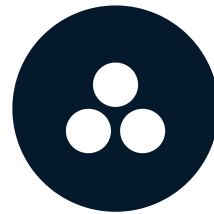


Introduction to strings

INTRODUCTION TO JULIA



James Fulton

Climate informatics researcher

Strings

```
# Strings are surrounded by " "  
name = "Jane" # Cannot use 'Jane'  
  
# Strings can be any length  
book = "It is a truth universally acknowledged, ..."  
  
println(name)  
println(book)
```

```
Jane  
It is a truth universally acknowledged, ...
```

Triple quotes

```
# Triple quotes
poem = """Beware the Jabberwock, my son!

    The jaws that bite, the claws that catch!"""

println(poem)
```

```
Beware the Jabberwock, my son!
```

```
The jaws that bite, the claws that catch!
```

Triple quotes

```
greeting = """ " Well hello there " """  
  
println(greeting)
```

```
" Well hello there "
```

```
greeting = " " Well hello there " "
```

```
ERROR: syntax: ...
```

Concatenating strings

```
name = "James"

greeting = "Well hello there, "

# Concatenate two strings
println(greeting*name)
```

```
Well hello there, James
```

String interpolation

```
name = "James"

# Interpolate with $ symbol
greeting = "Well hello there, $name"

println(greeting)
```

```
Well hello there, James
```

String interpolation

```
x_int = 10
```

```
# Insert integer into string  
println("The value is $x_int")
```

```
The value is 10
```

```
x_bool = true
```

```
# Insert boolean into string  
println("The value is $x_bool")
```

```
The value is true
```

```
x_float = 1.0
```

```
# Insert float into string  
println("The value is $x_float")
```

```
The value is 1.0
```

```
x_char = 'A'
```

```
# Insert character into string  
println("The value is $x_char")
```

```
The value is A
```

String interpolation

```
x = 10  
y = 3  
  
# Insert x*y into string  
println("The product of x and y is $(x*y)")
```

```
The product of x and y is 30
```


String interpolation

```
x = 10  
y = 3  
  
# Insert x*y into string  
println("The product of x and y is \$(x*y)")
```

```
The product of x and y is \$(x*y)
```

Indexing strings

```
# Customer's seat
seat = "E5"

# Select character
row = seat[1]      # this returns 'E'

println(row)
println(typeof(row))
```

E

Char

Indexing strings

```
# Customer's seat
seat = "E5"

# Select characters
row = seat[1]      # this returns 'E'
number = seat[2]   # this returns '5'

println("Your seat is in row $row, seat number $number.")
```

```
Your seat is in row E, seat number 5.
```

Indexing strings

```
# Customer's seat
seat = "E5"

# Select characters
row = seat[1]          # this returns 'E'
number = seat[end]    # this returns '5'

println("Your seat is in row $row, seat number $number.")
```

```
Your seat is in row E, seat number 5.
```

Indexing strings

```
# Customer's seat
seat = "E5"

# Select characters
row = seat[end-1] # this returns 'E'
number = seat[end] # this returns '5'

println("Your seat is in row $row, seat number $number.")
```

```
Your seat is in row E, seat number 5.
```

Slicing strings

```
receipt = "08:30 - coffee - \$3.50"
```

```
println(receipt)
```

```
08:30 - coffee - $3.50
```

Slicing strings

```
# Index position:  
#           12345...  
receipt = "08:30 - coffee - \"$3.50"  
  
time = receipt[1:5]           # Select first 5 characters  
  
println(time)
```

```
08:30
```

Slicing strings

```
# Index position from end:
#                               4321end
receipt = "08:30 - coffee - \"$3.50"

time = receipt[1:5]           # Select first 5 characters
price = receipt[end-4:end]    # Select last 5 characters

println(time)
println(price)
```

08:30

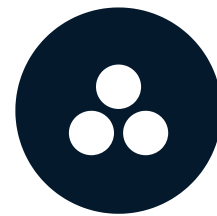
\$3.50

Let's practice!

