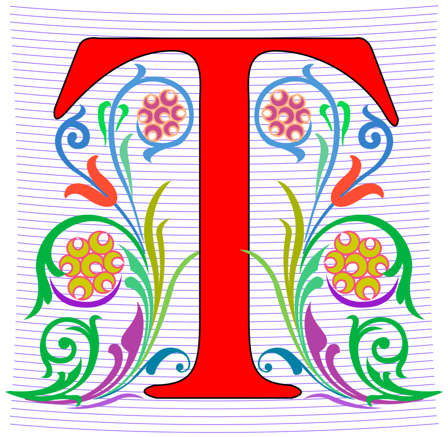
Compsci 101
Stable Sorting, Lambda

```
f = lambda x : x[1]
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**

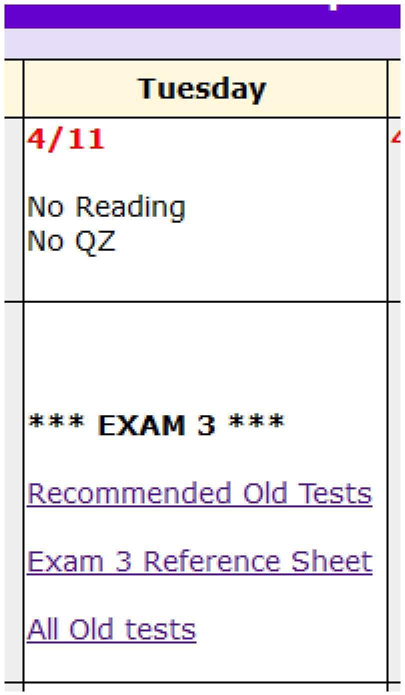
Announcements

- **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



Tuesday

4/11

No Reading
No QZ

*** EXAM 3 ***

Recommended Old Tests

Exam 3 Reference Sheet

All Old tests

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?

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

print(sorted(a, key=len))

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

Sorting Examples

```
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)
```

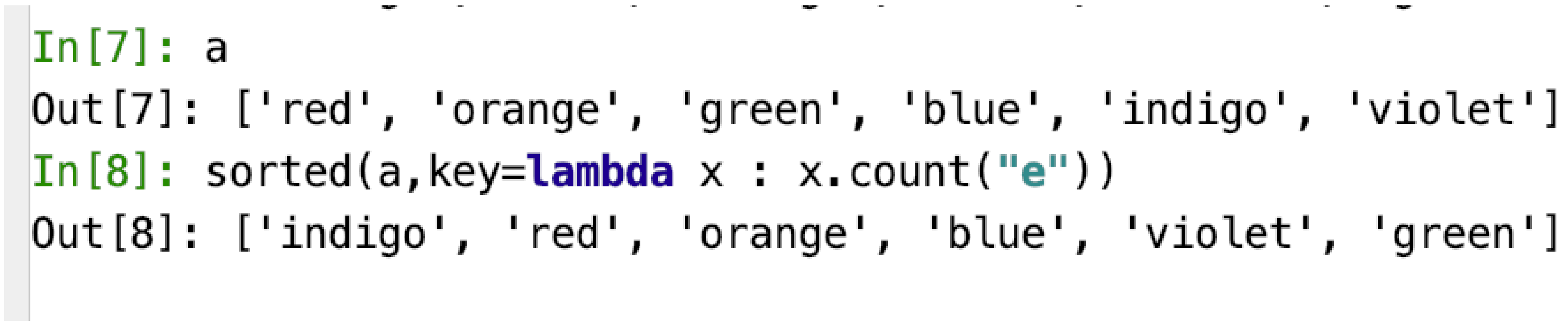
More Sorting Examples

```
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)
```

WOTO-1 Basic Sorting http://bit.ly/101s23-0404-1

The power of lambda

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



