STRINGS, BRANCHING, ITERATION

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

6.0001 LECTURE 2

Checklist

- Tablet works
- Projector works
- Slides are posted
  - Links work
- I have my lucky

LAST TIME

- Syntax and semantics
- Scalar objects
- Simple operations
- Expressions, variables and values
- Storage and binding
- Input & output
- Branching and conditionals
- Indentation

For sqrt fans

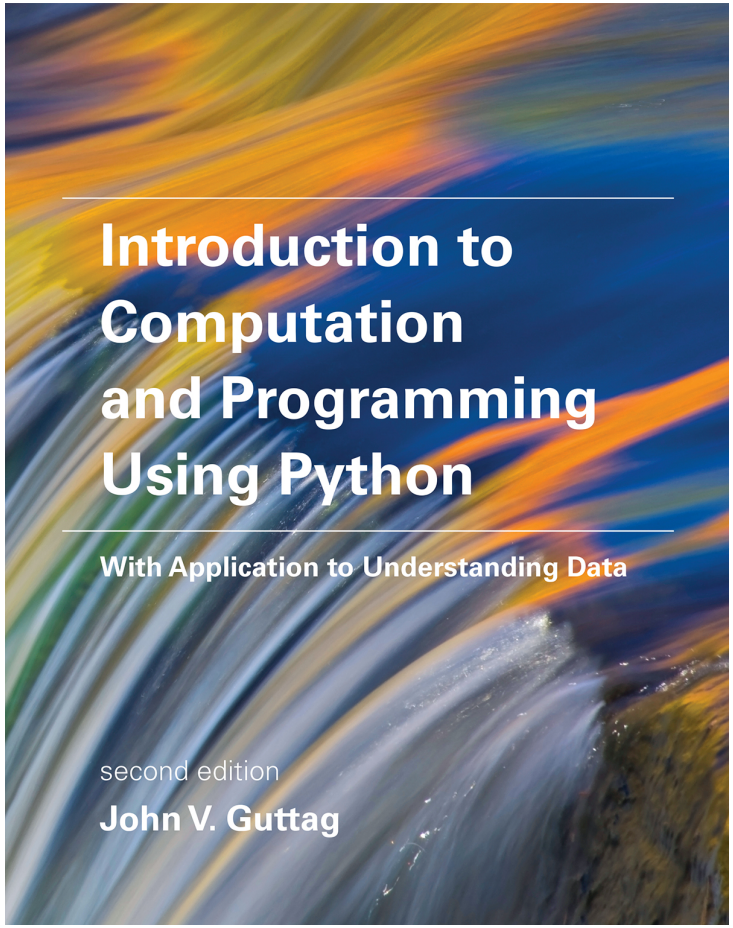
- Check Wikipedia
  - https://en.wikipedia.org/wiki/Methods_of_computing_square_roots
  - There is a whole industry of initial guesses
  - Leverage scientific or binary representations
  - Iterative methods

TODAY

- Recap of assignment, branching
- String object type
- Iteration and loops
- Guess-and-check algorithms

Assigned Reading

- ***Sections 2.3, 2.4***
- ***Sections 3.1, 3.2***



TYPES OF OBJECTS (RECAP)

- Variables and expressions
  - `int`
  - `float`
  - `bool`
  - `NoneType` ← **New**
  - `string` ← **New**
  - … and others we will see later

VARIABLES (RECAP)

- Need a way to refer to computed values abstractly – give them a "name"
- **name**
  - descriptive
  - meaningful
  - helps you re-read code
  - should not be keywords
- **value**
  - information stored
  - can be updated

STRINGS (RECAP)

- Made up from letters, special characters, spaces, digits
- Think of as a **sequence** of case sensitive characters
- Enclose in **quotation marks or single quotes**

```
today = 'Monday'
```

- **Concatenate** strings

```
this = "it is"
what = this + today
what = this + " " + today
```

- Do some **operations** on a string as defined in Python docs

```
announce = "It's " + today * 3
```

