# Lecture 4

## Functions, scoping, abstraction

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# PREVIOUS LECTURE

- iterations / loops

# TODAY

- structuring programs and hiding details
- functions
- specifications
- keywords: `return` vs `print`
- scope

# EXERCISE

- Write an AI program that will guess a user’s number.

```
## Choose a number between 1 and 100!
## Is it 50 (Y, H or L): H
## Is it 75 (Y, H or L): H
## Is it 87 (Y, H or L): L
## Is it 81 (Y, H or L): L
## Is it 78 (Y, H or L): H
## Is it 79 (Y, H or L): Y
## I guessed your number!!!
```

# EXERCISE

- Write an AI program that will guess a user’s number.

```
print("Choose a number between 1 and 100!")
low = 1
high = 100
while high >= low:
   guess = int((high + low) / 2)
   response = input("Is it " + str(guess) + " (Y, H or L): ")
   if response == "Y":
      print("I guessed your number!!!")
      break
   elif response == "H":
      low = guess
   else:
      high = guess
```

# FUNCTIONS

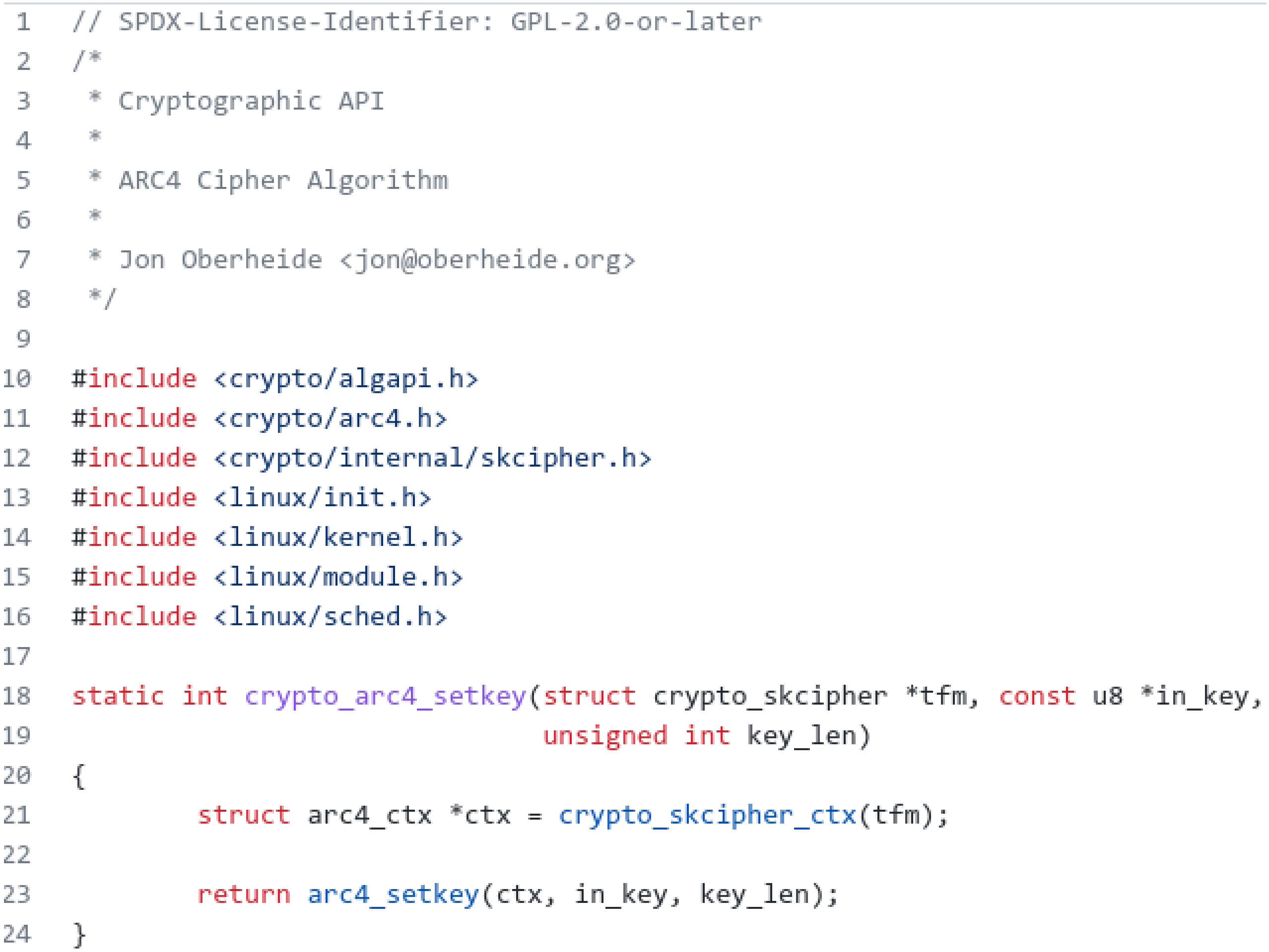
# HOW DO WE WRITE CODE?

