f = \texttt{lambda }x : x[1] \\
\texttt{sorted(lst, key=f)}

Susan Rodger
April 4, 2023
T is for …

• Type
  • From int to float to string to list to …

• Text
  • From .txt to editors to …

• Turing Award – Highest Honor in CS
  • Nobel, Fields, Turing
  • Turing Duke Alums:
    • Ed Clarke (MS)
    • John Cocke (BS, PhD)
    • Fred Brooks (BS)
Shaundra Daily

- Professor of the Practice, Duke University
- B.S. Florida State, Electrical Eng
- PhD Media Arts/Sciences – MIT
- Combines Dance with Robotics
- Focuses on technologies, programs and curricula to support Diversity, Equity and Inclusion in STEM Fields
Announcements

• Assignment 5 due Thursday!
  • Sakai quiz due tonight! (no grace day)
• Assignment 6 out Thursday, due April 20
• APT-6 out today, Due 11/29
• Still to come (APT-7 and Assign 7 (short))

• Lab 9 Friday
  • There is a prelab
•Coming up...
  • Exam 3 – Tues, April 11
Exam 3– Tues, April 11 – in one week!

• Exam is in class on paper – 10:15am
  • Need pen or pencil
• See materials under 4/11 date
  • Exam 3 Reference sheet - part of exam
• Covers
  • topics /reading through today
  • APTs through APT6
  • Labs through Lab 9
  • Assignments through Assignment 5
Exam 3 topics include ...

- List, tuples, list comprehensions
- Loops – for loop, while loop, indexing with a loop
- Reading from a file
  - Converting data into a list of things
- Parallel lists
- Sets – solving problems
- Dictionaries – solving problems
- Sorting – lists, tuples
- No turtles, no images - but note we are practicing other concepts with images
Exam 3

• Exam 3 is your own work!
• No looking at other people’s exam
• You cannot use any notes, books, computing devices, calculators, or any extra paper
• Bring only a pen or pencil
• The exam has extra white space and has the Exam 3 reference sheet as part of the exam.

• Do not discuss any problems on the exam with others until it is handed back
Exam 3 – How to Study

- Practice writing code on paper!
- Rewrite an APT
- Try to write code from lecture from scratch
- Try to write code from lab from scratch
- Practice from old exams
- Put up old Sakai quizzes, but better to practice writing code
- Look at Exam 3 reference sheet when writing code!
PFTD

• Sorting in Python and sorting in general
  • How to use .sort and sorted, differences
  • Key function – change how sorting works
  • Lambda – create anonymous functions

• Stable sorting
  • How to leverage when solving problems
  • Why Timsort is the sort-of-choice (! quicksort)
Python Sorting API

• We'll use both `sorted()` and `.sort()` API
  • How to call, what options are
  • How to sort on several criteria

• One creates a new list, one modifies existing list
  • `sorted(..)` creates list from .. Iterable
  • `x.sort()` modifies the list x, no return value!
API to change sorting

• In SongReader.py we changed order of tuples to change sorting order
  • Then we sliced the end to get "top" songs

• Can supply a function to compare elements
  • Function return value used to sort, key=function
  • Change order: reverse=True
Sorting Examples
(with optional parameters)

• Use key=function argument and reverse=True
  • What if we want to write our own function?

```python
a = ['red', 'orange', 'green', 'blue', 'indigo', 'violet']
print(sorted(a))

print(sorted(a, key=len))

print(sorted(a, key=len, reverse=True))
```
Sorting Examples

```python
a = [4, 1, 7, 3]
b = sorted(a)
a.sort()
a = ['Q', 'W', 'B', 'F']
b = sorted(a)
c = sorted(a, reverse = True)
a = ['hello', 'blue', 'car']
b = sorted(b, key=len)
```
More Sorting Examples

```python
a = [ [2, 2, 34], [2, 6, 7, -1], [1, 2, 3] ]
b = sorted(a)

c = sorted(a, key = len)
d = sorted(a, key=max)
e = sorted(a, key=min)
```
The power of lambda

• We want to create a function "on-the-fly"
  • aka anonymous function
  • aka "throw-away" function

• Why 'indigo' first and 'green' last?
  • What about order of ties? Later today! Stable
Anonymous Functions

• Useful when want “throw-away” function
  • Our case mainly sort

• Syntax: lambda PARAMETERS: EXPRESSION
  • PARAMETERS – 0 or more comma separated
  • EXPRESSION – evaluates to something
Why is lambda used?

• It doesn't matter at all could use zeta? iota? ...
  • https://en.wikipedia.org/wiki/Alonzo_Church

• Lisp and Scheme have lambda expressions
• Guido van Rossom, learned to live with lambda
What is a lambda expression?

