Recursion

You will learn the definition of recursion as well as seeing how simple recursive programs work

What Is Recursion?

"the determination of a succession of elements by operation on one or more preceding elements according to a rule or formula involving a finite number of steps"
(Merriam-Webster online)

What This Really Means

Breaking a problem down into a series of steps. The final step is reached when some basic condition is satisfied. ***The solution for each step is used to solve the previous step.*** *The solution for all the steps together form the solution to the whole problem.*

(The "Tam" translation)

Definition Of Philosophy

"…state of mind of the wise man; practical wisdom…" [1]

See Metaphysics

1 The New Webster Encyclopedic Dictionary of the English Language

Metaphysics

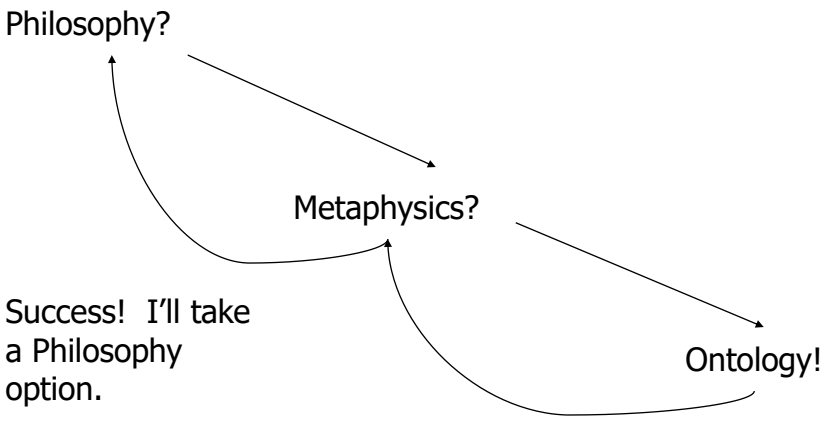
"…know the ultimate grounds of being or what it is that really exists, embracing both psychology and ***ontology****."* [2]

2 The New Webster Encyclopedic Dictionary of the English Language

Result Of Lookup , Possibility One: Success

- I know what Ontology means!

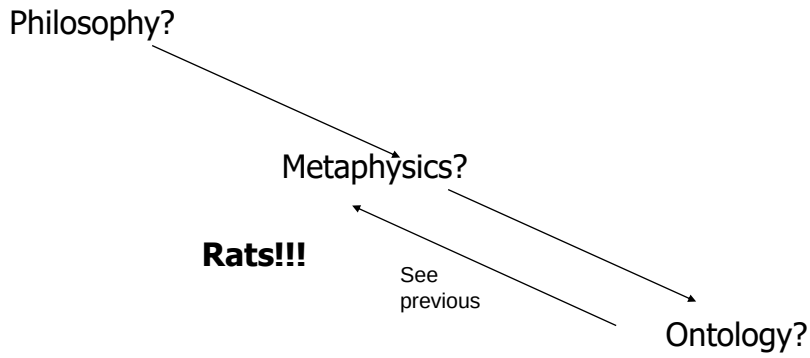
Result Of Lookup, Possibility One



Result Of Lookup, Possibility Two: Failure

- Lookup 'loops' back.

Result Of Lookup, Possibility Two



Ontology

"…equivalent to metaphysics."[3]

3 The New Webster Encyclopedic Dictionary of the English Language

Wav file from "The Simpsons"

Result Of Lookup, Possibility Three: Failure

- You've looked up everything and still don't know the definition!

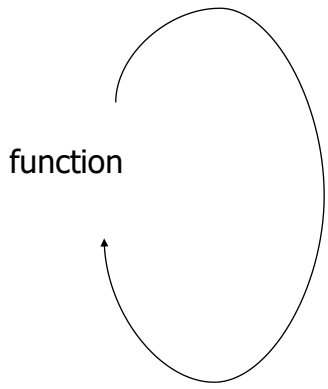
Looking Up A Word

```
if (you completely understand a definition) then
    return to previous definition (using the definition that's
    understood)
else
    lookup (unknown word(s))
```

Recursion In Programming

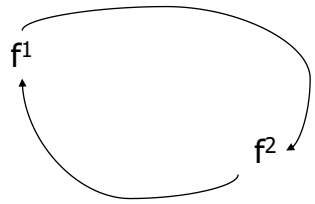
"A programming technique whereby a function calls itself either directly or indirectly."

Direct Call

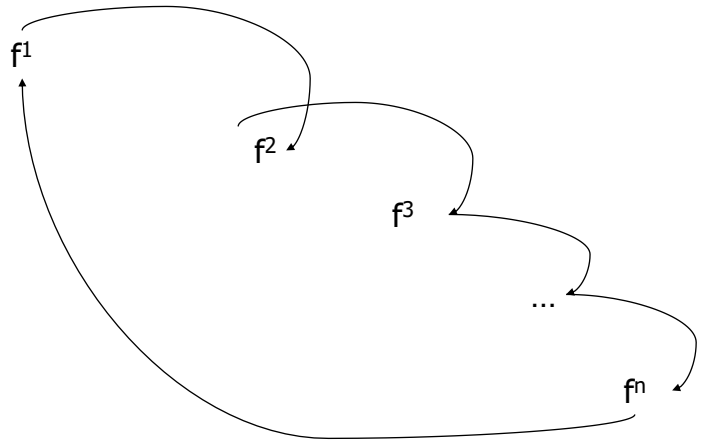



```
def fun ():
    …
  fun ()
    …
```

