NPTEL MOOC

PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 1

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When things go wrong

- `y = x/z`, but `z` has value `0`
- `y = int(s)`, but string `s` is not a valid integer
- `y = 5*x`, but `x` does not have a value
- `y = l[i]`, but `i` is not a valid index for list `l`
- Try to read from a file, but the file does not exist
- Try to write to a file, but the disk is full

When things go wrong …

- Some errors can be anticipated
- Others are unexpected
- Predictable error — exception
  - Normal situation vs exceptional situation
- Contingency plan — exception handling

Exception handling

- If something goes wrong, provide “corrective action”
  - File not found — display a message and ask user to retype filename
  - List index out of bounds — provide diagnostic information to help debug error
- Need mechanism to internally trap exceptions
- An untapped exception will abort the program

Types of errors

- Python notifies you of different types of errors
- Most common error, invalid Python code

```
SyntaxError: invalid syntax
```

- Not much you can do with this!
- We are interested in errors that occur when code is being executed

Types of errors

Some errors while code is executing (run-time errors)

- Name used before value is defined

```
NameError: name 'x' is not defined
```

- Division by zero in arithmetic expression

```
ZeroDivisionError: division by zero
```

- Invalid list index

```
IndexError: list assignment index out of range
```

Terminology

- Raise an exception
  - Run time error → signal error type, with diagnostic information

    ```
    NameError: name 'x' is not defined
    ```

- Handle an exception
  - Anticipate and take corrective action based on error type
- Unhandled exception aborts execution

Handling exceptions

```
try:
   . . .      ← Code where error may occur
   . . .
except IndexError:
   . . .      ← What to do if IndexError occurs
except (NameError,KeyError):
   . . .      ← Common code to handle multiple errors
except:
   . . .      ← Catch all other  exceptions
else:
   . . .      ← Execute if try terminates normally, no errors
```

“Positive” use of exceptions

- Add a new entry to this dictionary

```
scores = {'Dhawan':[3,22],'Kohli':[200,3]}
```

- Batsman `b` already exists, append to list

```
scores[b].append(s)
```

- New batsman, create fresh entry

```
scores[b] = [s]
```

“Positive” use of exceptions

- Traditional approach

```
if b in scores.keys():
  scores[b].append(s)
else:
  scores[b] = [s]
```

- Using exceptions

```
try:
  scores[b].append(s)
except KeyError:
  scores[b] = [s]
```

Flow of control

```
..
x = f(y,z)
```

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```

```
def g(m):
    ..
    h(m)
```

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```

```
def g(m):
    ..
    h(m)
```

```
def h(s):
    ..
    ..
```

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```

```
def g(m):
    ..
    h(m)
```

```
def h(s):
    ..
    ..
```

IndexError, not handled in h( )⟶

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```

```
def g(m):
    ..
    h(m)
```

IndexError inherited from h( )⟶

```
def h(s):
    ..
    ..
```

IndexError, not handled in h( )⟶

Flow of control

```
..
x = f(y,z)
```

```
def f(a,b):
    ..
    g(a)
```
←IndexError inherited from g( )

```
def g(m):
    ..
    h(m)
```
IndexError inherited from h( )⟶

Not handled?

```
def h(s):
    ..
    ..
```
IndexError, not handled in h( )⟶

Flow of control

```
..
x = f(y,z)
```

IndexError inherited from f( )

```
def f(a,b):
    ..
    g(a)
```

←IndexError inherited from g( ) Not handled?

```
def g(m):
    ..
    h(m)
```

IndexError inherited from h( )⟶ Not handled?

```
def h(s):
    ..
    ..
```

IndexError, not handled in h( )⟶

Flow of control

```
..
x = f(y,z)
```

IndexError inherited from f( )

Not handled?

