[220 / 319] Dictionary Nesting

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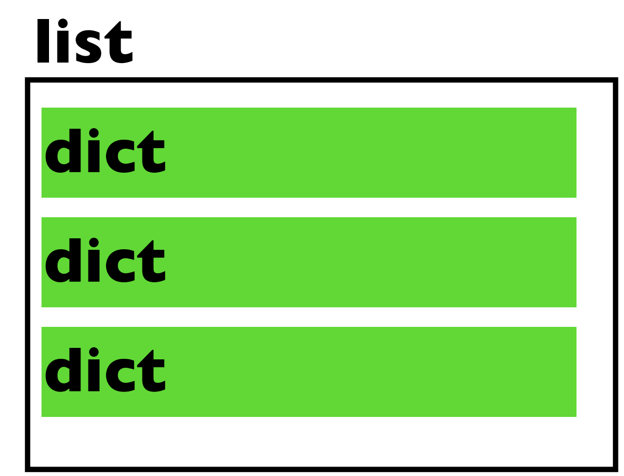
Learning Objectives Today

More dictionary operations

- len, in, for loop
- d.keys(), d.values()
- defaults for get and pop



Syntax for nesting (dicts inside dicts, etc)

- indexing/lookup
- step-by-step resolution

Understand common use cases for nesting

- binning/bucketing (`list` in `dict`)
- a more convenient table representation (`dict` in `list`)
- transition probabilities with Markov chains (`dict` in `dict`)

one of the most common data analysis tasks

we'll generate random English-like texts

Today's Outline

Dictionary Ops

Binning (dict of list)

Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict) – self-interest study; not required for quizzes and exams

Creation of Empty Dict - self-review

Non-empty dict:

```
d = {"a": "alpha", "b": "beta"}
```

Empty dict (way 1):

```
d = {}
```

Empty dict (way 2):

```
d = dict() # special function called constructor
```

similar for lists: `L = []`

similar for lists: `L = list()` **# special function called constructor**

similar for sets: `s = set()` **# special function called constructor**

len, in, for - self-review

```
num_words = {0:"zero", 1:"one", 2:"two", 3:"three"}
```

```
print(len(num_words))
```

4

```
print(1 in num_words)
```

True

```
print("one" in num_words)
```

False

(it is only checking keys, not vals)

```
for x in num_words:
    print(x, num_words[x])
```

0 zero
1 one
2 two
3 three

you can iterate over values
by combining a **for loop** with **lookup**

Extracting keys and values

```
num_words = {0:“zero”, 1:”one”, 2:”two”, 3:”three”}
```

```
print(type(num_words.keys()))
```

<class 'dict_keys'>

```
print(type(num_words.values()))
```

<class 'dict_values'>

don’t worry about these new types, because we can force them to be lists

Extracting keys and values

```
num_words = {0:“zero”, 1:”one”, 2:”two”, 3:”three”}
```

```
print(type(num_words.keys()))
```

<class 'dict_keys'>

```
print(type(num_words.values()))
```

<class 'dict_values'>

```
print(list(num_words.keys()))
```

[0, 1, 2, 3]

```
print(list(num_words.values()))
```

[“zero”, “one”, “two”, “three”]

Defaults with get and pop

```
suffix = {1:“st”, 2:”nd”, 3:”rd”}
```

✗
```
suffix.pop(0) # delete fails, because no key 0
```

✗
```
suffix[4] # lookup fails because no key 4
```

Defaults with get and pop

```
suffix = {1:"st", 2:"nd", 3:"rd"}
```

specify a default if
key cannot be found

✓
```
suffix.pop(0, "th") # returns "th" because no key 0
```

✗
```
suffix[4] # lookup fails because no key 4
```

✓
```
suffix.get(4, "th") # returns "th" because no key 4
```

specify a default if
key cannot be found

Defaults with get and pop

```
suffix = {1:“st”, 2:”nd”, 3:”rd”}


for num in range(6):
    print(str(num) + suffix.get(num, “th”))
```