- so far…
  - covered language mechanisms
  - wrote different codes for each computation
  - each code is a sequence of instructions
- problems with this approach
  - easy for small-scale problems
  - messy for larger problems
  - hard to keep track of details
  - how do you know the right info is supplied to the right part of code

# LINUX KERNEL EXAMPLE

- Linux is an operating system
- It is free and **open source**
    - meaning: you can download and examine its code
- However, it contains over **30 million** lines of code!
- No single person on earth can handle that much code!
- What is the solution?

# LINUX KERNEL CODE



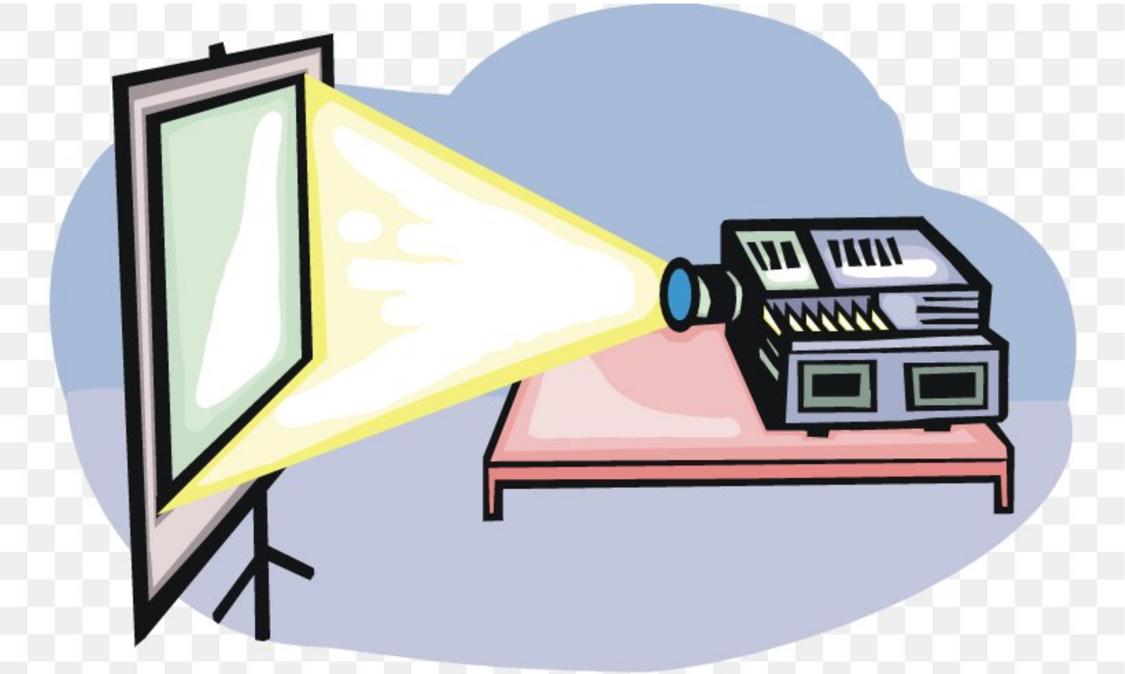
```c
// SPDX-License-Identifier: GPL-2.0-or-later
/*
 * Cryptographic API
 *
 * ARC4 Cipher Algorithm
 *
 * Jon Oberheide <jon@oberheide.org>
 */

#include <crypto/algapi.h>
#include <crypto/arc4.h>
#include <crypto/internal/skcipher.h>
#include <linux/init.h>
#include <linux/kernel.h>
#include <linux/module.h>
#include <linux/sched.h>

static int crypto_arc4_setkey(struct crypto_skcipher *tfm, const u8 *in_key,
                              unsigned int key_len)
{
        struct arc4_ctx *ctx = crypto_skcipher_ctx(tfm);

        return arc4_setkey(ctx, in_key, key_len);
}
```

