STRING MANIPULATION, GUESS-and-CHECK, APPROXIMATIONS, BISECTION

(download slides and .py files ˙follow along!)

6.0001 LECTURE 3

LAST TIME

- strings

- branching – if/elif/else

- while loops

- for loops

TODAY

- string manipulation

- guess and check algorithms

- approximate solutions

- bisection method

STRINGS

- think of as a **sequence** of case sensitive characters

- can compare strings with ==, >, < etc.

- `len()` is a function used to retrieve the **length** of the string in the parentheses

```
s = "abc"
len(s)  → evaluates to 3
```

STRINGS

- square brackets used to perform **indexing** into a string to get the value at a certain index/position

```
s = "abc"
```

index: 0 1 2   ← indexing always starts at 0

index: -3 -2 -1   ← last element always at index -1

```
s[0]        →   evaluates to "a"
s[1]        →   evaluates to "b"
s[2]        →   evaluates to "c"
s[3]        →   trying to index out of bounds, error
s[-1]       →   evaluates to "c"
s[-2]       →   evaluates to "b"
s[-3]       →   evaluates to "a"
```

STRINGS

- can **slice** strings using `[start:stop:step]`

- if give two numbers, `[start:stop]`, `step=1` by default

- you can also omit numbers and leave just colons

```
s = "abcdefgh"
```

`s[3:6]`   → evaluates to `"def"`, same as `s[3:6:1]`

`s[3:6:2]` → evaluates to `"df"`

`s[::]`   → evaluates to `"abcdefgh"`, same as `s[0:len(s):1]`

`s[::-1]`   → evaluates to `"hgfedbca"`, same as `s[-1:-(len(s)+1):-1]`

`s[4:1:-2]` → evaluates to `"ec"`

If unsure what some command does, try it out in your console!

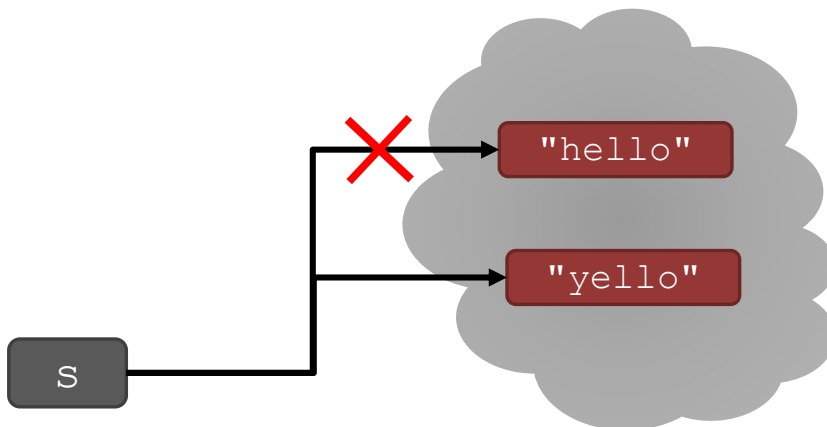# STRINGS

- strings are "**immutable**" – cannot be modified

```
s = "hello"

s[0] = 'y'                  → gives an error
s = 'y'+s[1:len(s)]         → is allowed,
                              s bound to new object
```

for LOOPS RECAP

- `for` loops have a **loop variable** that iterates over a set of values

```
for var in range(4):        →  var iterates over values 0,1,2,3
    <expressions>           →  expressions inside loop executed
                               with each value for var
```

```
for var in range(4,6):  →  var iterates over values 4,5
    <expressions>
```

- `range` is a way to iterate over numbers, but a for loop variable can **iterate over any set of values**, not just numbers!

STRINGS AND LOOPS

- these two code snippets do the same thing

- bottom one is more "pythonic"

```
s = "abcdefgh"
for index in range(len(s)):
    if s[index] == 'i' or s[index] == 'u':
        print("There is an i or u")


for char in s:
    if char == 'i' or char == 'u':
        print("There is an i or u")
```

CODE EXAMPLE:
ROBOT CHEERLEADERS

```python
an_letters = "aefhilmnorsxAEFHILMNORSX"

word = input("I will cheer for you! Enter a word: ")
times = int(input("Enthusiasm level (1-10): "))

i = 0
while i < len(word):
    char = word[i]
    if char in an_letters:
        print("Give me an " + char + "! " + char)
    else:
        print("Give me a  " + char + "! " + char)
    i += 1
print("What does that spell?")
for i in range(times):
    print(word, "!!!")
```

`for char in word:` ✔️

EXERCISE

```
s1 = "mit u rock"
s2 = "i rule mit"
if len(s1) == len(s2):
    for char1 in s1:
        for char2 in s2:
            if char1 == char2:
                print("common letter")
                break
```

GUESS-AND-CHECK

- the process below also called **exhaustive enumeration**

- given a problem…

- you are able to **guess a value** for solution

- you are able to **check if the solution is correct**

- keep guessing until find solution or guessed all values

GUESS-AND-CHECK – cube root

```
cube = 8

for guess in range(cube+1):

    if guess**3 == cube:

        print("Cube root of", cube, "is", guess)
```

