

Outline



Function definition

Function definition

Return statement

```
return [<expression>]
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```
return [<expression>]
```

Example

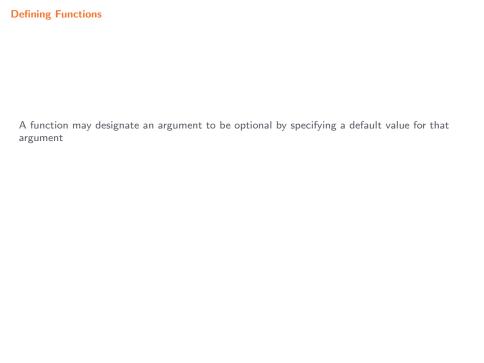
```
def is_prime(n):
    if n < 2:
        return False
    i = 2
    while i <= n // i:
        if n % i == 0:
            return False
        i += 1
    return True</pre>
```



Defining Functions
The scope of a function's local and parameter variables is limited to that function







A function may designate an argument to be optional by specifying a default value for that argument

Example (computing $H_{n,r} = 1 + 1/2^r + 1/3^r + \cdots + 1/n^r$)

```
def harmonic(n, r = 1):
    total = 0.0
    for i in range(1, n + 1):
        total += 1 / (i ** r)
    return total
```



If a function parameter refers to a mutable object, changing that object's value within the function also changes the object's value in the calling code

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Example

```
def exchange(a, i, j):
    temp = a[i]
    a[i] = a[j]
    a[j] = temp

a = [1, 2, 3, 4, 5]
    exchange(a, 1, 3)
    stdio.writeln(a)
```

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def exchange(a, i, j):
    temp = a[i]
    a[i] = a[j]
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a = [1, 2, 3, 4, 5]
    exchange(a, 1, 3)
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```
[1, 4, 3, 2, 5]
```



 $Program: {\scriptstyle \texttt{harmonicredux.py}}$

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- Standard output: the *n*th harmonic number $H_n = 1 + \frac{1}{2} + \frac{1}{3} + \cdots + \frac{1}{n}$

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>_ ~/workspace/ipp/programs

\$_

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>_ ~/workspace/ipp/program

\$ python3 harmonicredux.py 10

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>_ ~/workspace/ipp/programs

\$ python3 harmonicredux.py 10
2.9289682539682538

\$ _

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>_ ~/workspace/ipp/program:

- \$ python3 harmonicredux.py 10
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```
> _ T/workspace/ipp/programs

$ python3 harmonicredux.py 10
2.9289682539682538
$ python3 harmonicredux.py 1000
7.485470860550343
$ _
```

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```
>_ "/workspace/ipp/programs

$ python3 harmonicredux.py 10
2.9289682539682538
$ python3 harmonicredux.py 1000
7.485470860550343
$ python3 harmonicredux.py 10000
9.787606036044348
```



```
☑ harmonicredux.py

    import stdio
    import sys
4
    def main():
        n = int(sys.argv[1])
6
        stdio.writeln(_harmonic(n))
8
    def _harmonic(n):
9
       total = 0.0
        for i in range(1, n + 1):
            total += 1 / i
        return total
    if __name__ == '__main__':
        main()
```

```
import stdio
import stdio
import sys

def main():
    n = int(sys.argv[i])
    stdio.writeln(_harmonic(n))

def _harmonic(n):
    total = 0.0
    for i in range(i, n + i):
        total + i / i
    return total

if __name__ == '__main__':
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```

```
>_ '/workspace/ipp/programs
>>> _
```

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def main():
    import stdio
    import sys

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    return total

if __name__ == '__main__':
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```

```
>_ "/workspace/ipp/programs
>>> import harmonicredux
>>> harmonicredux._harmonic(10)
```

```
>- "/workspace/ipp/programs
>>> import harmonicredux
>>> harmonicredux.harmonic(10)
2.9289682539682538
>>> _
```



