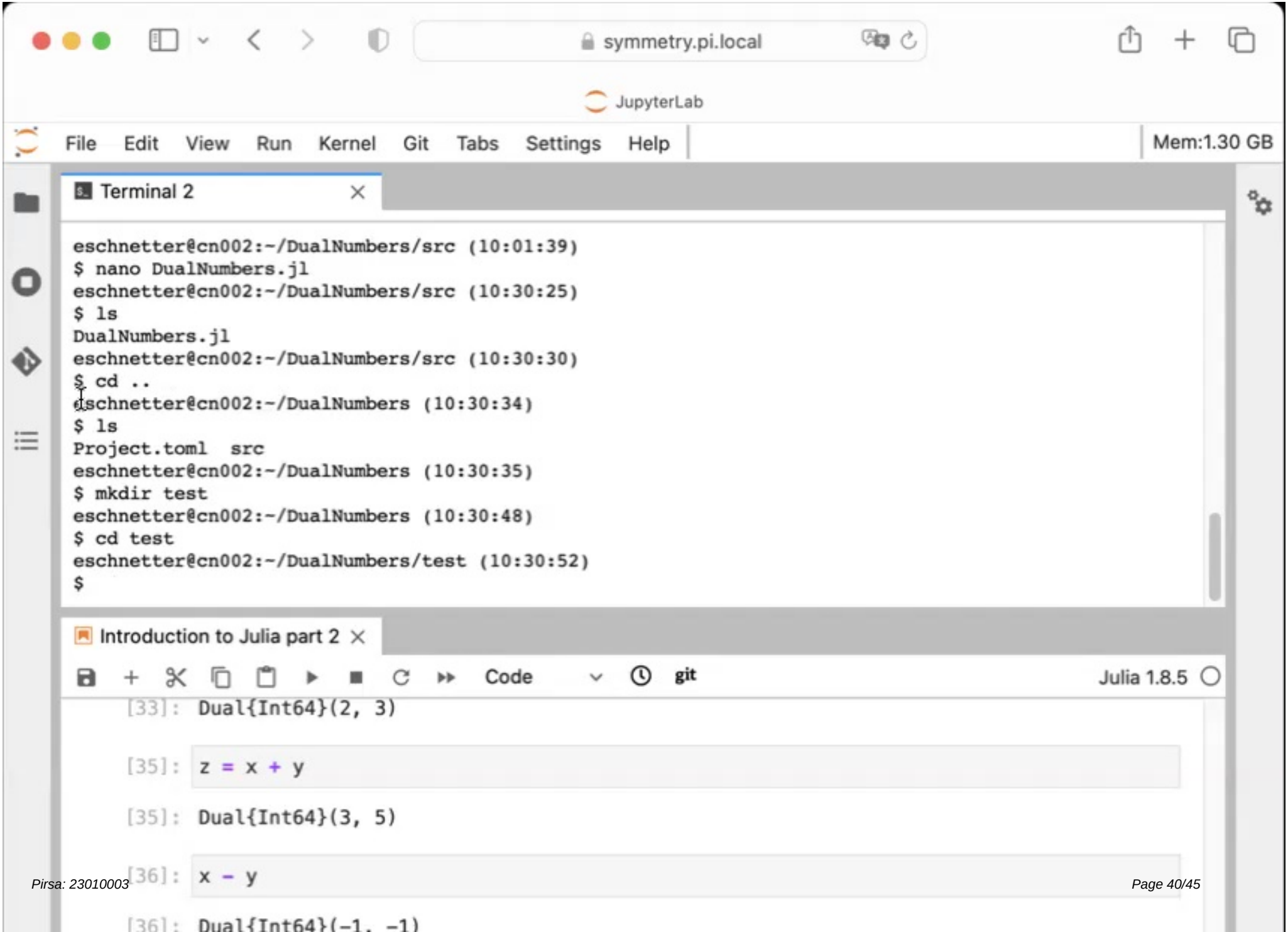

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.49 GB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl Modified
"""
struct Dual{T}
real::T
dual::T
end
Base.:+(x::Dual, y::Dual) =
end # module DualNumbers
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Re^R Read File ^\ ReplaceText ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[ ]:

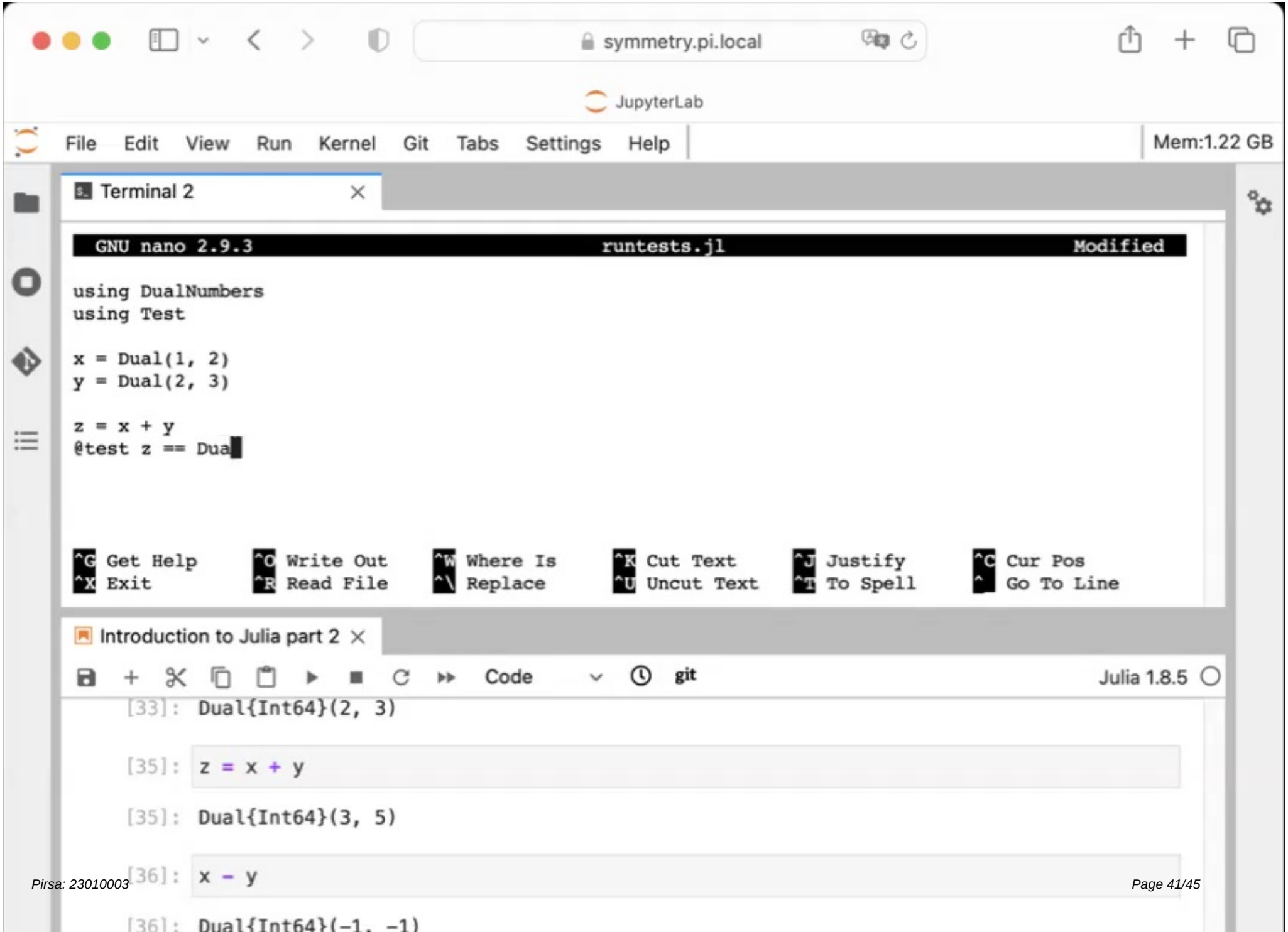

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.60 GB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
module DualNumbers
export Dual
"""
Dual: A dual number
"""
struct Dual{T}
real::T
dual::T
end
[Wrote 15 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Re^R Read File ^\ ReplaceText ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[34]: z = x + y
MethodError: no method matching +(::Dual{Int64}, ::Dual{Int64})
Closest candidates are:
+(::Any, ::Any, ::Any, ::Any...) at operators.jl:591
Stacktrace:
[1] top-level scope
@ In[34]:1