# GOOD PROGRAMMING

- more code does not mean good programming
- measure good programmers by the amount of functionality
- introduce **functions**
- mechanism to achieve **decomposition** and **abstraction**

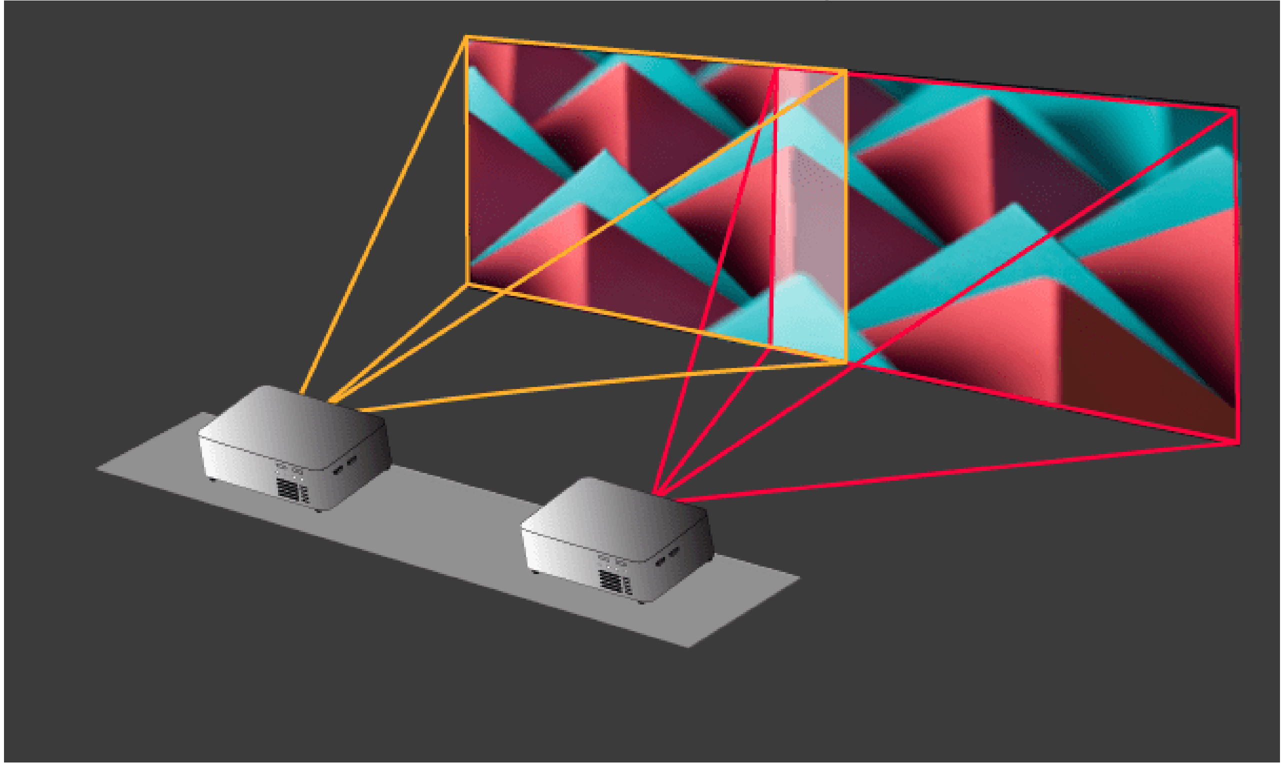
# EXAMPLE – PROJECTOR

- a projector is a black box
- we don’t know how it works
- we know the interface: input/output
- connect any electronic to it that can communicate with that input
- black box somehow converts image from input source to a wall, magnifying it
- **ABSTRACTION**: do not need to know how the projector works to use it