 $Program: {\tiny \texttt{couponcollectorredux.py}}$

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ullet Command-line input: n (int)

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- Command-line input: *n* (int)
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>_ ~/workspace/ipp/programs

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>_ ~/workspace/ipp/programs

\$ python3 couponcollectorredux.py 1000
6276

Program: couponcollectorredux.py

- Command-line input: *n* (int)
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>_ ~/workspace/ipp/programs

\$ python3 couponcollectorredux.py 1000
6276

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Program: couponcollectorredux.py

- Command-line input: *n* (int)
- ullet Standard output: number of coupons one must collect before obtaining one of each of n types

>_ ~/workspace/ipp/programs

```
$ python3 couponcollectorredux.py 1000
6276
$ python3 couponcollectorredux.py 1000
7038
```

Program: couponcollectorredux.py

- Command-line input: *n* (int)
- Standard output: number of coupons one must collect before obtaining one of each of n types

- \$ python3 couponcollectorredux.py 1000 6276
- \$ python3 couponcollectorredux.py 1000
- \$ python3 couponcollectorredux.py 1000000

Program: couponcollectorredux.py

- Command-line input: *n* (int)
- Standard output: number of coupons one must collect before obtaining one of each of n types

```
$ python3 couponcollectorredux.py 1000
6276
$ python3 couponcollectorredux.py 1000
7038
$ python3 couponcollectorredux.py 1000000
13401736
```



```
☑ couponcollectorredux.py

    import stdarray
    import stdio
    import stdrandom
    import sys
    def main():
         n = int(sys.argv[1])
         stdio.writeln(_collect(n))
    def _collect(n):
        count = 0
         collectedCount = 0
         isCollected = stdarrav.create1D(n. False)
         while collectedCount < n:
             value = _getCoupon(n)
             count += 1
             if not isCollected[value]:
                 collectedCount += 1
                 isCollected[value] = True
         return count
    def _getCoupon(n):
         return stdrandom.uniformInt(0, n)
    if __name__ == '__main__':
         main()
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```



 $Program: \ {\tiny \texttt{playthattunedeluxe.py}}$

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• Standard input: sound samples, each characterized by a pitch and a duration

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>_ ~/workspace/ipp/program

\$ cat ../data/elise.txt

Program: playthattunedeluxe.py

- Standard input: sound samples, each characterized by a pitch and a duration
- Standard audio output: the sound

```
>_ "/workspace/ipp/programs

$ cat ../data/elise.txt
7 .125
6 .125
7 .125
...
0 .25
$ _
```

Program: playthattunedeluxe.py

- Standard input: sound samples, each characterized by a pitch and a duration
- Standard audio output: the sound

```
>_ "/workspace/ipp/programs
$ cat ../data/elise.txt
7 .125
6 .125
7 .125
...
0 .25
$ python3 playthattunedeluxe.py < ../data/elise.txt</pre>
```

Program: playthattunedeluxe.py

- Standard input: sound samples, each characterized by a pitch and a duration
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```
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$ cat ../data/elise.txt
7   .125
6   .125
7   .125
...
0   .25
$ python3 playthattunedeluxe.py < ../data/elise.txt
$ $
$ $</pre>
```





24

35

```
g playthattunedeluxe.py
import math
import stdarray
import stdaudio
import stdio
def main():
    while not stdio.isEmptv():
        pitch = stdio.readInt()
        duration = stdio.readFloat()
        stdaudio.plavSamples( createRichNote(pitch, duration))
    stdaudio.wait()
def createRichNote(pitch, duration):
    NOTES ON SCALE = 12
    CONCERT A = 440.0
    hz = CONCERT A * math.pow(2, pitch / NOTES ON SCALE)
    mid = _createNote(hz, duration)
    hi = _createNote(2 * hz, duration)
    lo = _createNote(hz / 2, duration)
    hiAndLo = _superpose(hi, lo, 0.5, 0.5)
    return _superpose(mid, hiAndLo, 0.5, 0.5)
def _createNote(hz, duration):
    SPS = 44100
    n = int(SPS * duration)
    note = stdarray.create1D(n + 1, 0.0)
    for i in range(n + 1):
        note[i] = math.sin(2 * math.pi * i * hz / SPS)
    return note
def _superpose(a, b, aWeight, bWeight):
    c = stdarray.create1D(len(a), 0.0)
    for i in range(len(a)):
        c[i] = a[i] * aWeight + b[i] * bWeight
    return c
```