Abort!

```
def f(a,b):
    ..
    g(a)
```

←IndexError inherited from g( )

Not handled?

```
def g(m):
    ..
    h(m)
```

IndexError inherited from h( )⟶

Not handled?

```
def h(s):
    ..
    ..
```

IndexError, not handled in h( )⟶

Summary

- Exception handling allows us to gracefully deal with run time errors
- Can check type of error and take appropriate action based on type
- Can change coding style to exploit exception handling
- When dealing with files and input/output, exception handling becomes very important

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PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 2

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Interacting with the user

- Program needs to interact with the user
  - Receive input
  - Display output
- Standard input and output
  - Input from keyboard
  - Output to screen

Reading from the keyboard

- Read a line of input and assign to `userdata`

```
userdata = input()
```

- Display a message prompting the user

```
userdata = input("Enter a number")
```

- Add space, newline to make message readable

```
userdata = input("Enter a number: ")
```

```
userdata = input("Enter a number:\n")
```

Reading from the keyboard

- Input is always a string, convert as required

```
userdata = input("Enter a number")
usernum = int(userdata)
```

Reading from the keyboard

- Use exception handling to deal with errors

```
while(True):
    try:
      userdata = input("Enter a number: ")
      usernum = int(userdata)
    except ValueError:
      print("Not a number. Try again")
    else:
      break
```

Printing to screen

- Print values of names, separated by spaces

```
print(x,y)
print(a,b,c)
```

- Print a message

```
print("Not a number. Try again")
```

- Intersperse message with values of names

```
print("Values are x:", x, "y:", y)
```

Fine tuning `print()`

- By default, `print( )` appends new line character `'\n'` to whatever is printed
  - Each `print( )` appears on a new line
- Specify what to append with argument `end="..."`

```
print("Continue on the", end=" ")
print("same line", end=".\n")
print("Next line.")

Continue on the same line.
Next line.
```

Fine tuning `print()`

- By default, `print( )` appends new line character `'\n'` to whatever is printed
  - Each `print( )` appears on a new line

- Specify what to append with argument `end="..."`

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print("Continue on the", end=" ")
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Add space, no new line

```
Continue on the same line.
Next line.
```

Fine tuning `print()`

- By default, `print( )` appends new line character `'\n'` to whatever is printed
  - Each `print( )` appears on a new line

- Specify what to append with argument `end="..."`

```
print("Continue on the", end=" ")
print("same line", end=".\n")
print("Next line.")
```

Add space, no new line

Add full stop, new line

```
Continue on the same line.↓
Next line.
```

Fine tuning `print()`

- Items are separated by space by default

```
(x,y) = (7,10)
print("x is",x,"and y is",y,".")
```

```
x is 7 and y is 10 .
```

- Specify separator with argument `sep="…"`

```
print("x is ",x," and y is ",y,".", sep="")
```

```
x is 7 and y is 10.
```

Formatting print

- May need more control over printing
  - Specify width to align text
    - Align text within width — left, right, centre
    - How many digits before/after decimal point?
- See how to do this later

Summary

- Read from keyboard using `input()`
  - Can also display a message
- Print to screen using `print()`
  - Caveat: In Python 2, `()` is optional for `print`
- Can control format of `print()` output
  - Optional arguments `end="…"`, `sep="…"`
  - More precise control later

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PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 3