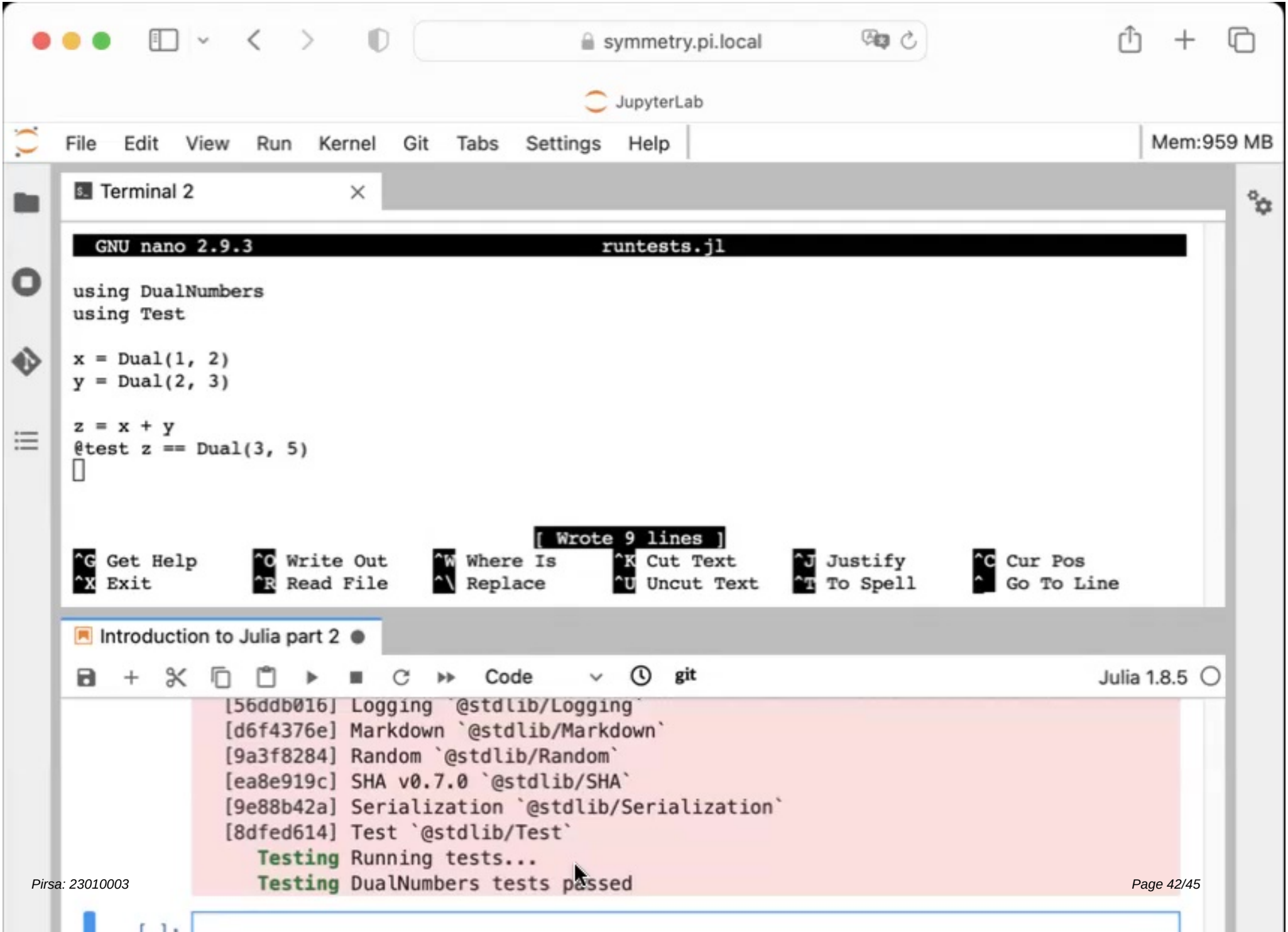

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.46 GB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
"""
struct Dual{T}
real::T
dual::T
end
Base.:+(x::Dual, y::Dual) = Dual(x.real + y.real, x.dual + y.dual)
end # module DualNumbers
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Re^R Read File ^\ ReplaceText ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[Info: Precompiling DualNumbers [2008ef51-30f0-46f1-933e-d54484ac2fea]
[31]: ?Dual
search: Dual DualNumbers MethodSummary
[31]: Dual: A dual number