Indirect Call



Indirect Call



Indirect Call (2)

Name of the example program: `recursive.1py`

```
def fun1():
   fun2()

def fun2():
   fun1()

fun1()
```

Requirements For *Sensible* Recursion

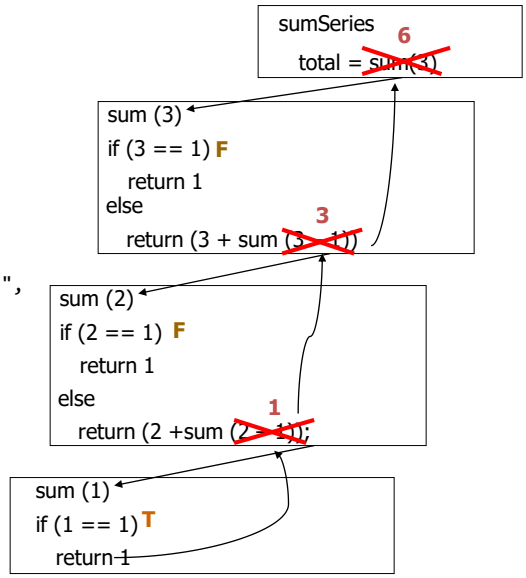
1) Base case
2) Progress is made (towards the base case)

Example Program: sumSeries.py

```
def sum(no):
   if (no == 1):
      return 1
   else:
      return (no + sum(no-1) )


def start():
   last = input ("Enter the last
                  number: ")
   last = (int)last
   total = sum(last)
   print ("The sum of the series
           from 1 to", last, "is",
           total)

start()
```



When To Use Recursion

- When a problem can be divided into steps.
- The result of one step can be used in a previous step.
- There is a scenario when you can stop sub-dividing the problem into steps (step = recursive call) and return to a previous step.
  - Algorithm goes back to previous step with a partial solution to the problem (back tracking)
- All of the results together solve the problem.

When To Consider Alternatives To Recursion

- When a loop will solve the problem just as well
- Types of recursion (for both types a `return` statement is excepted)
  - **Tail recursion**
    - The last statement in the function is another recursive call to that function This form of recursion can easily be replaced with a loop.
  - **Non-tail recursion**
    - The last statement in the recursive function is not a recursive call.
    - This form of recursion is very difficult (read: impossible) to replace with a loop.

Example: Tail Recursion

- Tail recursion: A recursive call is the last statement in the recursive function.
- Name of the example program: `tail.py`

```
def tail(no):
   if (no <= 3):
      print (no)
      tail(no+1)
   return()

tail(1)
```

Example: Non-Tail Recursion

- Non-Tail recursion: A statement which is not a recursive call to the function comprises the last statement in the recursive function.
- Name of the example program: `nonTail.py`

```
def nonTail(no):s
   if (no < 3):
      nonTail(no+1)
   print(no)
   return()

nonTail(1)
```

Error Handling Example Using Recursion

- Name of the example program: `errorHandling.py`

  – Iterative/looping solution (month must be between 1 – 12)

```
month = -1
while ((month < 1) or (month > 12)):
        month = int(input("Enter birth month (1-12): "))
```

James Tam

Error Handling Example Using Recursion (2)

– Iterative/looping solution (day must be between 1 – 31)

```
def promptDay():
    day = int(input("Enter day of birth (1-31): "))
    if ((day < 1) or (day > 31)):
        day = promptDay()
    return(day)

...
day = promptDay()
```

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Drawbacks Of Recursion

Function calls can be costly

- Uses up memory
- Uses up time

Benefits Of Using Recursion

- Simpler solution that's more elegant (for some problems)
- Easier to visualize solutions (for some people and certain classes of problems – typically require either: non-tail recursion to be implemented or some form of "backtracking")

Common Pitfalls When Using Recursion

- These three pitfalls can result in a runtime error
  - No base case
  - No progress towards the base case
  - Using up too many resources (e.g., variable declarations) for each function call

No Base Case

```
def sum(no):
     return(no + sum (no - 1))
```

No Base Case

```
def sum (no):
  return (no + sum (no - 1))
```

When does it stop???

No Progress Towards The Base Case

```
def sum (no):
    if (no == 1):
        return 1
    else:
        return (no + sum (no))
```

No Progress Towards The Base Case

```
def sum (no):
    if (no == 1):
        return 1
    else:
        return (no + sum (no))
```

The recursive case doesn't make any progress towards the base (stopping) case

Using Up Too Many Resources

- Name of the example program: `recursiveBloat.py`

```
def fun(no):
    print(no)
    aList = []
    for i in range (0, 10000000, 1):
       aList.append("*")
    no = no + 1
    fun(no)

fun(1)
```

Undergraduate Student Definition Of Recursion

Word: **re·cur·sion**

Pronunciation: ri-'k&r-zh&n

Definition: See recursion

Wav file courteously of "James Tam"

Recursion: Job Interview Question

- http://www.businessinsider.com/apple-interview-questions-2011-5#write-a-function-that-calculates-a-numbers-factorial-using-recursion-9

You Should Now Know

- What is a recursive computer program
- How to write and trace simple recursive programs
- What are the requirements for recursion/What are the common pitfalls of recursion