OPERATOR OVERLOAD

- **Same operator** used on **different object types**
- + operator
  - E.g. Between two numbers: adds
  - E.g. Between two strings: concatenates
- * operator
  - E.g. Between two numbers: multiplies
  - E.g. Between a number and a string: repeats the string

STRING OPERATIONS

- Can compare strings with ==, >, < etc.
  - compares letters one by one, order is alphabetical
  - E.g. 'a'<'b' return True, so does 'alex'<'bea'
  - Try it in console if you're not sure
- `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]
s[1]
s[2]
s[3]
s[-1]
s[-2]
s[-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
- Get characters at start until stop-1
- You can also omit numbers and leave just colons

SLICING STRINGS EXAMPLE

- Recall: s[start:stop:step]

```
s = "abcdefgh"
```

```
s[3:6]
s[3:6:2]
s[3::]
s[::-1]
s[4:1:-2]
```

SLICING STRINGS EXAMPLE

```
s = "abcdefgh"
```

index: 0 1 2 3 4 5 6 7
index: -8 -7 -6 -5 -4 -3 -2 -1

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

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

`s[3:6:2]` → evaluates to `"df"`

`s[3::]` → evaluates to `"defgh"`, 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"`

STRINGS

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

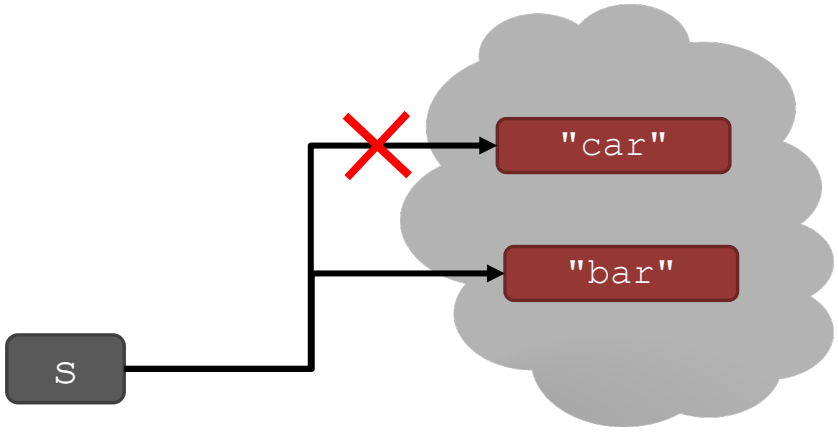
```
s = "car"
```

```
s[0] = 'b'
```

→ gives an error

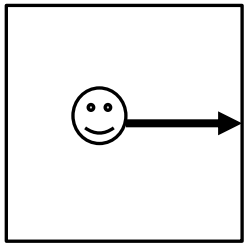
```
s = 'b'+s[1:len(s)]
```

→ is allowed,
s bound to new object

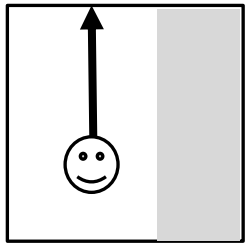


BOOLS (RECAP)

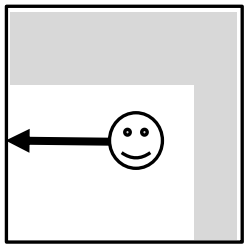
- Boolean values
  - `True`
  - `False`
- Useful with conditions
  - In **branching**:
    If it's hot, go to the beach, otherwise stay at home.
  - In **repetitions**
    As long as it's sunny, keep eating ice cream.