```
In[7]: a
Out[7]: ['red', 'orange', 'green', 'blue', 'indigo', 'violet']
In[8]: sorted(a,key=lambda x : x.count("e"))
Out[8]: ['indigo', 'red', 'orange', 'blue', 'violet', 'green']
```

- **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?

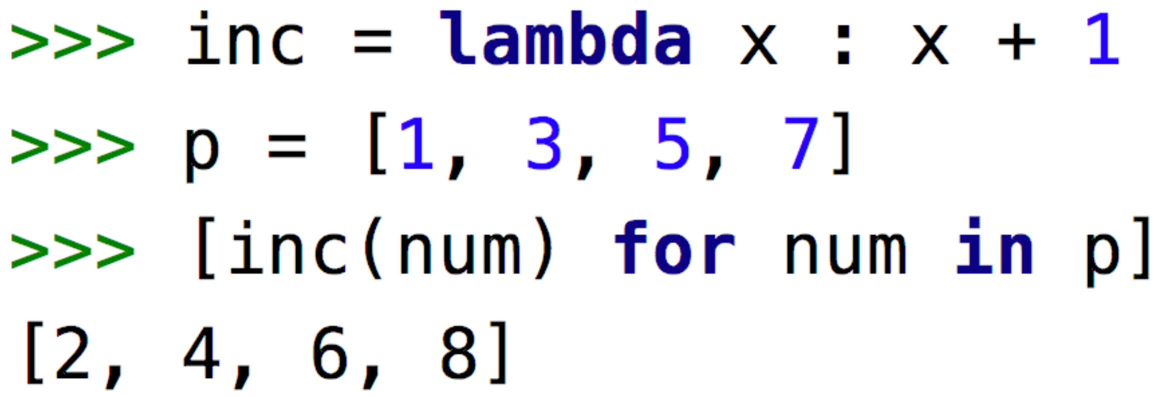
- **It doesn't matter at all could use zeta? iota? …**
  - https://en.wikipedia.org/wiki/Alonzo_Church

  - Lisp and Scheme have lambda expressions
  - Guido van Rossom, learned to live with lambda

λ

What is a lambda expression?

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



```
>>> 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**

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

```
>>> 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**

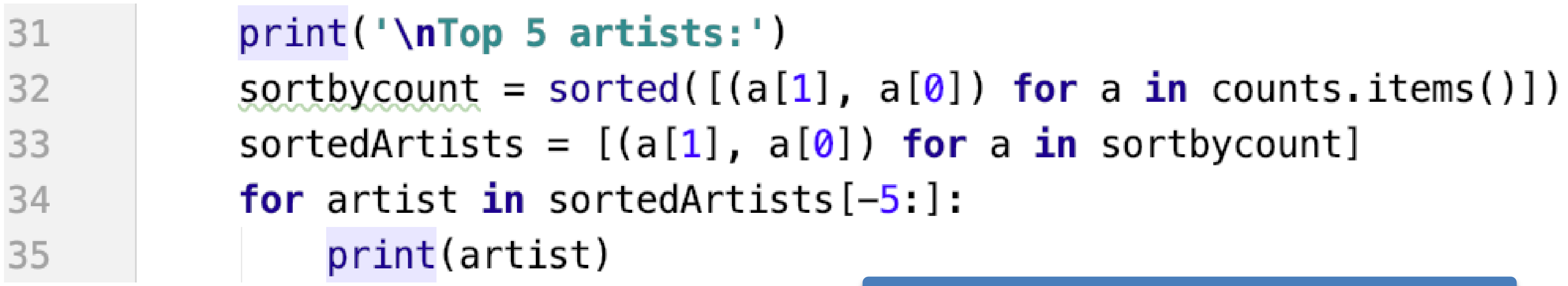
```
fruits = [‘banana’, ‘apple’, ’lemon’, ’kiwi’, ’pineapple’]
b = sorted(fruits)