INTRODUCTION TO JULIA

Introduction to arrays

INTRODUCTION TO JULIA



James Fulton

Climate informatics researcher

What is an array?

```
# Store run times with many variables  
runtime1 = 33.1  
runtime2 = 32.7  
runtime3 = 34.2  
runtime4 = 31.9
```

```
# Store runtimes in array  
runtimes = [33.1, 32.7, 34.2, 31.9]
```

- List of values
- Surrounded by `[]`
- With `,` in between values

Arrays vs. vectors vs. matrices

```
# Store runtimes in array  
runtimes = [33.1, 32.7, 34.2, 31.9]  
  
println(typeof(runtimes))
```

```
Vector{Float64}
```

Arrays vs. vectors vs. matrices

Vector is 1D array

33.1	32.7	34.2	31.9
------	------	------	------

Arrays vs. vectors vs. matrices

Vector is 1D array

33.1	32.7	34.2	31.9
------	------	------	------

Matrix is 2D array

Arrays vs. vectors vs. matrices

Vector is 1D array

33.1	32.7	34.2	31.9
------	------	------	------

Arrays can have any number of dimensions

Matrix is 2D array

Array data types

```
# Store runtimes in array  
runtimes = [33.1, 32.7, 34.2, 31.9]  
  
println(typeof(runtimes))
```

```
Vector{Float64}
```


Array data types

```
# Store runtimes in array  
runtimes = [33.1, 32.7, 34.2, 31.9]  
  
println(eltype(runtimes))
```

Float64

Array data types

```
# Store integers in array
number_of_customers = [11, 19, 31, 27]

println(typeof(number_of_customers))
```

Vector{Int64}

```
# Store characters in array
grades = ['A', 'B', 'B', 'A']

println(typeof(grades))
```

Vector{Char}

```
# Store strings in array
names = ["Amit", "Barbara", "Carlos"]

println(typeof(names))
```

Vector{String}

```
# Store booleans in array
correct_answers = [true, false, true]

println(typeof(correct_answers))
```

Vector{Bool}

Mixed data types

```
# Store multiple types in array
#           string    bool  int char float
items = ["James", true, 10, 'B', -20.3]

println(typeof(items))
```

```
Vector{Any}
```

Mixed data types

```
# Store array of item names
item_names = ["chalk", "cheese", "eggs", "ham"]

# Store array of item prices
item_prices = [2.30, 3.50, 4.25, 2.00]

println(typeof(item_names))
println(typeof(item_prices))
```

```
Vector{String}
Vector{Float64}
```

Indexing arrays

```
# Index:           1           2           3           4
item_names = ["chalk", "cheese", "eggs", "ham"]
```

```
# Index:           1           2           3           4
item_prices = [2.30, 3.50, 4.25, 2.00]
```

```
println(item_names[1])
println(item_prices[1])
```

```
chalk
2.30
```

Indexing arrays

```
# Index:           1           2           3           4
item_names = ["chalk", "cheese", "eggs", "ham"]
```

```
# Index:           1           2           3           4
item_prices = [2.30, 3.50, 4.25, 2.00]
```

```
println(item_names[end])
println(item_prices[end])
```

```
ham
2.00
```

Indexing arrays

```
# Index:           1           2           3           4
item_names = ["chalk", "cheese", "eggs", "ham"]

# Index:           1           2           3           4
item_prices = [2.30, 3.50, 4.25, 2.00]

println(item_names[end-1])
println(item_prices[end-1])
```

```
eggs
4.25
```

Slicing arrays

```
# Index:          1      2      3      4
item_names = ["chalk", "cheese", "eggs", "ham"]

# Index:          1      2      3      4
item_prices = [2.30, 3.50, 4.25, 2.00]

println(item_names[1:2])
```

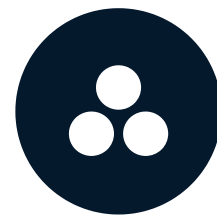
```
["chalk", "cheese"]
```


Let's practice!