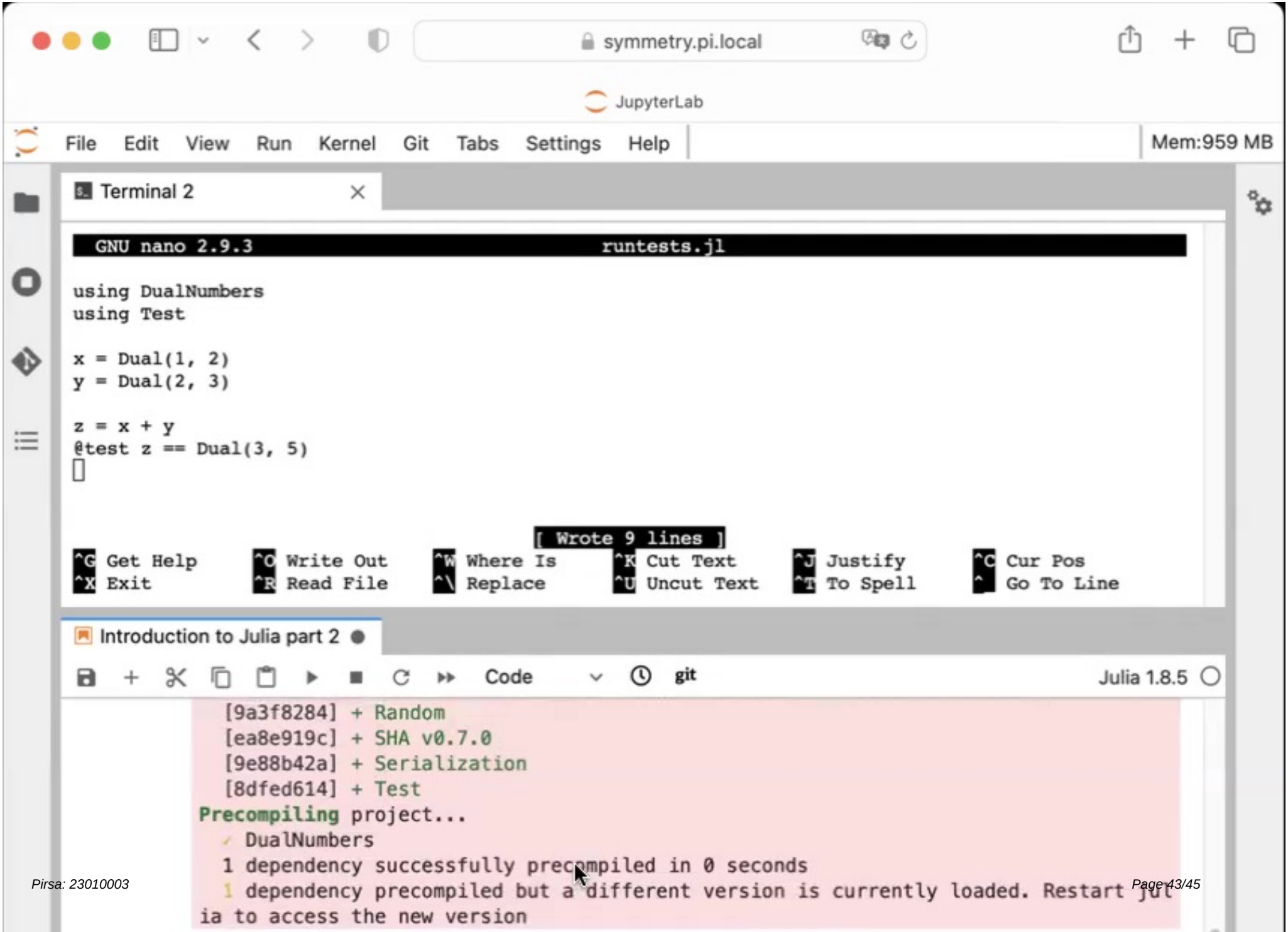

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.50 GB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
"""
struct Dual{T}
real::T
dual::T
end
Base.:+(x::Dual, y::Dual) = Dual(x.real + y.real, x.dual + y.dual)
end # module DualNumbers
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ ReplaceText ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[33]: y = Dual(2, 3)
[33]: Dual{Int64}(2, 3)
[35]: z = x + y
[35]: Dual{Int64}(3, 5)
[ ]:

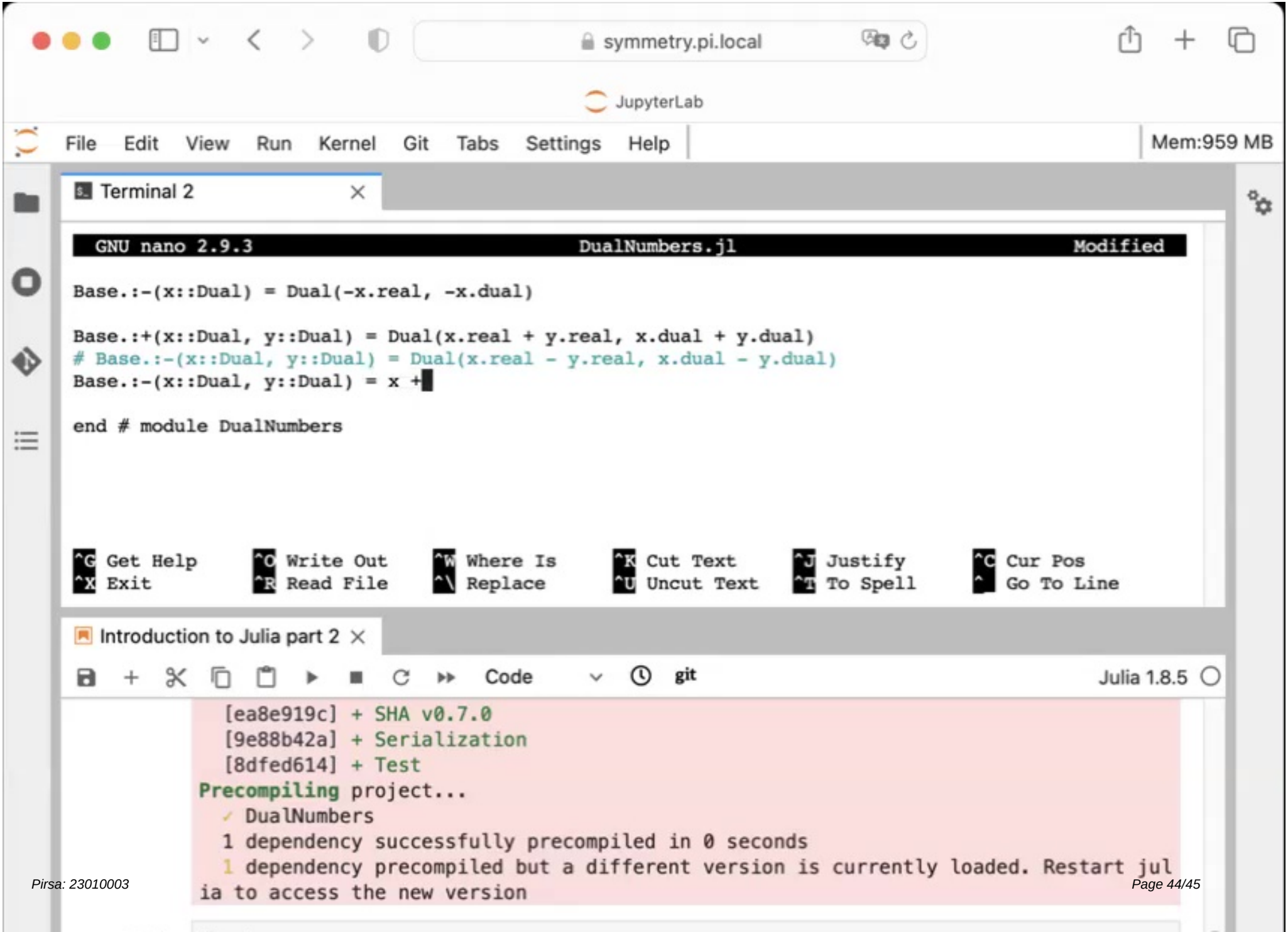

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.50 GB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
"""
struct Dual{T}
real::T
dual::T
end
Base.:+(x::Dual, y::Dual) = Dual(x.real + y.real, x.dual + y.dual)
Base.:-(x::Dual, y::Dual) = Dual(x.real - y.real, x.dual - y.dual)
end # module DualNumbers
[Wrote 16 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Re^R Read File ^\ ReplaceText ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[33]: Dual{Int64}(2, 3)
[35]: z = x + y
[35]: Dual{Int64}(3, 5)
[36]: x - y
[36]: Dual{Int64}(-1, -1)