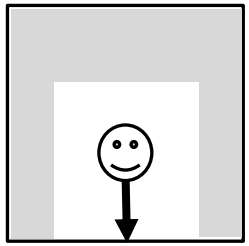
If right clear,
go right



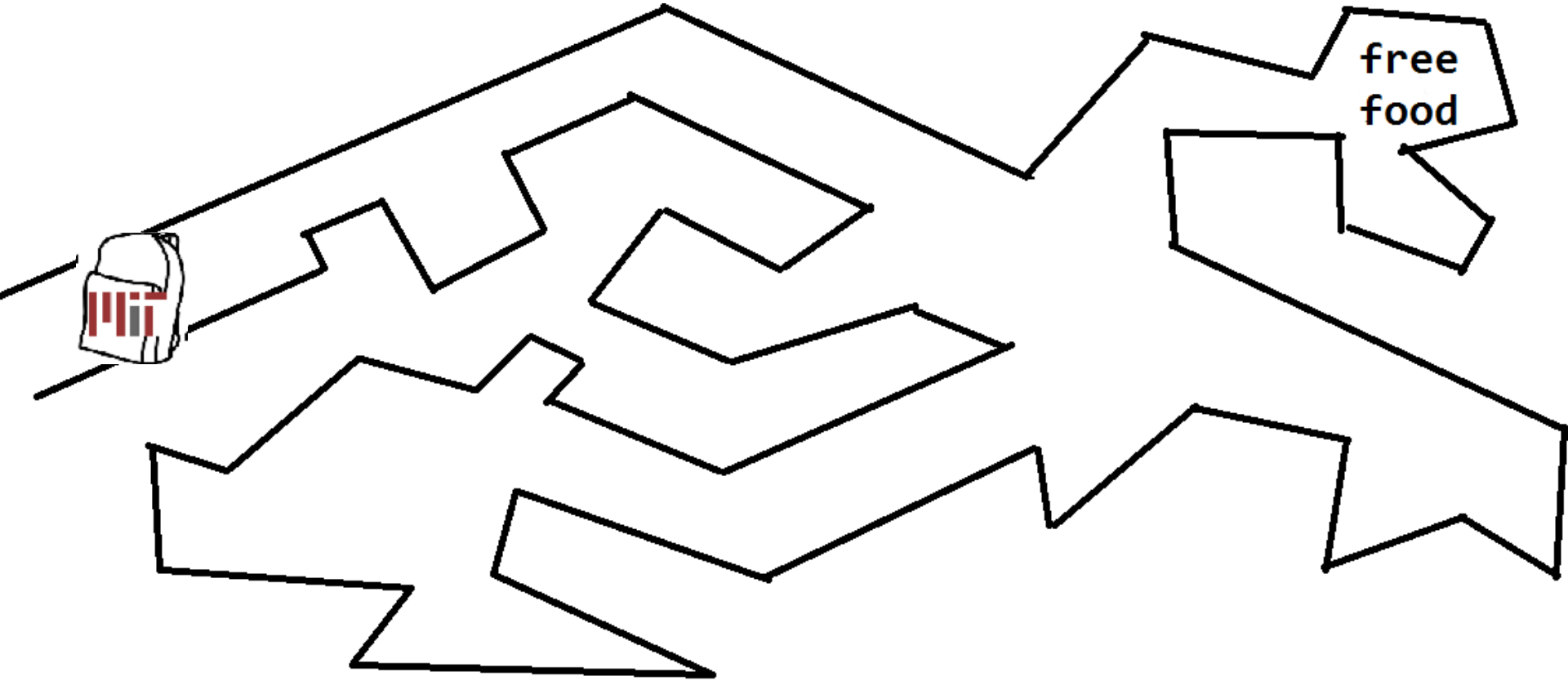
If right blocked,
go forward



If right and
front blocked,
go left



If right , front,
left blocked,
go back



BRANCHING

```
if <condition>:
    <expression>
    <expression>
    ...
```

```
if <condition>:
    <expression>
    <expression>
    ...
else:
    <expression>
    <expression>
    ...
```

```
if <condition>:
    <expression>
    <expression>
    ...
elif <condition>:
    <expression>
    <expression>
    ...
else:
    <expression>
    <expression>
    ...
```

- `<condition>` has a value `True` or `False`
- Evaluate expressions in that block if `<condition>` is `True`