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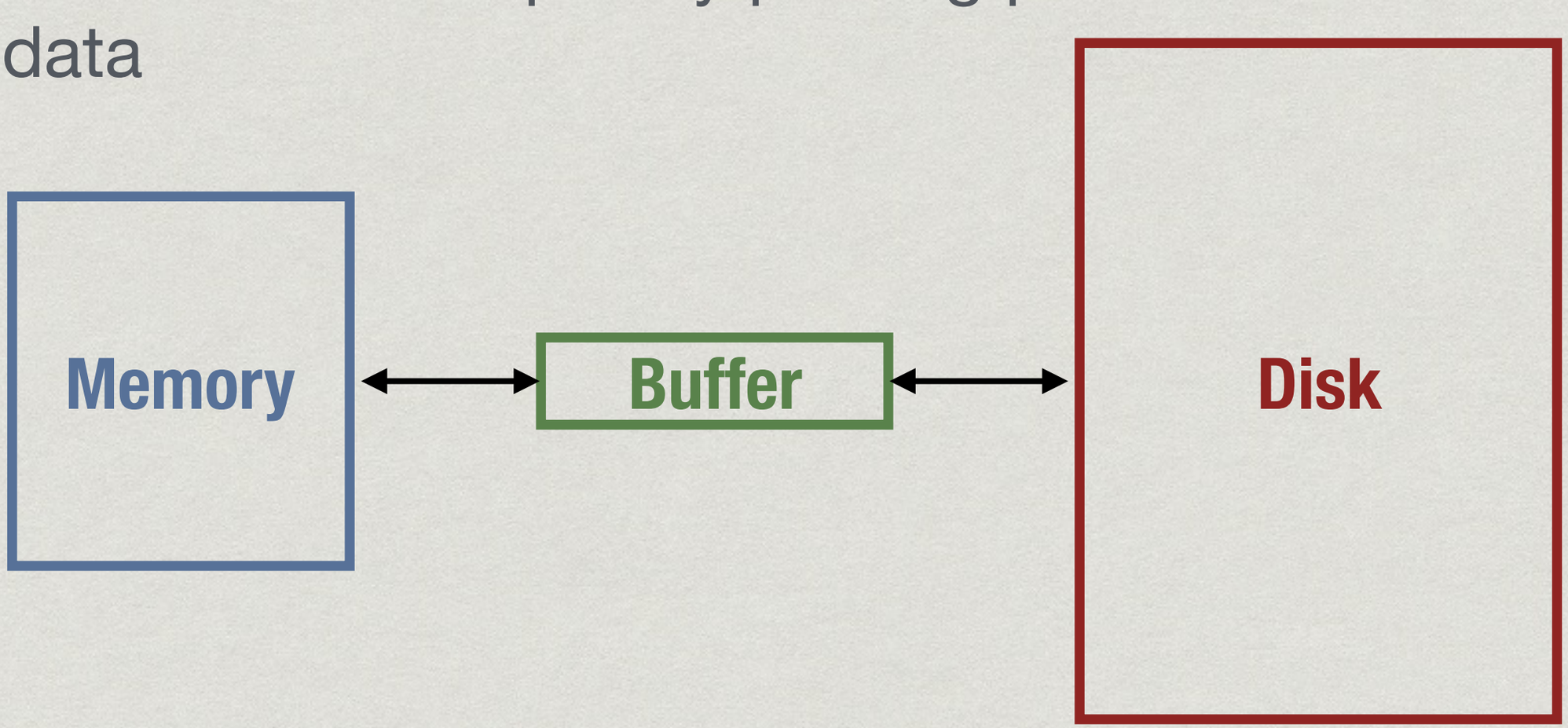
Dealing with files

- Standard input and output is not convenient for large volumes of data
- Instead, read and write files on the disk
- Disk read/write is much slower than memory

Disk buffers

- Disk data is read/written in large blocks
- “Buffer” is a temporary parking place for disk data



Reading/writing disk data

Reading/writing disk data

- Open a file — create file handle to file on disk
  - Like setting up a buffer for the file

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Reading/writing disk data

- Open a file — create file handle to file on disk
  - Like setting up a buffer for the file
- Read and write operations are to file handle
- Close a file
  - Write out buffer to disk (flush)
  - Disconnect file handle

Opening a file

Opening a file

```
fh = open("gcd.py", "r")
```

Opening a file

```
fh = open("gcd.py", "r")
```

- First argument to `open` is file name
  - Can give a full path

Opening a file

```
fh = open("gcd.py", "r")
```

- First argument to `open` is file name
  - Can give a full path
- Second argument is mode for opening file
  - Read, `"r"`: opens a file for reading only
  - Write, `"w"`: creates an empty file to write to
  - Append, `"a"`: append to an existing file

Read through file handle

Read through file handle

```
contents = fh.read()
```

- Reads entire file into name as a single string

Read through file handle

```
contents = fh.read()
```

- Reads entire file into name as a single string

```
contents = fh.readline()
```

- Reads one line into name—lines end with `'\n'`
  - String includes the `'\n'`, unlike `input()`

Read through file handle

```
contents = fh.read()
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- Reads entire file into name as a single string

```
contents = fh.readline()
```

- Reads one line into name—lines end with `'\n'`
  - String includes the `'\n'`, unlike `input()`