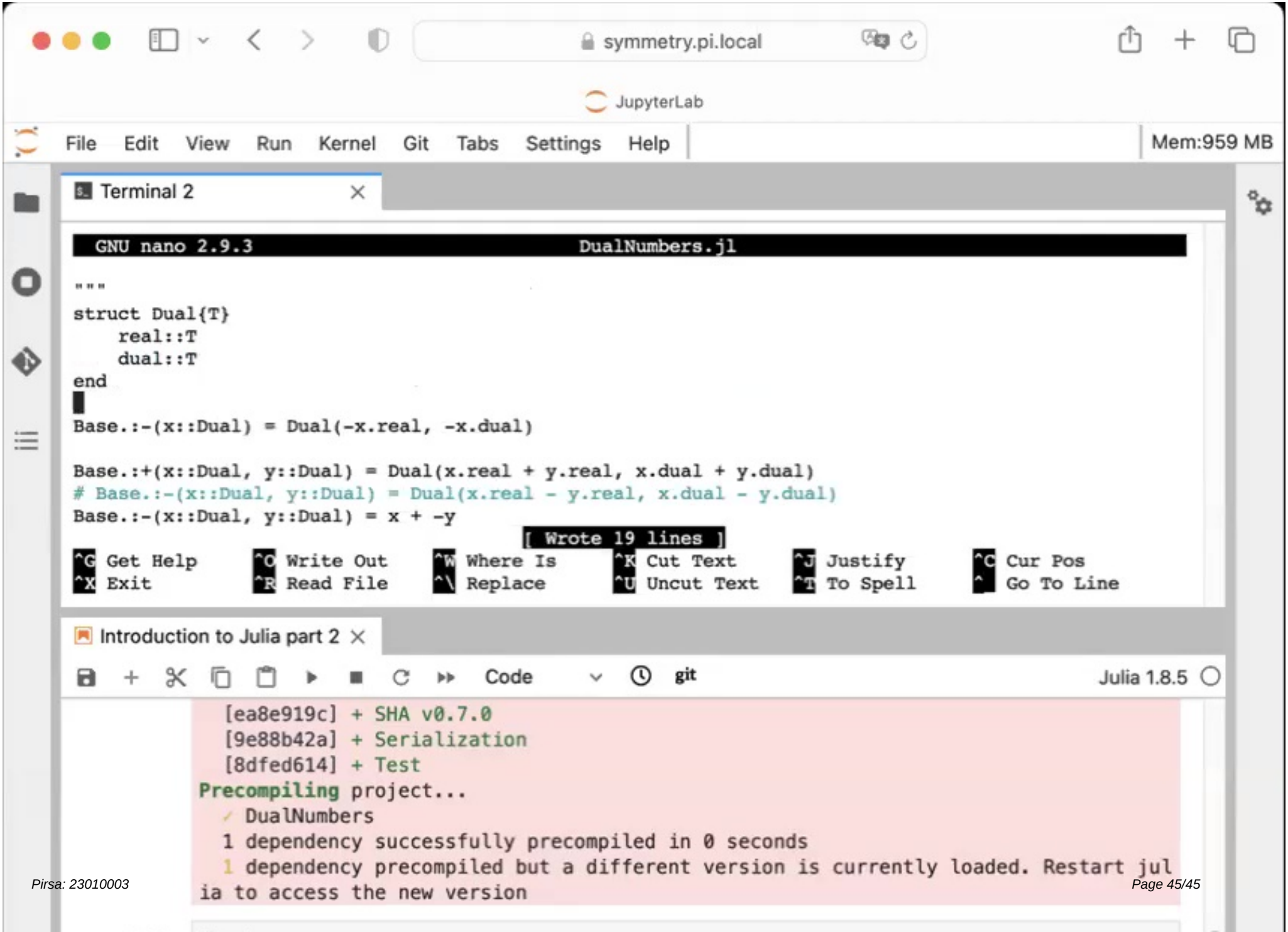

symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.30 GB
Terminal 2
eschnetter@cn002:~/DualNumbers/src (10:01:39)
$ nano DualNumbers.jl
eschnetter@cn002:~/DualNumbers/src (10:30:25)
$ ls
DualNumbers.jl
eschnetter@cn002:~/DualNumbers/src (10:30:30)
$ cd ..
eschnetter@cn002:~/DualNumbers (10:30:34)
$ ls
Project.toml src
eschnetter@cn002:~/DualNumbers (10:30:35)
$ mkdir test
eschnetter@cn002:~/DualNumbers (10:30:48)
$ cd test
eschnetter@cn002:~/DualNumbers/test (10:30:52)
$
Introduction to Julia part 2
Code
git
Julia 1.8.5
[33]: Dual{Int64}(2, 3)
[35]: z = x + y
[35]: Dual{Int64}(3, 5)
[36]: x - y
[36]: Dual{Int64}(-1, -1)


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:1.22 GB
Terminal 2
GNU nano 2.9.3 runtests.jl Modified
using DualNumbers
using Test
x = Dual(1, 2)
y = Dual(2, 3)
z = x + y
@test z == Dua
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[33]: Dual{Int64}(2, 3)
[35]: z = x + y
[35]: Dual{Int64}(3, 5)
[36]: x - y
[36]: Dual{Int64}(-1, -1)


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:959 MB
Terminal 2
GNU nano 2.9.3 runtests.jl
using DualNumbers
using Test
x = Dual(1, 2)
y = Dual(2, 3)
z = x + y
@test z == Dual(3, 5)
[Wrote 9 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[56ddb016] Logging `@stdlib/Logging`
[d6f4376e] Markdown `@stdlib/Markdown`
[9a3f8284] Random `@stdlib/Random`
[ea8e919c] SHA v0.7.0 `@stdlib/SHA`
[9e88b42a] Serialization `@stdlib/Serialization`
[8dfed614] Test `@stdlib/Test`
Testing Running tests...
Testing DualNumbers tests passed


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:959 MB
Terminal 2
GNU nano 2.9.3 runtests.jl
using DualNumbers
using Test
x = Dual(1, 2)
y = Dual(2, 3)
z = x + y
@test z == Dual(3, 5)
[Wrote 9 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[9a3f8284] + Random