- It's a function object, treat like expression/variable
  - Like list comprehensions, access variables

```python
g>>> inc = lambda x: x + 1
>>> p = [1, 3, 5, 7]
>>> [inc(num) for num in p]
[2, 4, 6, 8]
```
Syntactic sugar (makes the medicine go down)

- Syntactic sugar for a normal function definition

```python
def f(x):
    return x[1]
sorted(lst, key=f)
```

```python
>>> d.items()
dict_items([(('a', [1, 2, 3]), ('b', [4, 7]), ('c', [1, 1, 5, 8]))]
>>> sorted(d.items(), key=lambda x : len(x[1]))

>>> sorted(d.items(), key=lambda sparky : len(sparky[1]))
```
Syntax and Semantics of Lambda

• Major use: single variable function as key

```python
fruits = ['banana', 'apple', 'lemon', 'kiwi', 'pineapple']
b = sorted(fruits)
c = min(fruits)
d = max(fruits)
```
Syntax and Semantics of Lambda (2)

fruits = ['banana', 'apple', 'lemon', 'kiwi', 'pineapple']

e = min(fruits, key=lambda f: len(f) )

g = max(fruits, key=lambda z: z.count('e'))

h = sorted(fruits, key=lambda z: z.count('e'))
Review: CSV and Sort for top artists

- Using two sorts to get top artists

```python
print('Top 5 artists:')
sortbycount = sorted([(a[1], a[0]) for a in counts.items()])
sortedArtists = [(a[1], a[0]) for a in sortbycount]
for artist in sortedArtists[:5]:
    print(artist)
```

- Reverse tuples to sort
- Reverse tuples to print

Top 5 artists:
('John, Elton', 21)
('Who', 24)
('Rolling Stones', 36)
('Led Zeppelin', 38)
('Beatles', 51)
Top 5 Artists

• Instead of intermediary list, use lambda
• Instead of [-5:], use reverse=True

```python
print('Top 5 artists: ')
sortbycount = sorted([(a[1], a[0]) for a in counts.items()])
sortedArtists = [(a[1], a[0]) for a in sortbycount]
for artist in sortedArtists[-5:]:
    print(artist)

print("repeat it")
sortedArtists = sorted(counts.items(), key=lambda item: item[1], reverse=True)
for tup in sortedArtists[:5]:
    print(tup)
```

repeat it
('Beatles', 51)
('Led Zeppelin', 38)
('Rolling Stones', 36)
('Who', 24)
('Eagles', 21)
How is the sorting happening?

```python
>>> d
{'a': [1, 2, 3], 'b': [4, 7], 'c': [1, 1, 5, 8]}
```
```
>>> sorted(d.items())
```
```
>>> sorted(d.items(), key=lambda x: x[1])
```
```
>>> sorted(d.items(), key=lambda x: x[1][-1])
```
How to do some “fancy” sorting

• lambda PARAMETER : EXPRESSION

• Given data: list of tuples: (first name, last name, age)
  [('Percival', 'Avram', 51),
   ('Melete', 'Sandip', 24), …]

• What does this do?
  • sorted(data, key=lambda z : (z[0], z[1], z[2]))
  • Sorts by first name, break ties with last name, break further ties with age

• What is the lambda key to sort the following?
  • Sort by last name, break ties with first name
  • Sort by last name, break ties with age
  • Alphabetical by last name, then first name, then reverse age order
Creating Tuples with lambda

• Sort by last name, break ties with first name

• Sort by last name, break ties with age

• Alphabetical by last name, then first name, then reverse age order
Leveraging the Algorithm

- Can’t sort by creating a tuple with lambda, use: 
  - Pattern: Multiple-pass stable sort – first sort with last tie breaker, then next to last tie breaker, etc. until at main criteria

- Sort by index 0, break tie in reverse order with index 1
  
  [('b', 'z'), ('c', 'x'), ('b', 'x'), ('a', 'z')]  

- Stable sort respects original order of "equal" keys
Stable sorting: respect "equal" items

- Women before men, each group height-sorted
  - First sort by height
Understanding Multiple-Pass Sorting

```python
> data
[('f', 2, 0), ('e', 1, 4), ('a', 2, 0),
 ('c', 2, 5), ('b', 3, 0), ('d', 2, 4)]
> a0 = sorted(data, key = lambda x: x[0])
> a0

> a1 = sorted(a0, key = lambda x: x[2])
> a1

> a2 = sorted(a1, key = lambda x: x[1])
> a2
```
WOTO-3 Multipass Sorting