INDENTATION and BLOCKS

- Matters in Python
- How you **denote blocks of code**

```
x = int(input("Enter a number for x: "))
y = int(input("Enter a number for y: "))
if x == y:
    print("x and y are equal")
    if y != 0:
        print("therefore, x / y is", x/y)
elif x < y:
    print("x is smaller")
else:
    print("y is smaller")
print("thanks!")
```

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```

5 5 0

5 0 0

INDENTATION and BLOCKS

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elif x < y:
    print("x is smaller")
else:
    print("y is smaller")
print("thanks!")
```

5	5	0
5	0	0
True	False	True
<-		<-
True		False
<-		
	False	
	<-	
<-	<-	<-

CONTROL FLOW: `while` LOOPS

```
while <condition>:
    <expression>
    <expression>
    ...
```

- `<condition>` **evaluates to a Boolean**
- If `<condition>` is `True`, **execute all the steps inside** the while code block
- **Check** `<condition>` again
- **Repeat** until `<condition>` is `False`
- If `<condition>` is never `False`, then will loop forever!!

Recall square root

```
x = 16.0
g = 3.0

tolerance = 0.0001

while abs( g * g - x ) > tolerance:
    g = (g + x / g) /2.0
    print (g)
```

- Legend of Zelda – Lost Woods
- Keep going right, takes you back to this same screen, stuck in a loop

`while` LOOP EXAMPLE

```
You are in the Lost Forest.
************
************
  ☺
************
************
Go left or right?
```

PROGRAM:

```
where = input("You're in the Lost Forest. Go left or right? ")
while where == "right":
    where = input("You're in the Lost Forest. Go left or right? ")
print("You got out of the Lost Forest!")
```

CONTROL FLOW: when `while` loops aren't ideal

- Iterate and print through numbers in a sequence, e.g. 0 to 4 (included)

```
# a little complicated with while loop
```

CONTROL FLOW: `while` vs. `for` LOOPS

- Iterate through numbers in a sequence

```
# more complicated with while loop
n = 0
while n < 5:
    print(n)
    n = n+1
```

Set loop variable outside while loop

Test loop variable in condition

Increment loop variable inside while loop

n = n+1 equivalent to n += 1

```
# shortcut with for loop
for n in range(5):
    print(n)
```

CONTROL FLOW: `for` LOOPS

```
for <variable> in range(<some_num>):
    <expression>
    <expression>
    ...
```

- **Each time through the loop**, `<variable>` takes a value
- First time, `<variable>` **starts at the smallest value**
- Next time, `<variable>` gets the **prev value + 1**
- etc. until `<variable>` gets **some_num -1**

range(start,stop,step)

- Default values are `start = 0` and `step = 1` and optional
- Loop until value reaches `stop - 1`

```
mysum = 0
for i in range(7, 10):
    mysum += i
print(mysum)
```

```
mysum = 0
for i in range(5, 11, 2):
    mysum += i
print(mysum)
```

`break` STATEMENT

- Immediately exits whatever loop it is in
- Skips remaining expressions in code block
- **Exits only innermost loop**!