```
contents = fh.readlines()
```

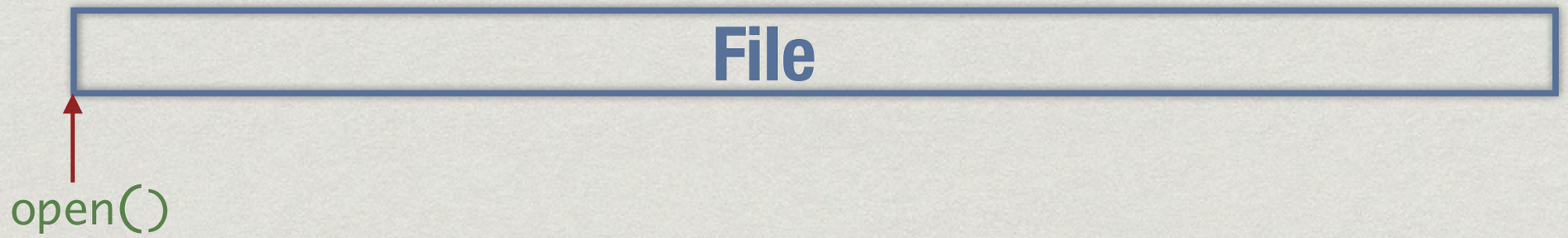
- Reads entire file as list of strings
  - Each string is one line, ending with`'\n'`

Reading files

Reading files

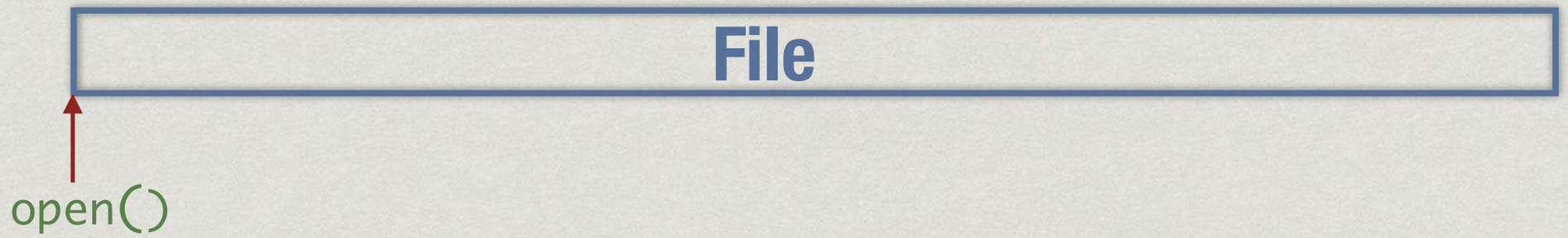
- Reading is a sequential operation

Reading files



- Reading is a sequential operation
  - When file is opened, point to position 0, the start

Reading files



- Reading is a sequential operation
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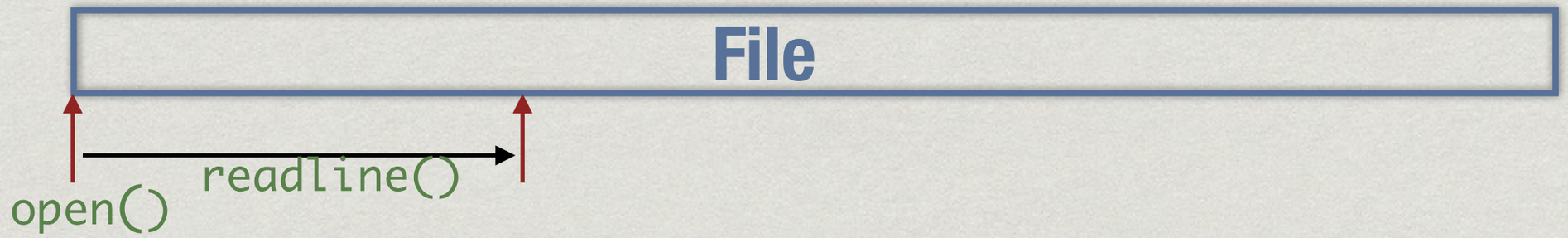
  - Each successive `readline()` moves forward

Reading files



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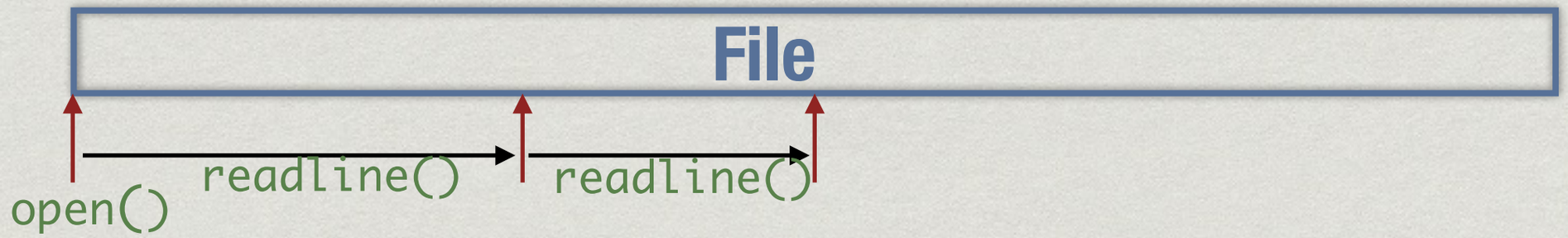
Reading files



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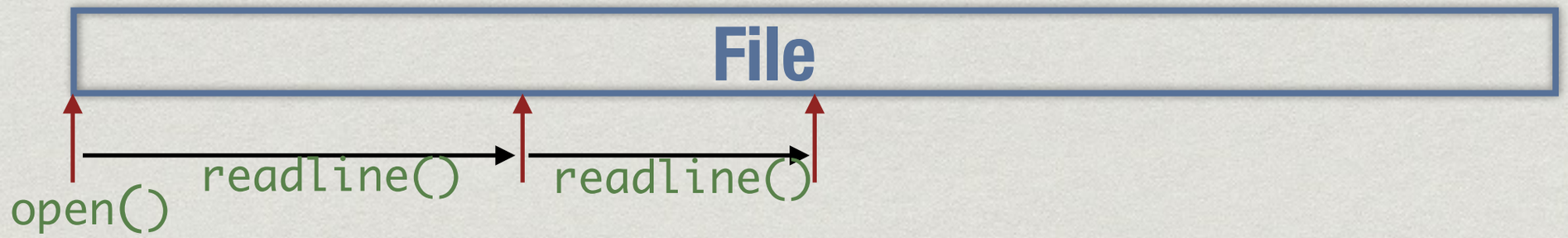
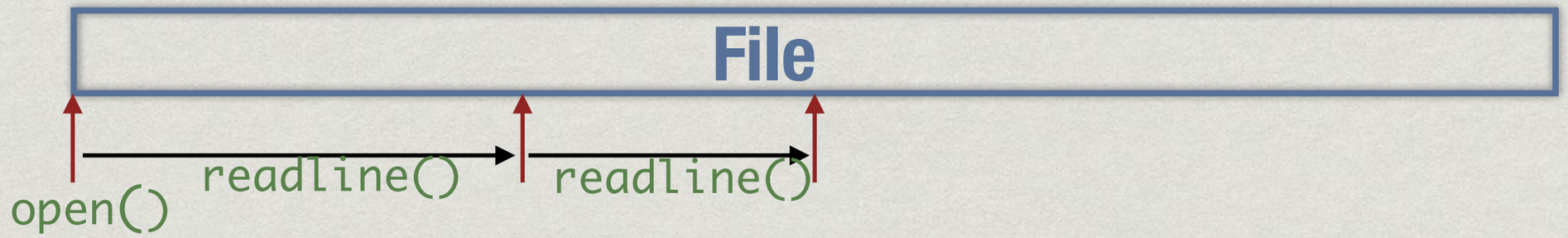
Reading files



- Reading is a sequential operation
  - When file is opened, point to position 0, the start
  - Each successive `readline()` moves forward
- `fh.seek(n)` — moves pointer to position `n`

Reading files



- Reading is a sequential operation
  - When file is opened, point to position 0, the start
  - Each successive `readline()` moves forward
- `fh.seek(n)` — moves pointer to position `n`
- `block = fh.read(12)` — read a fixed number of characters

End of file

End of file

- When reading incrementally, important to know when file has ended

End of file

- When reading incrementally, important to know when file has ended
- The following both signal end of file
  - `fh.read()` returns empty string `""`
  - `fh.readline()` returns empty string `""`

Writing to a file

Writing to a file