0th
1st
2nd
3rd
4th
5th

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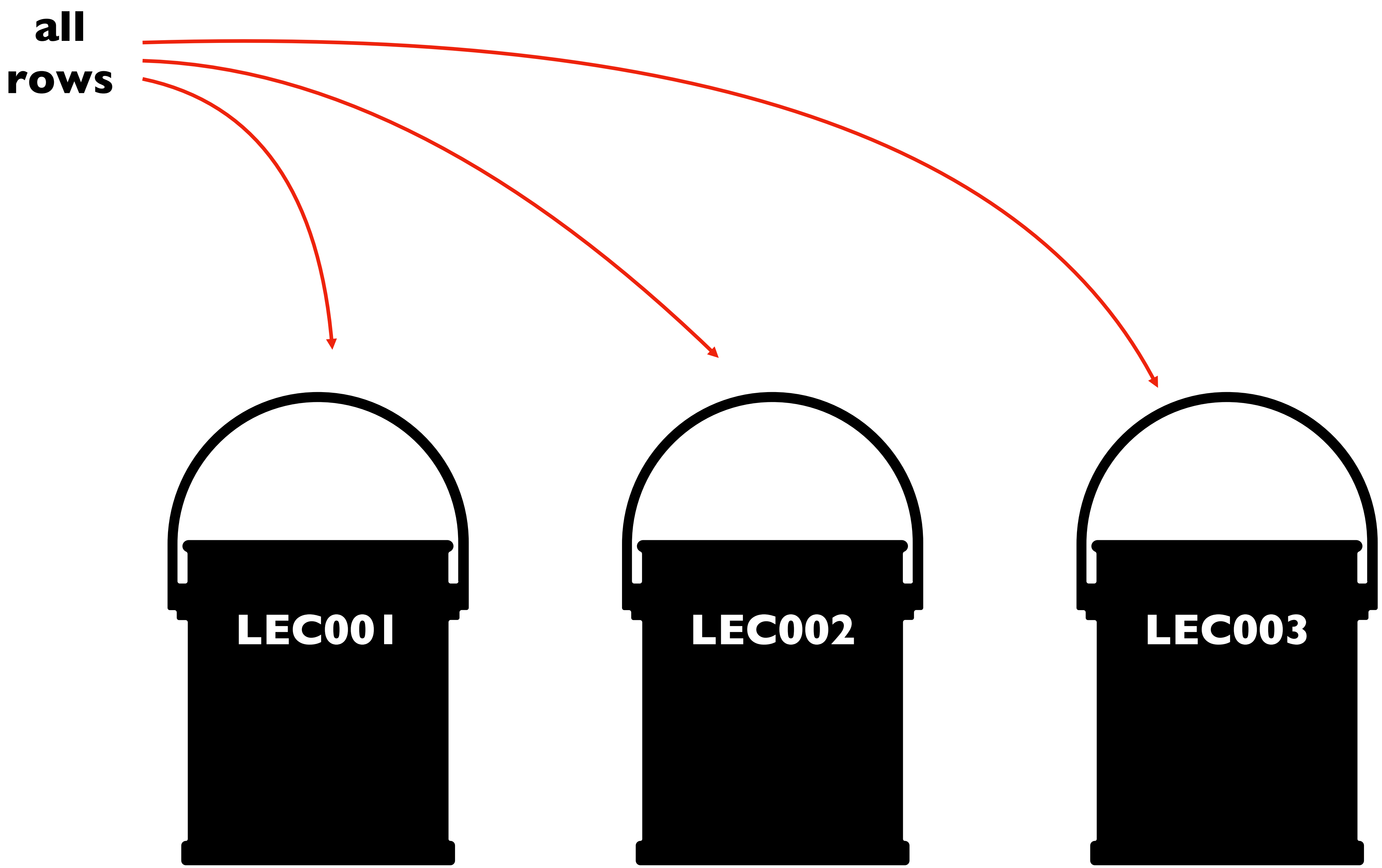
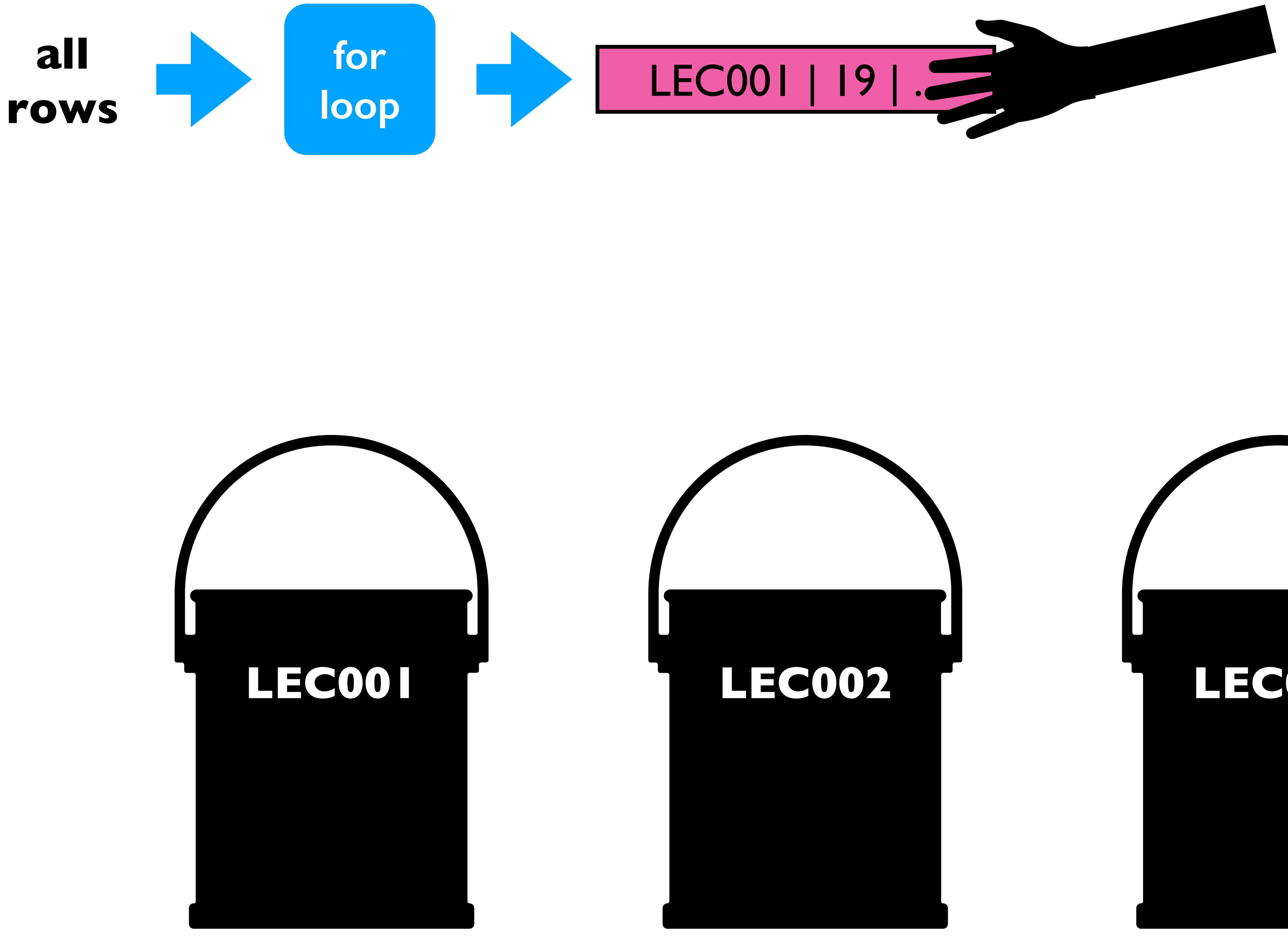