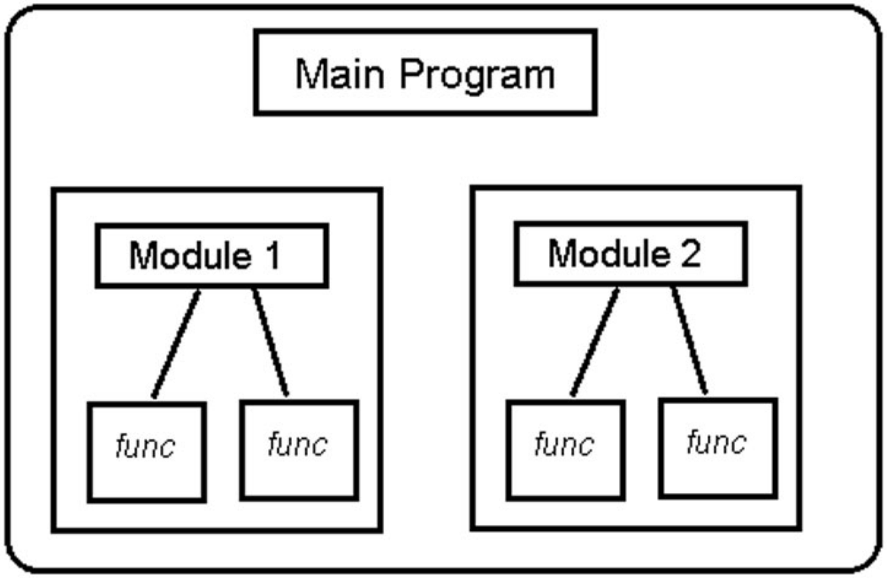
# EXAMPLE – PROJECTOR

- projecting very large images
  - decomposed into separate tasks for separate projectors
- each projector takes **partial** input and produces separate output
- all projectors work together to produce larger image
- **DECOMPOSITION**: different devices work together to achieve an end goal



# APPLY TO PROGRAMMING

- We can decompose code into **modules**
  - self-contained
  - used to break-up code
  - reusable
  - organized
  - coherent (logical and consistent)
- We can abstract code blocks
  - do not need the details
  - do not want the details
  - interested in input/output



# FUNCTIONS

- Both decomposition and abstraction can be achieved by **functions**
- write reusable pieces/chunks of code, called **functions**
- functions are not run in a program until they are **called** or **invoked** in a program
- function characteristics:
    - has a **name**
    - has **parameters** (0 or more)
    - has a **docstring** (optional but recommended)
    - has a **body**
    - **returns** something

# FUNCTION DEFINITIONS

```python
def is_even(i):
    """
    Input: i, a positive int
    Returns True if i is even, otherwise False
    """
    print("inside function is_even()")
    return i%2 == 0
```

# FUNCTION CALLS

```
print("some code...")
is_even(3)
print("some other code ...")
```

```
## some code...
## inside function is_even()
## False
## some other code ...
```

# EXERCISE

- Write a function that returns the square of a number

# EXERCISE

- Write a function that returns the square of a number

```
def square(i):
   return i**2
```

- Now call the function to test it:

```
square(2)
```

```
## 4
```

```
square(-3)
```

```
## 9
```

```
square(0)
```

```
## 0
```

# EXERCISE

- Write a function that returns the sum of two numbers

# EXERCISE

- Write a function that returns the sum of two numbers

```
def sum_of_two(i, j):
   return i + j
```

- Test:

```
sum_of_two(3, 5)
```

```
## 8
```

```
sum_of_two(-2, 4)
```

```
## 2
```

# EXERCISE

- Write a function that returns True if the given number is prime

# EXERCISE

- Write a function that returns True if the given number is prime

```
def is_prime(number):
   prime = True
   for i in range(2, int(number / 2)):
      if number % i == 0:
         prime = False
         break
   return prime
```