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 = sortedfruits, key=lambda  z: z.count(‘e’) )
```

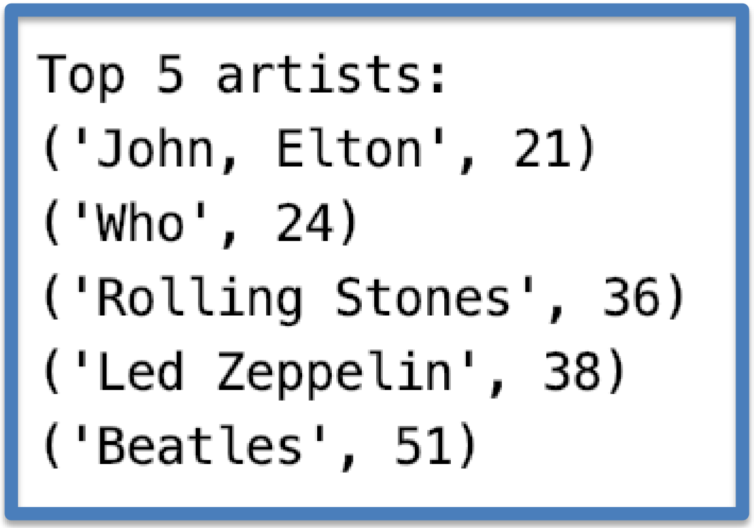
Review: CSV and Sort for top artists

- **Using two-sorts to get top artists**