36 37

```
if __name__ == '__main__':
38
        main()
```



Filter, Lambda, Map, and Reduce Functions	
Functions in Python are first-class objects, meaning they can take functions as arguments and return functions as results	



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Example

>_ ~/workspace/ipp/programs

>>> _

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```
>_ "/workspace/ipp/programs
>>> primes = filter(is_prime, range(11))
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>_ "/workspace/ipp/programs
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>>> list(primes)
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filter(f, seq) returns those items of seq for which f(item) is True

```
>_ "/workspace/ipp/programs
>>> primes = filter(is_prime, range(11))
>>> list(primes)
[2, 3, 5, 7]
>>> _
```



Filter, Lambda, Map, and Reduce Functions
A lambda function is a "disposable" function that we can define just when we need it and then immediately throw it away after we are done using it



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Example

>_ ~/workspace/ipp/programs

>>> _



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>_ '/workspace/ipp/programs
>>> odds = filter(lambda x : x % 2 != 0, range(11))
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```
>_ "/workspace/ipp/programs
>>> odds = filter(lambda x : x % 2 != 0, range(11))
>>> list(odds)
[1, 3, 5, 7, 9]
>>> _
```





 $\mathtt{map(f,\ seq)}$ returns a list of the results of applying the function \mathtt{f} to the items of \mathtt{seq}



 $_{\mathtt{map(f,\ seq)}}$ returns a list of the results of applying the function $_{\mathtt{f}}$ to the items of $_{\mathtt{seq}}$

Example

>_ ~/workspace/ipp/programs

>>> _

 $_{\text{map}(\texttt{f},~\text{seq})}$ returns a list of the results of applying the function $_{\texttt{f}}$ to the items of $_{\text{seq}}$

```
>- ~/workspace/ipp/programs
>>> squares = map(lambda x : x ** 2, range(11))
```

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>> "/workspace/ipp/programs
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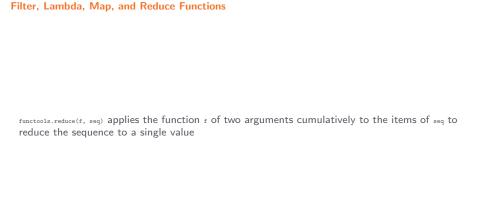
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>>> list(squares)
```

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```
>_ "/workspace/ipp/programs
>>> squares = map(lambda x : x ** 2, range(i1))
>>> list(squares)
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
>>> _
```







functionls.reduce(f, seq) applies the function f of two arguments cumulatively to the items of seq to reduce the sequence to a single value

Example

>_ ~/workspace/ipp/programs

>>> -

functionls.reduce(f, seq) applies the function f of two arguments cumulatively to the items of seq to reduce the sequence to a single value

```
>- "/workspace/ipp/programs
>>> total = functools.reduce(lambda x, y: x + y, range(ii))
```

 ${\tt functiools.reduce}({\tt f}, {\tt seq}) \ applies \ the \ function \ {\tt f} \ of \ two \ arguments \ cumulatively \ to \ the \ items \ of \ {\tt seq} \ to \ reduce \ the \ sequence \ to \ a \ single \ value$

```
>_ '/workspace/ipp/programs
>>> total = functools.reduce(lambda x, y: x + y, range(11))
55
>>> _
```