INTRODUCTION TO JULIA

Working with arrays

INTRODUCTION TO JULIA



James Fulton

Climate informatics researcher

Adding an element to the end of an array

```
# Predefine array
x = [1, 2, 3, 4]

# Add the number 5 to end of array
push!(x, 5)

println(x)
```

```
[1, 2, 3, 4, 5]
```

Adding an element to the end of an array

```
# Predefine array
x = [1, 2, 3, 4]

# Add the float 5.0 to end of array
push!(x, 5.0)

println(x)
println(eltypes(x))
```

```
[1, 2, 3, 4, 5]
Int64
```

Adding an element to the end of an array

```
# Predefine array  
x = [1, 2, 3, 4]  
  
# Add the float 5.2 to end of array  
push!(x, 5.2)
```

```
ERROR: InexactError: Int64(5.2)
```

Creating an array of given type

```
# Create float array
x = Float64[1,2,3,4]

println(typeof(x))

# Add the float 5.2 to end of array
push!(x, 5.2)

println(x)
```

```
Vector{Float64}
[1.0, 2.0, 3.0, 4.0, 5.2]
```

Creating an array of given type

```
# Create empty float array  
x = Float64[]  
  
println(typeof(x))  
println(x)
```

```
Vector{Float64}  
Float64[]
```

Creating an array of given type

```
# Create empty string array  
x = String[]  
  
println(typeof(x))  
println(x)
```

```
Vector{String}  
String[]
```


Adding elements to the end of an array

```
# Create empty string array  
x = String[]
```

```
# Add some elements to the array
```

```
push!(x, "one")  
push!(x, "two")  
push!(x, "three")
```

```
println(x)
```

```
["one", "two", "three"]
```

```
# Create empty string array  
x = String[]
```

```
# Add some elements to the array
```

```
append!(x, ["one", "two", "three"])
```

```
println(x)
```

```
["one", "two", "three"]
```

Removing the last element

```
x = [1, 2, 3, 4]

# Remove 1 element from end
x = x[1:end-1]

println(x)
```

```
[1, 2, 3]
```

```
x = [1, 2, 3, 4]

# Remove 1 element from end
last_element = pop!(x)

println(x)
println(last_element)
```

```
[1, 2, 3]
```

```
4
```

Creating array of defined length

```
# Create integer array with 4 zeros  
x = zeros{Int64, 4}  
  
println(x)
```

```
[0, 0, 0, 0]
```

Replacing an element

```
# Create integer array with 4 zeros
x = zeros{Int64, 4}

# Replace element in position 3 with value 1
x[3] = 1

println(x)
```

```
[0, 0, 1, 0]
```

Replacing many elements

```
# Create integer array with 4 zeros
x = zeros{Int64, 4}

# Replace many elements
x[2:3] = [2, 3]

println(x)
```

```
[0, 2, 3, 0]
```

Cheatsheet

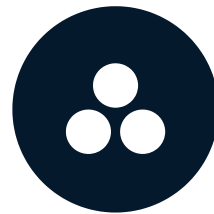
- Add single element - `push!(x, 1)`
- Add many elements - `append!(x, [1,2,3])`
- Remove last element - `pop!(x)`
- Create array of given type - `Int64[1,2,3]` , `Float64[1,2,3]` , etc.
- Create empty array of given type - `Int64[]` , `Float64[]` , etc.
- Create an array full of zeros - `zeros{Int64}(n)`
- Replace element - `x[index] = value`
- Replace many elements - `x[a:b] = [value1, value2, ...]`

Let's practice!