```
fh.write(s)
```

- Write string `s` to file
  - Returns number of characters written
- Include `'\n'` explicitly to go to a new line

Writing to a file

`fh.write(s)`

- Write string `s` to file
  - Returns number of characters written
  - Include `'\n'` explicitly to go to a new line

`fh.writelines(l)`

- Write a list of lines `l` to file
  - Must includes `'\n'` explicitly for each string

Closing a file

Closing a file

```
fh.close()
```

- Flushes output buffer and decouples file handle
  - All pending writes copied to disk

Closing a file

```
fh.close()
```

- Flushes output buffer and decouples file handle
  - All pending writes copied to disk

```
fh.flush()
```

- Manually forces write to disk

Processing file line by line

Processing file line by line

```
contents = fh.readlines()
for l in contents:
    . . .
```

Processing file line by line

```
contents = fh.readlines()
for l in contents:
    . . .
```

- Even better

```
for l in fh.readlines():
    . . .
```

Copying a file

```
infile = open("input.txt", "r")

outfile = open("output.txt", "w")

for line in infile.readlines():

  outfile.write(line)

infile.close()

outfile.close()
```

Copying a file

```
infile = open("input.txt", "r")

outfile = open("output.txt", "w")

contents = infile.readlines()

outfile.writelines(contents)

infile.close()

outfile.close()
```

Strip new line character

Strip new line character

- Get rid of trailing `'\n'`

```
contents = fh.readlines()
for line in contents:
  s = line[:-1]
```

Strip new line character

- Get rid of trailing `'\n'`

```
contents = fh.readlines()
for line in contents:
  s = line[:-1]
```

- Instead, use `rstrip()` to remove trailing whitespace

```
for line in contents:
  s = line.rstrip()
```

Strip new line character

- Get rid of trailing `'\n'`

```
contents = fh.readlines()
for line in contents:
  s = line[:-1]
```

- Instead, use `rstrip()` to remove trailing whitespace

```
for line in contents:
  s = line.rstrip()
```

- Also `strip()` — both sides, `lstrip()` — from left
  - String manipulation functions — coming up

Summary

- Interact with files through file handles
- Open a file in one of three modes — read, write, append
- Read entire file as a string, or line by line
- Write a string, or a list of strings to a file
- Close handle, flush buffer
- String operations to strip white space

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PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 4

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String processing

- Easy to read and write text files
- String processing functions make it easy to analyse and transform contents
  - Search and replace text
  - Export spreadsheet as text file (csv) and process columns
  - …

Strip whitespace

* `s.rstrip()` removes trailing whitespace

```
for line in contents:
    s = line.rstrip()
```

* `s.lstrip()` removes leading whitespace

* `s.strip()` removes leading and trailing whitespace

Searching for text

```
s.find(pattern)
```

- Returns first position in `s` where `pattern` occurs, `-1` if no occurrence of `pattern`

```
s.find(pattern,start,end)
```

- Search for `pattern` in slice `s[start:end]`

```
s.index(pattern), s.index(pattern,l,r)
```

- Like `find`, but raise `ValueError` if `pattern` not found

Search and replace

```
s.replace(fromstr,tostr)
```

- Returns copy of `s` with each occurrence of `fromstr` replaced by `tostr`

```
s.replace(fromstr,tostr,n)
```

- Replace at most first `n` copies
- Note that `s` itself is unchanged — strings are immutable

Splitting a string

- Export spreadsheet as “comma separated value” text file
- Want to extract columns from a line of text
- Split the line into chunks between commas

```
columns = s.split(",")
```

  - Can split using any separator string

- Split into at most `n` chunks

```
columns = s.split(" : ", n)
```

Joining strings

- Recombine a list of strings using a separator