```python
    print('\nTop 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)
```

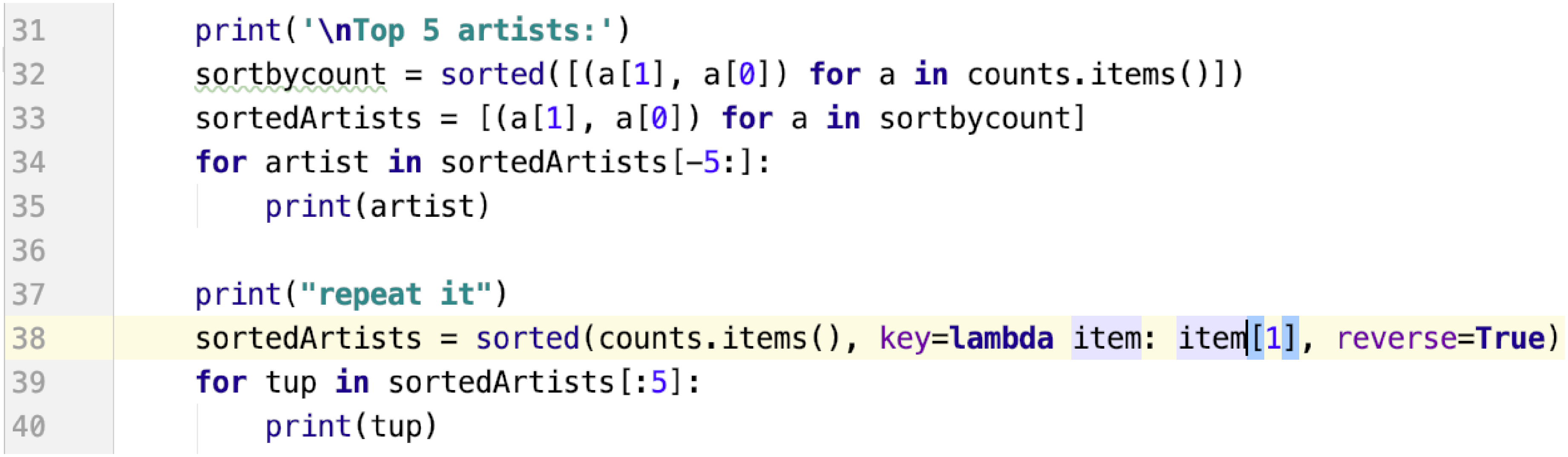
- **Reverse tuples to sort**
- **Reverse tuples to print**



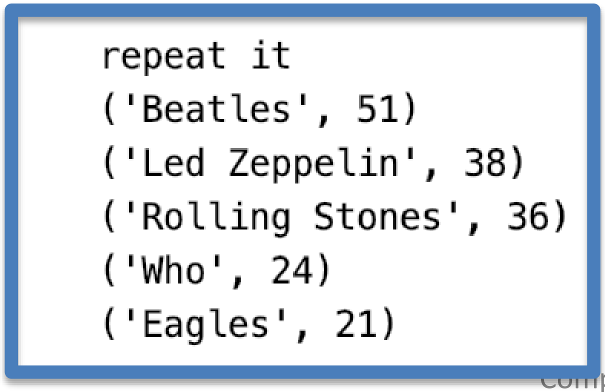
```
Top 5 artists:
('John, Elton', 21)
('Who', 24)
('Rolling Stones', 36)
('Led Zeppelin', 38)
('Beatles', 51)
```

Top 5 Artists

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

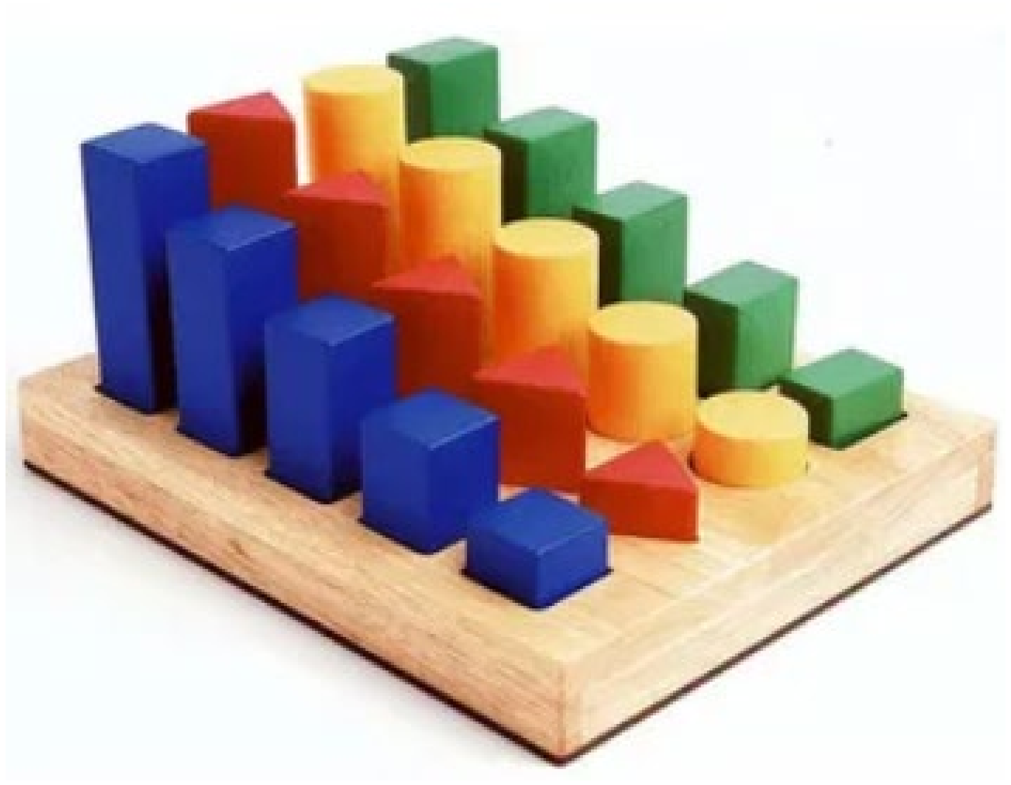


```
print('\nTop 5 artists:')
sortbycount = sorted([(a[1], a[0]) for a in counts.items()])
sortedArtists = [(a[1], a[0]) for a in sortbycount]
for artist in sortedArtists[-5:]:
    print(artist)