INTRODUCTION TO JULIA

Operating on arrays

INTRODUCTION TO JULIA



James Fulton

Climate informatics researcher

Basic array functions

```
# An array with 6 elements
x = ["a", "b", "sea", "d", "e", "f"]

# Find the length of the array
l = length(x)

println(l)
```

6

Basic array functions

```
# An array with 6 elements  
x = ["a", "b", "sea", "d", "e", "f"]
```

```
x_sorted = sort(x)  
println(x_sorted)
```

```
["a", "b", "d", "e", "f", "sea"]
```

```
# An array with 6 elements  
x = [100, 95, 9, 22, 75, 58]
```

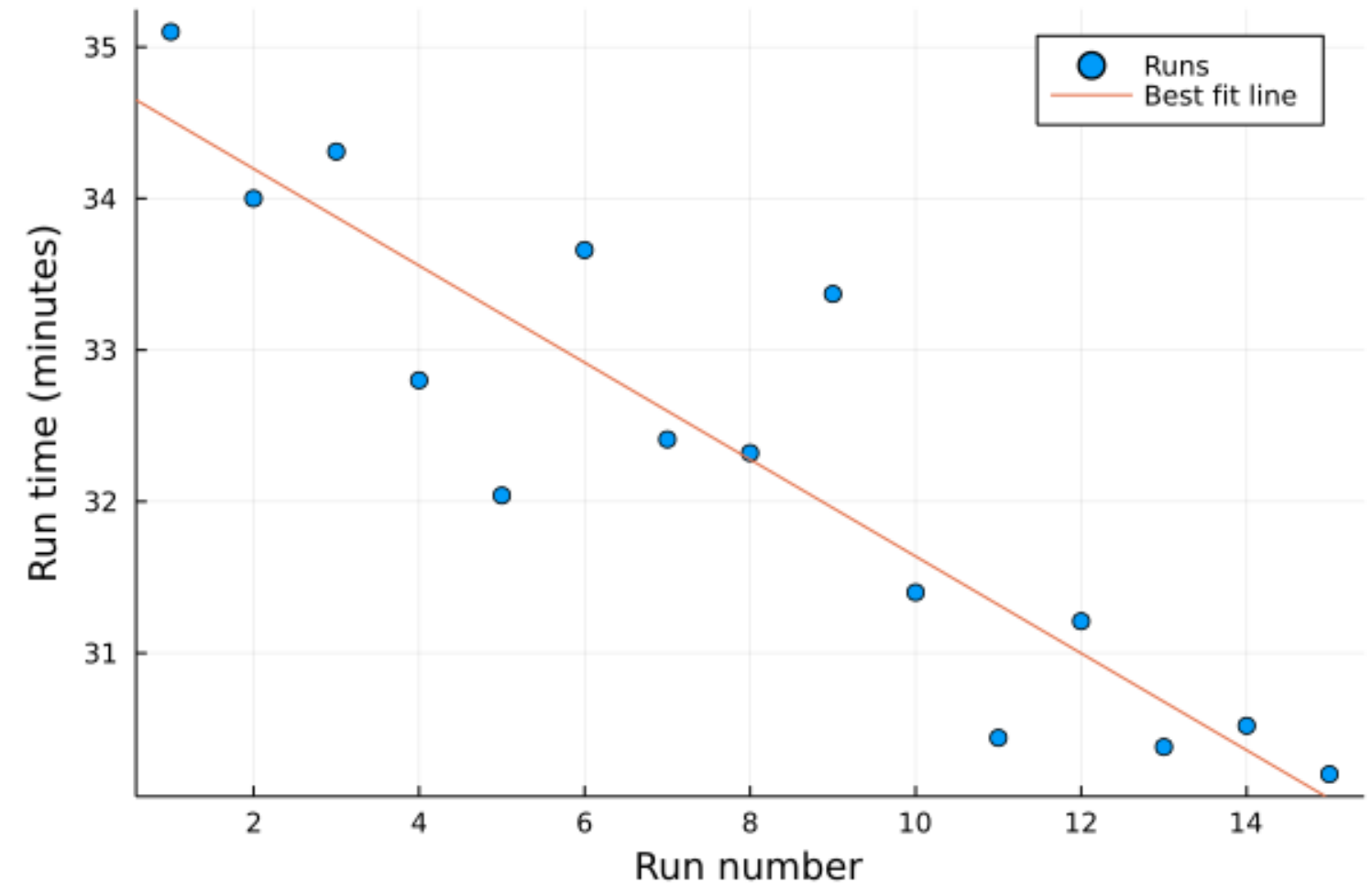
```
x_sorted = sort(x)  
println(x_sorted)
```

```
[9, 22, 58, 75, 95, 100]
```