[ea8e919c] + SHA v0.7.0
[9e88b42a] + Serialization
[8dfed614] + Test
Precompiling project...
DualNumbers
1 dependency successfully precompiled in 0 seconds
1 dependency precompiled but a different version is currently loaded. Restart jul
ia to access the new version


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:959 MB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl Modified
Base.:-(x::Dual) = Dual(-x.real, -x.dual)
Base.:+(x::Dual, y::Dual) = Dual(x.real + y.real, x.dual + y.dual)
Base.:-(x::Dual, y::Dual) = Dual(x.real - y.real, x.dual - y.dual)
Base.:-(x::Dual, y::Dual) = x +
end # module DualNumbers
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[ea8e919c] + SHA v0.7.0
[9e88b42a] + Serialization
[8dfed614] + Test
Precompiling project...
✓ DualNumbers
1 dependency successfully precompiled in 0 seconds
1 dependency precompiled but a different version is currently loaded. Restart julia to access the new version


symmetry.pi.local
JupyterLab
File Edit View Run Kernel Git Tabs Settings Help
Mem:959 MB
Terminal 2
GNU nano 2.9.3 DualNumbers.jl
"""
struct Dual{T}
real::T
dual::T
end
Base.:-(x::Dual) = Dual(-x.real, -x.dual)
Base.:+(x::Dual, y::Dual) = Dual(x.real + y.real, x.dual + y.dual)
Base.:-(x::Dual, y::Dual) = Dual(x.real - y.real, x.dual - y.dual)
Base.:-(x::Dual, y::Dual) = x + -y
[Wrote 19 lines]
^G Get Help ^O Write Out ^W Where Is ^K Cut Text ^J Justify ^C Cur Pos
^X Exit ^R Read File ^\ Replace ^U Uncut Text ^T To Spell ^_ Go To Line
Introduction to Julia part 2
Code
git
Julia 1.8.5
[ea8e919c] + SHA v0.7.0
[9e88b42a] + Serialization
[8dfed614] + Test
Precompiling project...
✓ DualNumbers
1 dependency successfully precompiled in 0 seconds
1 dependency precompiled but a different version is currently loaded. Restart julia to access the new version