GUESS-AND-CHECK – cube root

```
cube = 8

for guess in range(abs(cube)+1):

    if guess**3 >= abs(cube):

        break

if guess**3 != abs(cube):

    print(cube, 'is not a perfect cube')

else:

    if cube < 0:

        guess = -guess

    print('Cube root of '+str(cube)+' is '+str(guess))
```

APPROXIMATE SOLUTIONS

- **good enough** solution

- start with a guess and increment by some **small value**

- keep guessing if `|guess³-cube| >= epsilon` for some **small epsilon**

- decreasing increment size → slower program

- increasing epsilon   → less accurate answer

APPROXIMATE SOLUTION – cube root

```
cube = 27
epsilon = 0.01
guess = 0.0
increment = 0.0001
num_guesses = 0
while abs(guess**3 - cube) >= epsilon  and guess <= cube :
    guess += increment
    num_guesses += 1
print('num_guesses =', num_guesses)
if abs(guess**3 - cube) >= epsilon:
    print('Failed on cube root of', cube)
else:
    print(guess, 'is close to the cube root of', cube)
```

BISECTION SEARCH

- half interval each iteration

- new guess is halfway in between

- to illustrate, let's play a game!
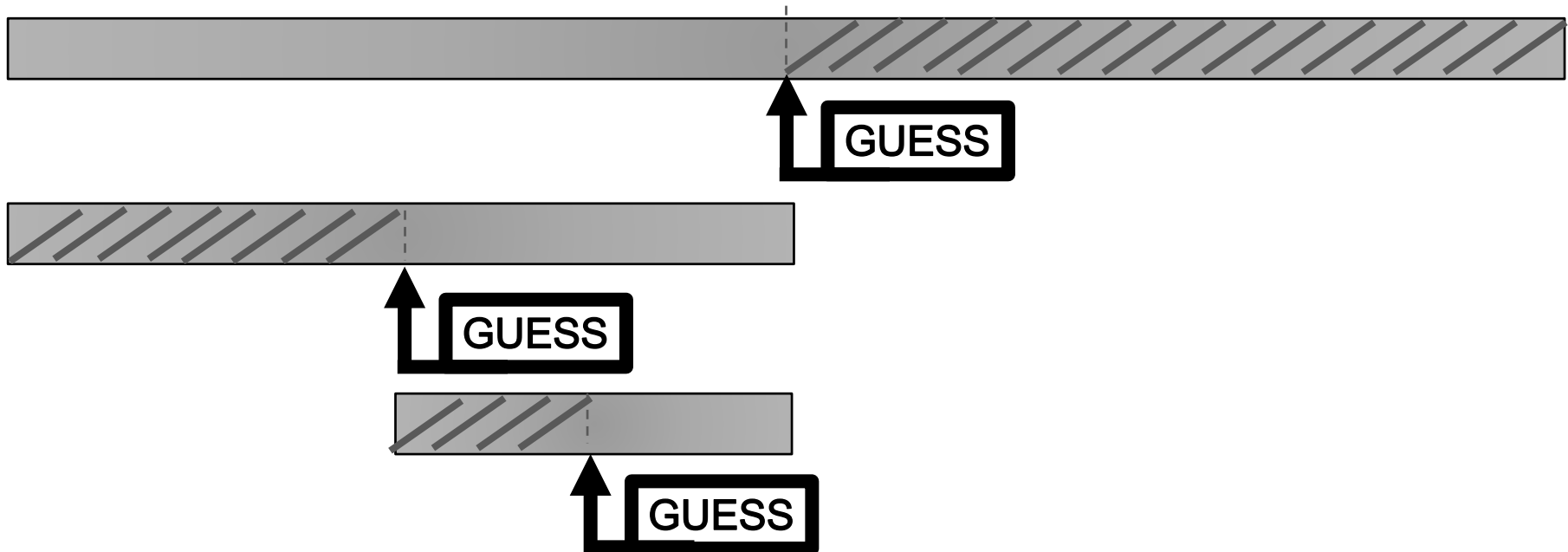
BISECTION SEARCH – cube root

```
cube = 27
epsilon = 0.01
num_guesses = 0
low = 0
high = cube
guess = (high + low)/2.0
while abs(guess**3 - cube) >= epsilon:
    if guess**3 < cube :
        low = guess
    else:
        high = guess
    guess = (high + low)/2.0
    num_guesses += 1
print 'num_guesses =', num_guesses
print guess, 'is close to the cube root of', cube
```

BISECTION SEARCH CONVERGENCE

- search space
  - first guess: N/2
  - second guess: N/4
  - kth guess: $N/2^k$

- guess converges on the order of $\log_2 N$ steps

- bisection search works when value of function varies monotonically with input

- code as shown only works for positive cubes > 1 – why?

- challenges   → modify to work with negative cubes!
               → modify to work with x < 1!

x < 1

- if x < 1, search space is 0 to x but cube root is greater than x and less than 1

- modify the code to choose the search space depending on value of x

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