Vectorized operations

```
# Gradient and intercept  
m = -0.32  
c = 34.8  
  
# Next run number is 16  
x = 16  
  
# Predict next run time  
y = m * x + c  
  
println(y)
```

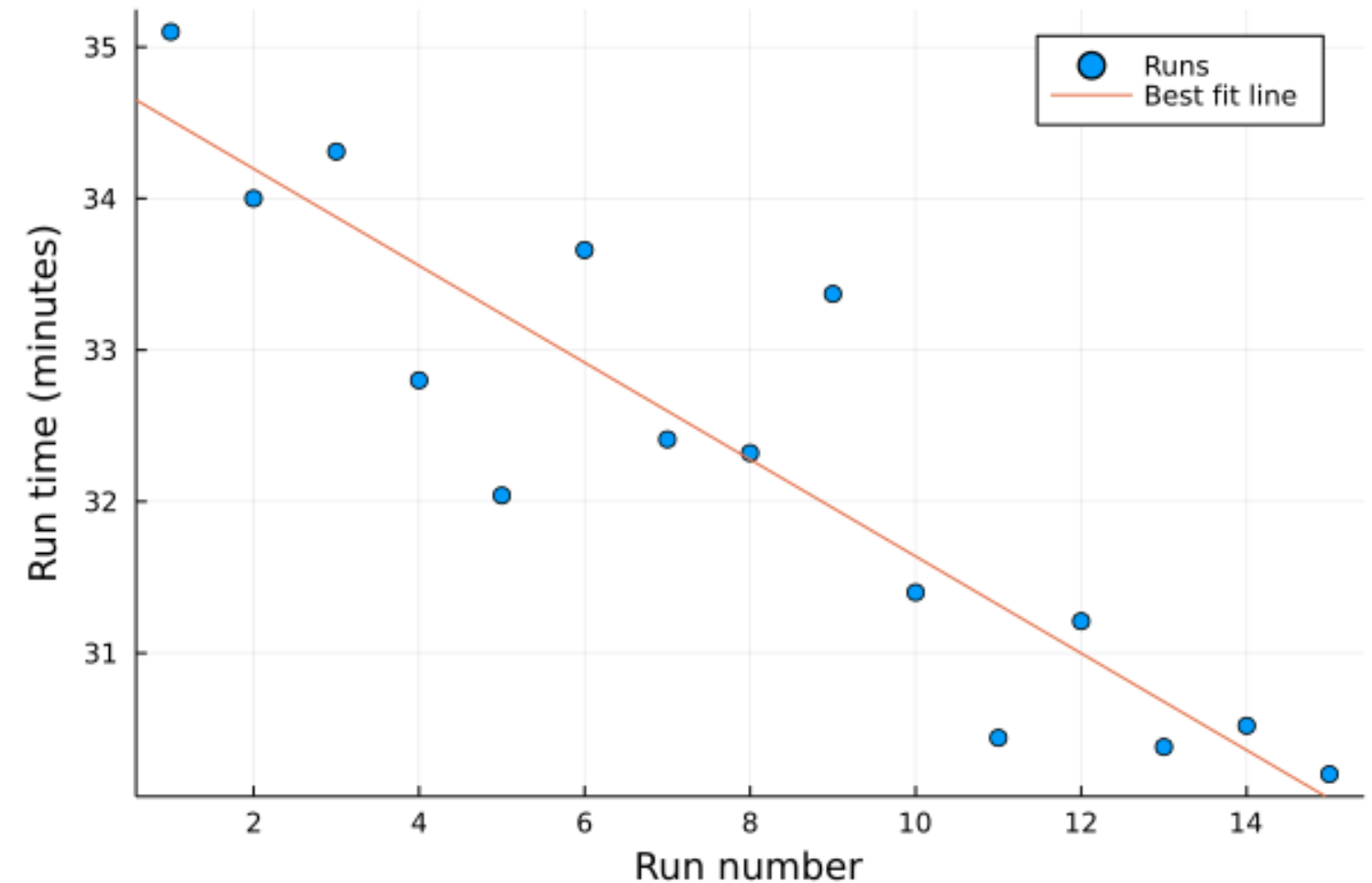
29.68



Vectorized operations

```
# Gradient and intercept  
m = -0.32  
c = 34.8  
  
# Next run numbers  
x = [16, 17, 18, 19, 20]  
  
# Predict next run time  
y = m * x + c
```

ERROR: MethodError: ...