```
x = 16
for i in range(x):
    if i*i >= x:
        break
print(i)
```

`for` VS `while` LOOPS

`for` loops

- **know** number of iterations
- can **end early** via `break`
- uses a **counter**
- **can rewrite** a `for` loop using a `while` loop

`while` loops

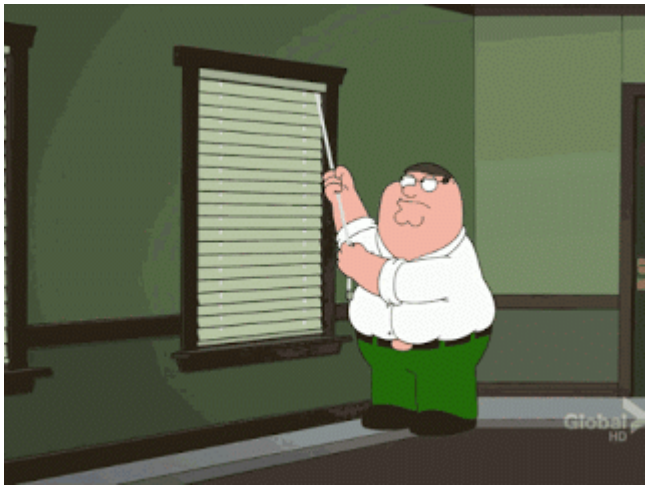
- (potentially) **unbounded** number of iterations
- can **end early** via `break`
- can use a **counter but must initialize** before loop and increment it inside loop
- **may not be able to rewrite** a `while` loop using a `for` loop

STRINGS AND LOOPS

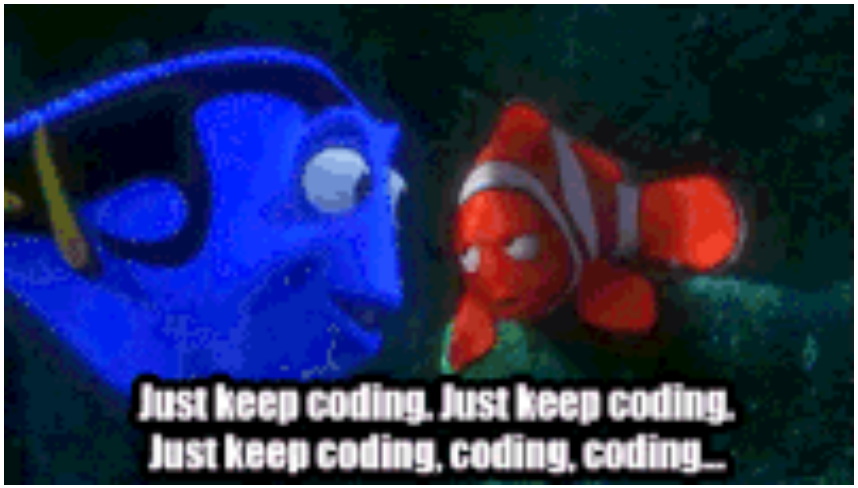
```
s = "demo loops – fruit loops"
for index in range(len(s)):
    if s[index] == 'i' or s[index] == 'u':
        print("There is an i or u")

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

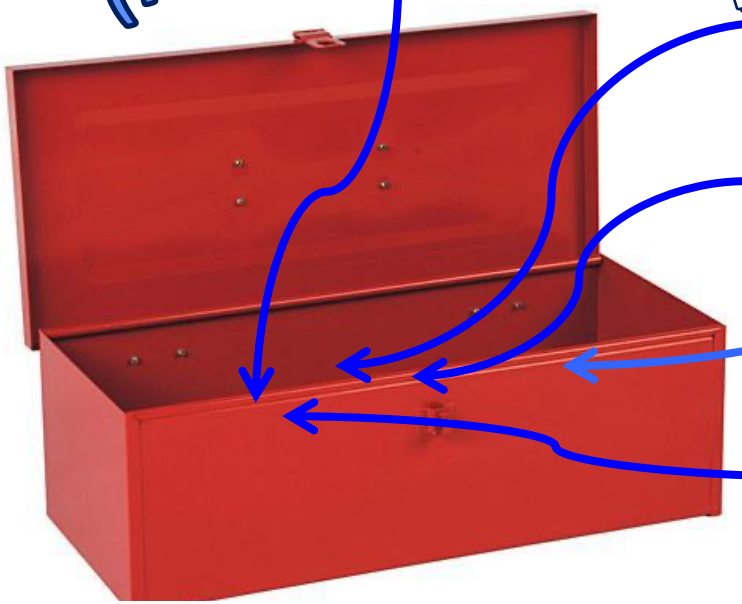
These two code snippets do the same thing; bottom one is more "pythonic"