```
columns = s.split(",")
joinstring = ","
csvline = joinstring.join(columns)

date = "16"
month = "08"
year = "2016"
today = "-".join([date,month,year])
```

Converting case

- Convert lower case to upper case, …
- `s.capitalize()` — return new string with first letter uppercase, rest lower
- `s.lower()` — convert all uppercase to lowercase
- `s.upper()` — convert all lowercase to uppercase
- `s.title()`, `s.swapcase()`, …

Resizing strings

```
s.center(n)
```

- Returns string of length `n` with `s` centred, rest blank

```
s.center(n,"*")
```

- Fill the rest with `*` instead of blanks

```
s.ljust(n), s.ljust(n,"*"), s.rjust(n), …
```

- Similar, but left/right justify `s` in returned string

Other functions

- Check the nature of characters in a string

  `s.isalpha()`, `s.isnumeric()`, …

- Many other functions
- Check the Python documentation

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PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 5

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Formatted printing

- Recall that we have limited control over how `print()` displays output
  - Optional argument `end="..."` changes default new line at the end of print
  - Optional argument `sep="..."` changes default separator between items

String format() method

- By example

```
>>> "First: {0}, second: {1}".format(47,11)
'First: 47, second: 11'

>>> "Second: {1}, first: {0}".format(47,11)
'Second: 11, first: 47'
```

- Replace arguments by position in message string

format() method ...

- Can also replace arguments by name

```
>>> "One: {f}, two: {s}".format(f=47,s=11)
'One: 47, two: 11'

>>> "One: {f}, two: {s}".format(s=11,f=47)
‘One: 47, two: 11'
```

Now, real formatting

```
>>> "Value: {0:3d}".format(4)
```

- `3d` describes how to display the value `4`
  - `d` is a code specifies that `4` should be treated as an integer value
  - `3` is the width of the area to show `4`

```
'Value:   4'
```

Now, real formatting

```
>>> "Value: {0:6.2f}".format(47.523)
```

- `6.2f` describes how to display the value `47.523`
- `f` is a code specifies that `47.523` should be treated as a floating point value
- `6` — width of the area to show `47.523`
- `2` — number of digits to show after decimal point

```
"Value:  47.52"
```

Real formatting

- Codes for other types of values
  - String, octal number, hexadecimal …
- Other positioning information
  - Left justify
  - Add leading zeroes
- Derived from `printf()` of C, see Python documentation for details

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PROGRAMMING, DATA STRUCTURES AND ALGORITHMS IN PYTHON

Week 5, Lecture 6

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Doing nothing

- Recall: reading a number from the keyboard

```
while(True):
    try:
      userdata = input("Enter a number: ")
      usernum = int(userdata)
    except ValueError:
      print("Not a number. Try again")
    else:
      break
```

Doing nothing

- What if we just want to repeat the loop on an error?

```
while(True):
  try:
    userdata = input("Enter a number: ")
    usernum = int(userdata)
  except ValueError:
    # Do nothing
  else:
    break
```

Doing nothing

- Blocks such as `except:`, `else:`, …cannot be empty
- Use `pass` for a null statement

```
while(True):
    try:
        userdata = input("Enter a number: ")
        usernum = int(userdata)
    except ValueError:
        pass
    else:
        break
```

Removing a list entry

- Want to remove `l[4]`?

  ```
  del(l[4])
  ```

- Automatically contracts the list and shifts elements in `l[5:]` left

- Also works for dictionaries

- `del(d[k])` removes the key `k` and its associated value

Undefining a value

- In general, `del(x)` removes the value associated with `x`, makes `x` undefined

```
x = 7
del(x)
y = x+5

NameError: name 'x' is not defined
```

Checking undefined name

- Assign a value to x only if x is undefined

```
try:
   x
except NameError:
   x = 5
```

The value None

- None is a special value used to denote “nothing”
- Use it to initialise a name and later check if it has been assigned a valid value

```
x = None
…

if x is not None:
   y = x
```

- Exactly one value None
- `x is None` is same as `x == None`

Summary

- Use `pass` for an empty block
- Use `del()` to remove elements from a list or dictionary
- Use the special value `None` to check if a name has been assigned a valid value