Array addition

Add scalar

```
a = [1, 2, 3]
```

```
# Answer we expect is [3, 4, 5]
```

```
println(a .+ 2)
```

```
[3, 4, 5]
```

Add array

```
a = [1, 2, 3]
```

```
b = [1, 2, 3]
```

```
# Answer we expect is [2, 4, 6]
```

```
println(a .+ b)
```

```
[2, 4, 6]
```

Array addition

Add scalar

```
a = [1, 2, 3]
```

```
# Answer we expect is [3, 4, 5]
```

```
println(a + 2)
```

```
ERROR: MethodError: ...
```

Add array

```
a = [1, 2, 3]
```

```
b = [1, 2, 3]
```

```
# Answer we expect is [2, 4, 6]
```

```
println(a + b)
```

```
[2, 4, 6]
```

Array subtraction

```
# Subtract scalar  
println(a .- 1)
```

```
[0, 1, 2]
```

```
# Subtract scalar  
println(a - 1)
```

```
ERROR: MethodError: ...
```

```
# Subtract array  
println(a .- b)
```

```
[0, 0, 0]
```

```
# Subtract array  
println(a - b)
```

```
[0, 0, 0]
```

Array multiplication

Multiply by scalar

```
a = [1, 2, 3]
```

```
# Answer we expect is [5, 10, 15]
```

```
println(a .* 5)
```

```
[5, 10, 15]
```

Multiply by array

```
a = [1, 2, 3]
```

```
b = [1, 2, 3]
```

```
# Answer we expect is [1, 4, 9]
```

```
println(a .* b)
```

```
[1, 4, 9]
```


Array multiplication

Multiply by scalar

```
a = [1, 2, 3]
```

```
# Answer we expect is [5, 10, 15]
```

```
println(a * 5)
```

```
[5, 10, 15]
```

Multiply by array

```
a = [1, 2, 3]
```

```
b = [1, 2, 3]
```

```
# Answer we expect is [1, 4, 9]
```

```
println(a * b)
```

```
ERROR: MethodError: ...
```

Array division

```
# Divide by scalar  
println(a ./ 2)
```

```
[0.5, 1.0, 1.5]
```

```
# Divide by scalar  
println(a / 2)
```

```
[0.5, 1.0, 1.5]
```

```
# Divide by array  
println(a ./ b)
```