Five Minute Break



Trying to fix my code





LOOPS
(for and while)

ints, floats, booleans

CONDITIONALS
AND BRANCHING

MATHEMATICAL
OPERATIONS

STRING
MANIPULATION

ALGORITHMS

GUESS-and-CHECK

BISECTION SEARCH

APPROXIMATION

GUESS-AND-CHECK

- Process called **exhaustive enumeration**
- Applies to a problem where …
  - You are able to **guess a value** for solution
  - You are able to **check if the solution is correct**
  - You can **keep guessing** until
    - Find solution or
    - Have guessed all values

GUESS-AND-CHECK – square root

- Basic idea:
  - Given an `int`, call it `x`, want to see if there is another `int` which is its square root
  - Start with a `guess` and check if it is the right answer
  - To be **systematic**, start with `guess` = 0, then 1, then 2, etc
- If `x` is a **perfect square**, we will **eventually find its root** and can stop
- But what if `x` is **not a perfect square**?
  - Need to know when to stop
  - **Use algebra** – if `guess` squared is bigger than `x`, then can stop

GUESS-AND-CHECK – square root

```
guess = 0
x = int(input("Enter an integer: "))
while guess**2 < x:
    guess = guess + 1
if guess**2 == x:
    print("Square root of", x, "is", guess)
else:
    print(x, "is not a perfect square")
```

Exit loop when guess**2 >= x

GUESS-AND-CHECK – square root

- Does this work for any integer value of `x`?
- What if `x` is negative?
  - `while` loop immediately terminates
  - Actually turns out to be correct (if you don't believe in imaginary numbers)
- Could check for negative input, and handle differently

GUESS-AND-CHECK – square root

```
guess = 0
neg_flag = False
x = int(input("Enter a positive integer: "))
if x < 0:
    neg_flag = True
while guess**2 < x:
    guess = guess + 1
if guess**2 == x:
    print("Square root of", x, "is", guess)
else:
    print(x, "is not a perfect square")
    if neg_flag:
        print("Just checking... did you mean", -x, "?")
```

`while` LOOP OR `for` LOOP?

- Already saw that code looks cleaner when iterating over sequence of values
  - Don't set up the iterant yourself as with a while loop
  - Less likely to introduce errors
- Consider an example that uses a `for` loop and an explicit `range` of values

GUESS-AND-CHECK – cube root

```
cube = int(input("Enter an integer: "))

for guess in range(cube+1):
    if guess**3 == cube:
        print("Cube root of", cube, "is", guess)
```

This ensures we get to value of cube

GUESS-AND-CHECK – cube root

```
cube = int(input("Enter an integer: "))

for guess in range(abs(cube)+1):
    if guess**3 == abs(cube):
        if cube < 0:
            guess = -guess
        print("Cube root of "+str(cube)+" is "+str(guess))
```

This properly handles cube roots of negative integers

GUESS-AND-CHECK – cube root

```
cube = int(input("Enter an integer: "))
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))
```

Terminate search once know you have passed possible answer

ANOTHER EXAMPLE

- Remember those word problems from your childhood?
- For example:
  - Alyssa, Ben, and Cindy are selling tickets to a fundraiser
  - Ben sells 20 fewer than Alyssa
  - Cindy sells twice as many as Alyssa
  - 1000 total tickets were sold by the three people
  - How many did Alyssa sell?
- Could solve this algebraically, but we can also use guess-and-check

GUESS-AND-CHECK WORD PROBLEM

```
for alyssa in range(1001):
    ben = max(alyssa - 20, 0)
    cindy = alyssa * 2
    if ben + cindy + alyssa == 1000:
        print("Alyssa sold " + str(alyssa) + " tickets")
        print("Ben sold " + str(ben) + " tickets")
        print("Cindy sold " + str(cindy) + " tickets")
```

Fredo's guess and check

SUMMARY

- Strings provide a new data type
  - Strings can be indexed and sliced
  - Strings are immutable
- Looping mechanisms
  - `while` and `for` loops
  - Can loop over ranges of numbers
  - Can loop over elements of a string
- Exhaustive search (aka guess-and-check) provides a simple algorithm for solving problems where the set of potential solutions is enumerable