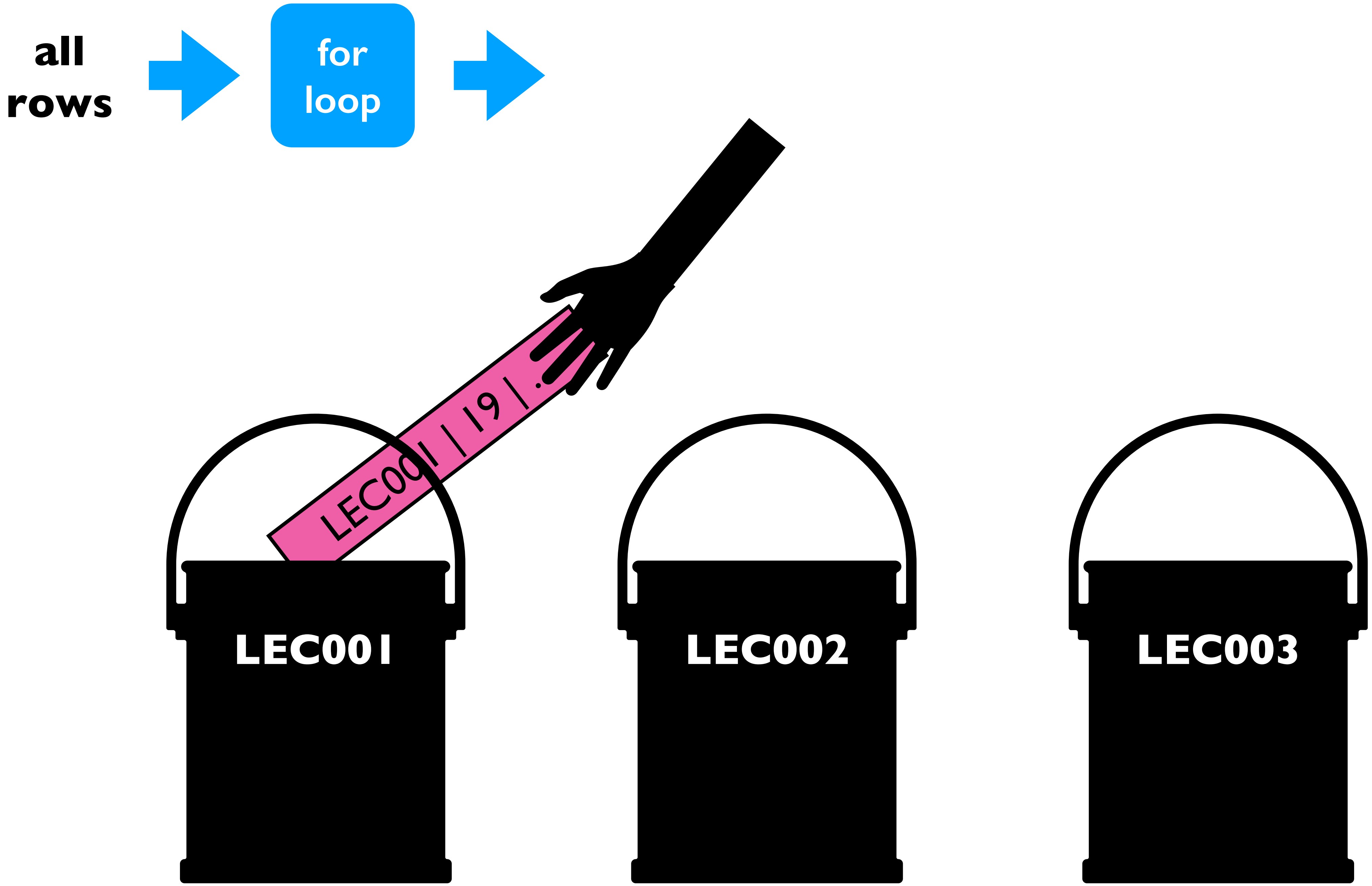
Bucketizing/Binning