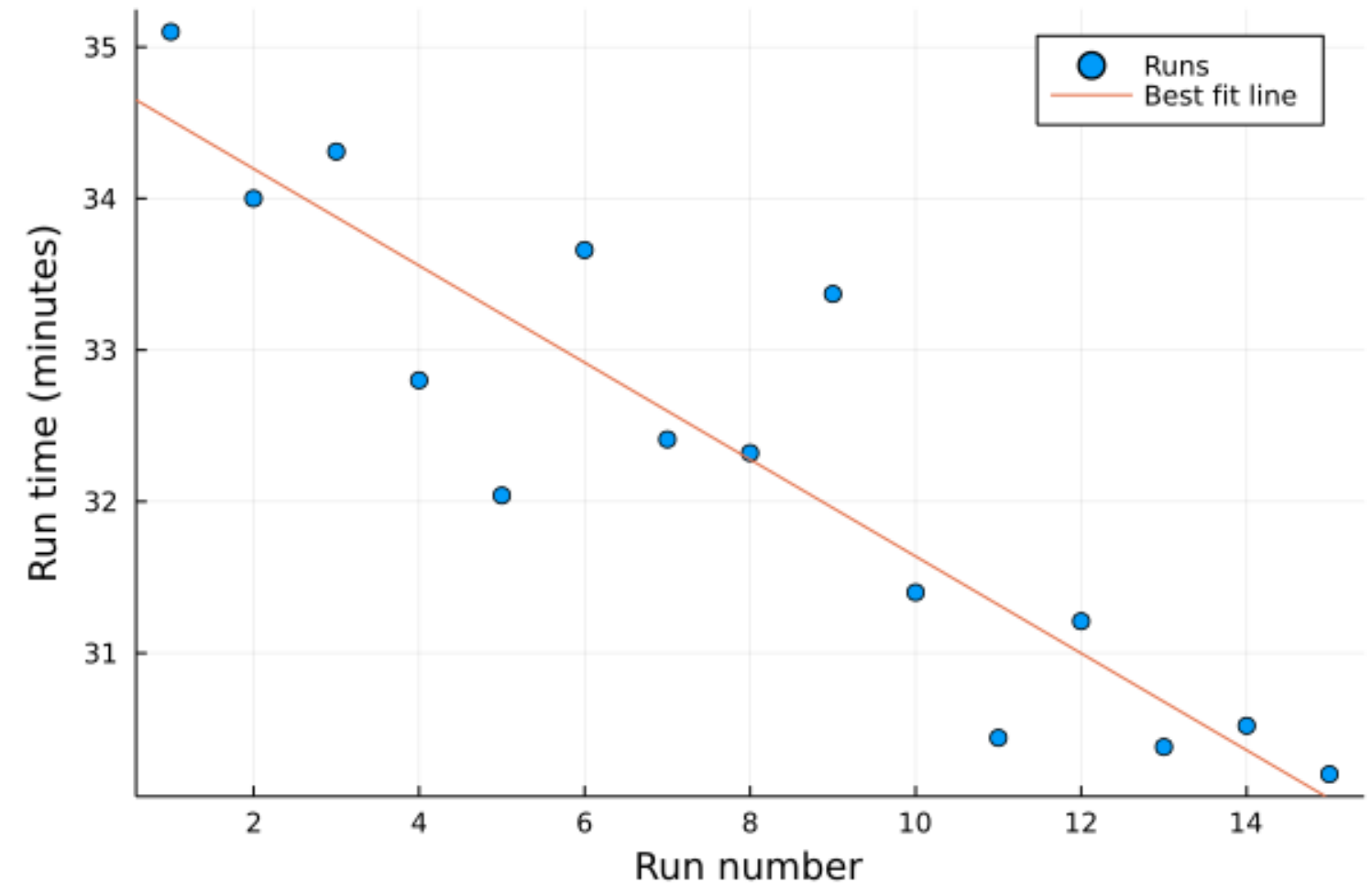
```
[1.0, 1.0, 1.0]
```

```
# Divide by array  
println(a / b)
```

```
0.071  0.142  0.214  
0.142  0.285  0.428  
0.214  0.428  0.642
```

Vectorized operations

```
# Gradient and intercept  
m = -0.32  
c = 34.8  
  
# Next run numbers  
x = [16, 17, 18, 19, 20]  
  
# Predict next run time  
y = m * x + c
```