- Test:

```
is_prime(7)
```

```
## True
```

```
is_prime(10)
```

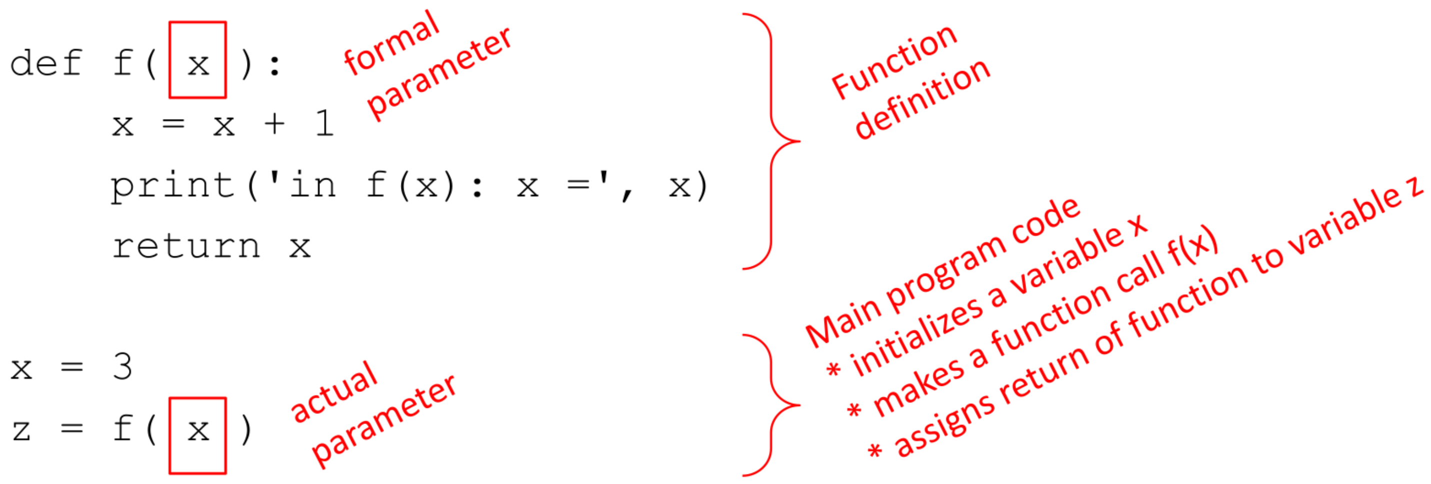
```
## False
```

```
is_prime(79)
```

```
## True
```

# VARIABLE SCOPE

- **formal parameter** gets bound to the value of **actual parameter** when function is called
- new **scope/frame/environment** created when enter a function
- **scope** is mapping of names to objects



```
def f( x ):
    x = x + 1
    print('in f(x): x =', x)
    return x

x = 3
z = f( x )
```

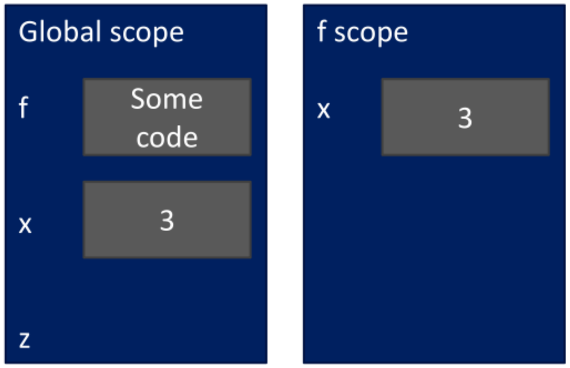
formal parameter
Function definition
Main program code
* initializes a variable x
* makes a function call f(x)
* assigns return of function to variable z
actual parameter

- Check in Python Tutor

# VARIABLE SCOPE

```
def f( x ):
    x = x + 1
    print('in f(x): x =', x)
    return x

x = 3
z = f( x )
```



- Check in Python Tutor

# VARIABLE SCOPE

```
def f( x ):
    x = x + 1
    print('in f(x): x =', x)
    return x

x = 3
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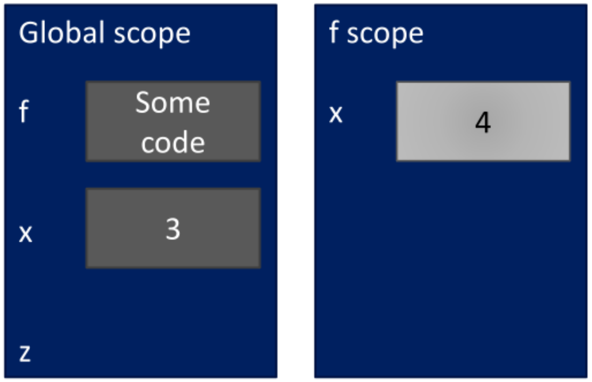

# VARIABLE SCOPE

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    x = x + 1
    print('in f(x): x =', x)
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x = 3
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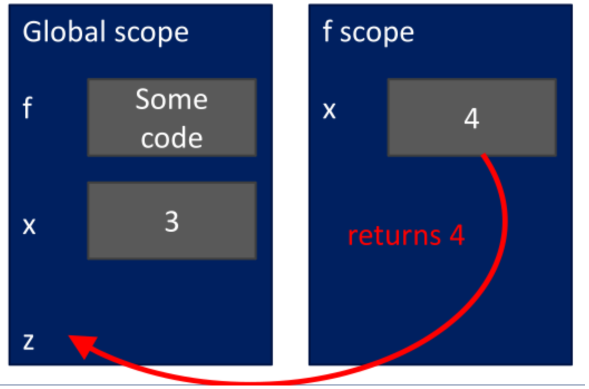
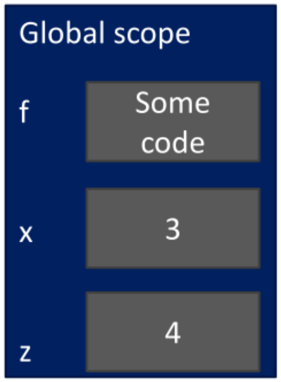


# VARIABLE SCOPE