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

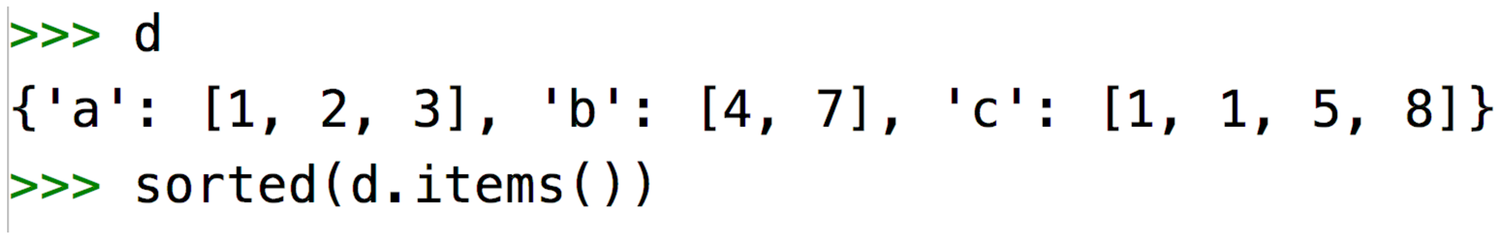


```
repeat it
('Beatles', 51)
('Led Zeppelin', 38)
('Rolling Stones', 36)
('Who', 24)
('Eagles', 21)
```

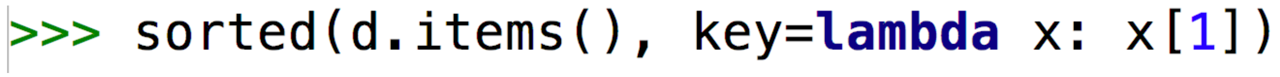
WOTO-2 Sorting
http://bit.ly/101s23-0404-2



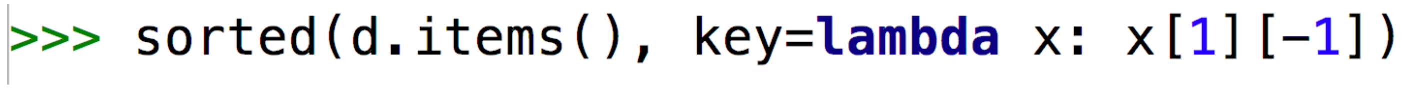
How is the sorting happening?



```
>>> 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]))`**

- **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

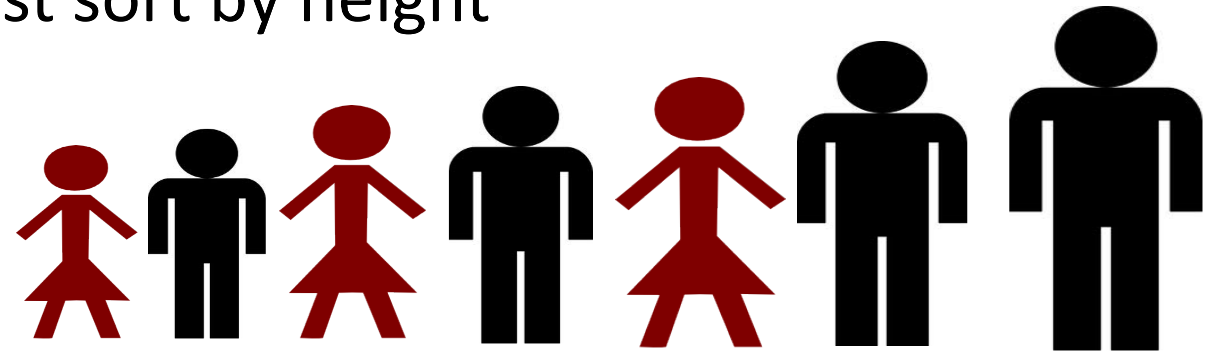
- **Sort by index 0, break tie in reverse order with index 1**

```
[(‘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

```
> 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
http://bit.ly/101s23-0404-3