Vectorized operations

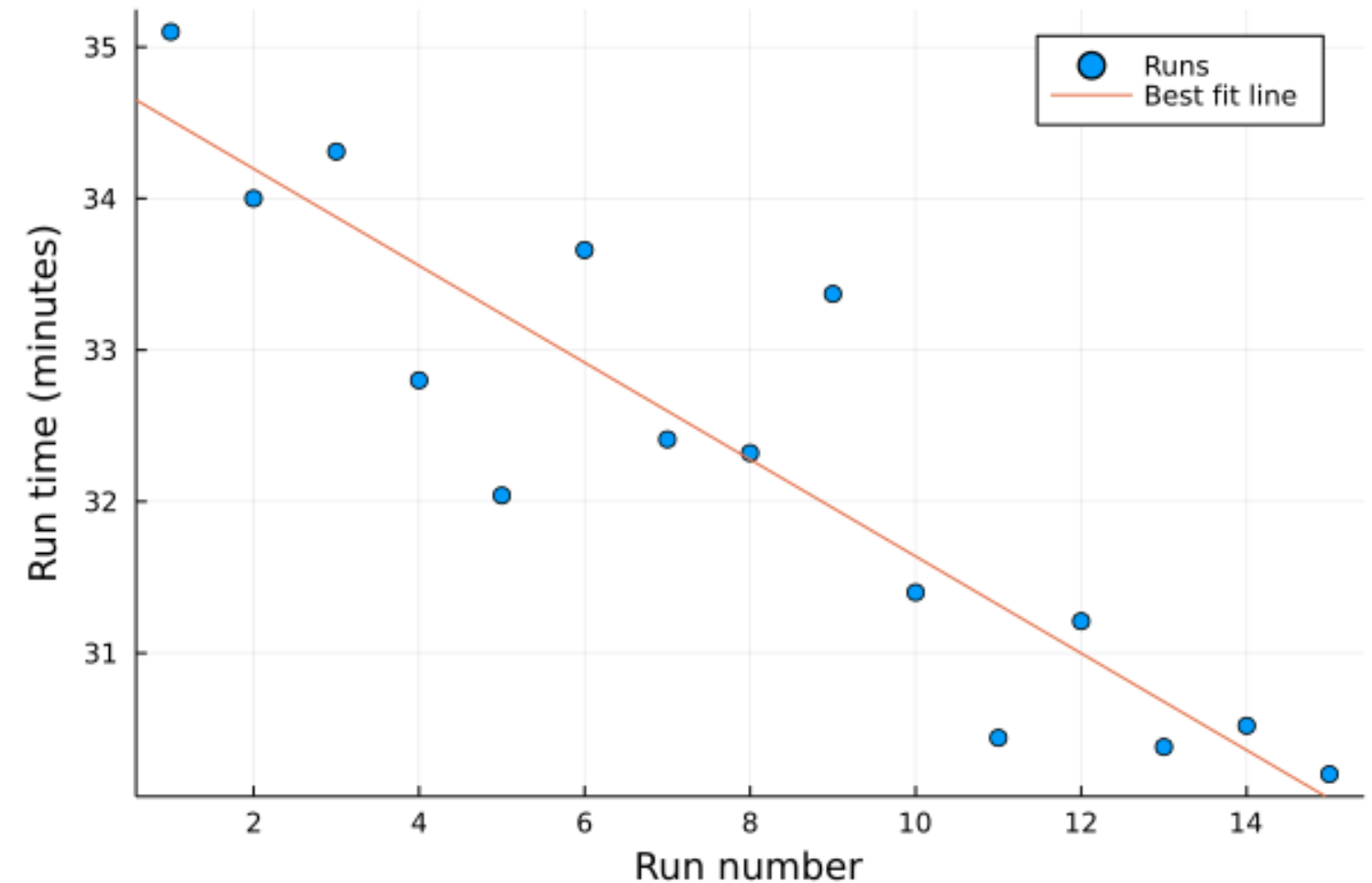
```
# Gradient and intercept
m = -0.32
c = 34.8

# Next run numbers
x = [16, 17, 18, 19, 20]

# Predict next run time
y = m .* x .+ c

println(y)
```

```
[29.68, 29.36, 29.04, 28.72, 28.40]
```



Cheatsheet

For arrays `a` and `b`

Operation	Scalar example	Array example
Addition	<code>a .+ 1</code>	<code>a .+ b</code> or <code>a + b</code>
Subtraction	<code>a .- 1</code>	<code>a .- b</code> or <code>a - b</code>
Multiplication	<code>2 .* a</code> or <code>2 * a</code>	<code>a .* b</code>
Division	<code>a ./ 2</code> or <code>a / 2</code>	<code>a ./ b</code>

Let's practice!

INTRODUCTION TO JULIA