```
def f( x ):
    x = x + 1
    print('in f(x): x =', x)
    return x

x = 3
z = f( x )
```



Global scope

f Some code

x 3

z 4

# EXERCISE

```python
def foo(x):
   x = 2 * x
   print(x)

x = 5
foo(x)
```

```
## 10
```

```python
print(x)
```

```
## 5
```

- Check in Python Tutor

# EXERCISE

- To make things less confusing, use different names for actual and formal parameters

```
def foo(x):
   x = 2 * x
   print(x)

i = 5
foo(i)
```

```
## 10
```

```
print(i)
```

```
## 5
```

- Check in Python Tutor

# NO `return` STATEMENT

```
def is_even(i):
    """
    Input: i, a positive int
    Does not return anything
    """
    i%2 == 0

print(is_even(5))
```

```
## None
```

- Python returns the value **None**, *if no return given*
- represents the absence of a value

# `return` vs. `print`

- return only has meaning **inside** a function
- only **one** return executed inside a function
- code inside function but **after** return statement **not executed**
- has a value associated with it, **given to function caller**

- print can be used **outside** functions
- can execute **many** print statements inside a function
- code inside function **can be executed after** a print statement
- has a value associated with it, **outputted** to the console

# ACCESS OUTSIDE

- It is possible to access the **outside** from within a function scope

```
def foo(x):
   print (x)
   print (i)

i = 5
foo(2 * i)
```

```
## 10
## 5
```

- Check in Python Tutor

# ACCESS OUTSIDE

- But you cannot change an outside variable

```
def foo(x):
   i = 10       # i is re-assigned in function scope
   print (i)

i = 5
foo(i)
```

```
## 10
```

```
print(i)        # actual i keeps its original value
```

```
## 5
```

- Check in Python Tutor

# ACCESS OUTSIDE

- But you cannot change an outside variable
    - Unless you define it as `global` (advanced topic)

```
def foo(x):
   global i      # i is defined in the global scope
   i = 10        # the global i variable is reassigned
   print (i)

i = 5
foo(i)
```

```
## 10
```

```
print(i)         # the global value has been changed
```

```
## 10
```

- Check in Python Tutor

# EXERCISE

- Write a function that returns the minimum value in a sequence

# EXERCISE

- Write a function that returns the minimum value in a sequence

```
def min_val(sequence):
   curMin = sequence[0]
   for val in sequence:
      if val < curMin:
         curMin = val
   return curMin

min_val([1,2,3,4,5,6,7,-1,-2,-3,-4,-5])
```

```
## -5
```

```
min_val(["burkay", "ahmet", "ayşe", "hatice", "orkun", "zeynep"])
```

```
## 'ahmet'
```

# EXERCISE

- Write a function to reverse a string

# EXERCISE

- Write a function to reverse a string

```
def reverse_str(s):
   r = ""
   for char in s:
      r = char + r
   return r

reverse_str("burkay genc")
```

```
## 'cneg yakrub'
```

- Carefully examine this solution!

# DECOMPOSITION & ABSTRACTION

- powerful together
- code can be used many times but only has to be debugged once!

# HOME EXERCISE

1. Write a function to convert a given length in centimeters to inches
2. Write a function that takes three arguments
   - a number
   - another number
   - an operator (“+”, “-”, “*”, “/”)
   - and returns the result of the operation
3. Write a function to build a pyramid of given height
4. Write a function to check whether a given substring is found in a given string and returns its index if found, return -1 otherwise.
5. Write a function that takes two arguments and returns their smallest common multiple.
6. Write a function that returns the $k^{th}$ fibonacci number for a given $k$ value.

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