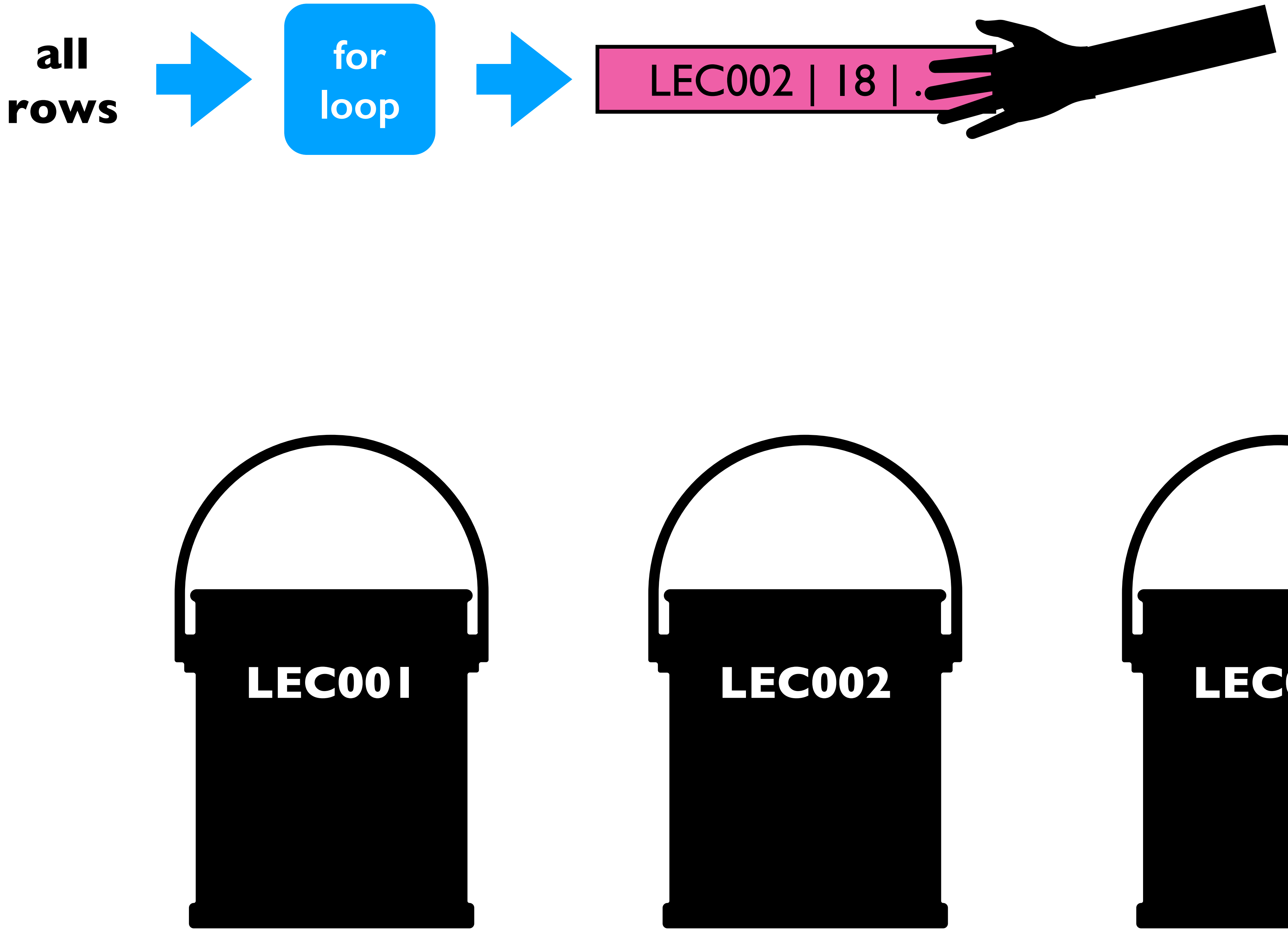
Bucketizing/Binning



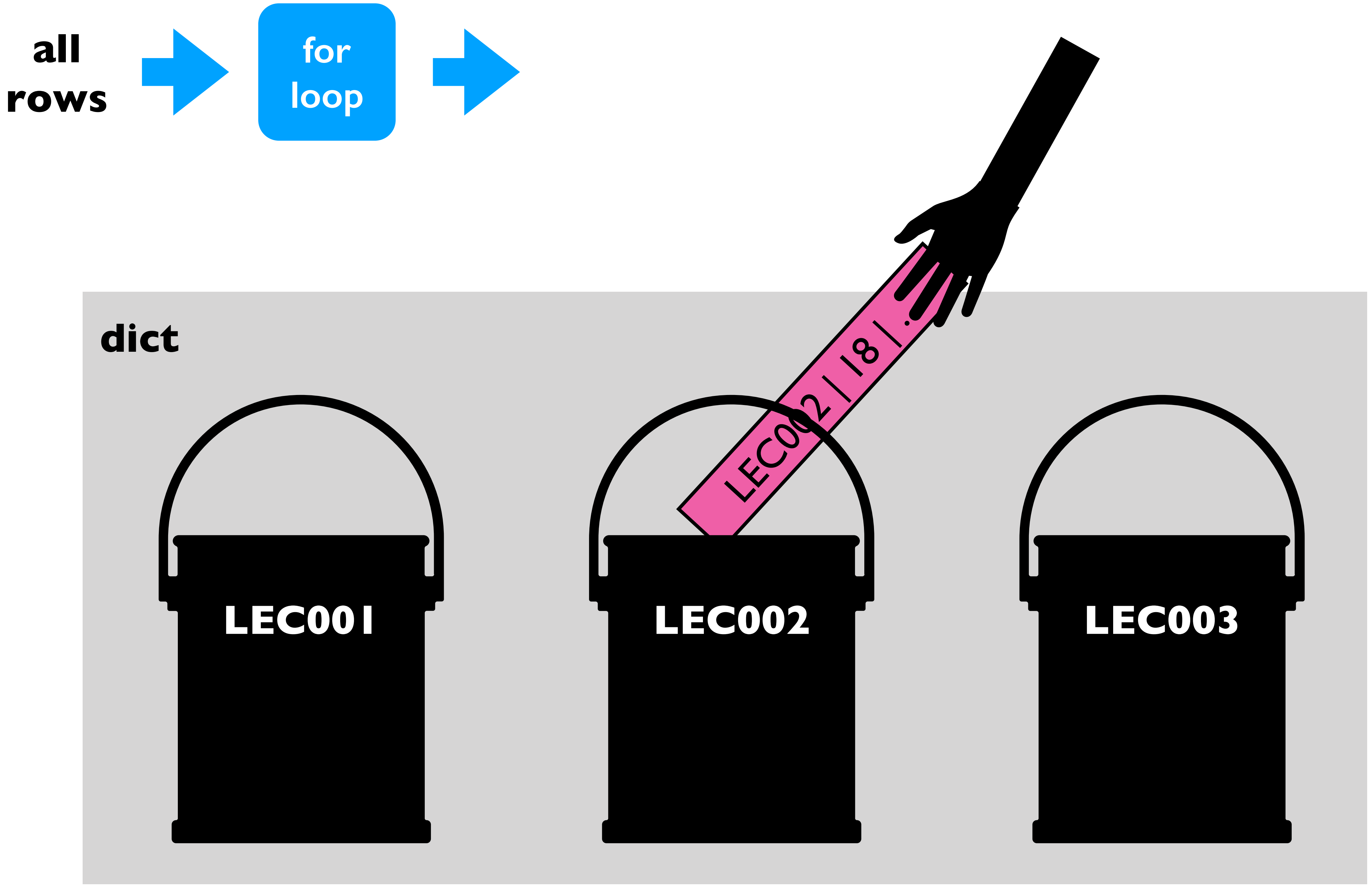
Bucketizing/Binning



Bucketizing/Binning



Bucketizing/Binning



Bins with lists and dicts

all data

```
rows = [
   ["LEC001”, 19, ”CS”],
   [”LEC002”, 18, “Eng”],
   [”LEC002”, 21, “Econ”],
   [”LEC003”, 25, ”Stat”],
   [”LEC002”, , ”DS”],
   [”LEC003”, , ”DS”],
]
```

```
bins = {
   ”LEC001”: [
      ["LEC001”, 19, ”CS”],
   ],
   ”LEC002”: [
      [”LEC002”, 18, “Eng”],
      [”LEC002”, 21, “Econ”],
      [”LEC002”, , ”DS”],
   ],
   ”LEC003”: [
      [”LEC003”, 25, ”Stat”],
      [”LEC003”, , ”DS”],
   ]
}
```

avg 19

avg 19.5

avg 25

Demo 1: Average Age per Section

Goal: print **average age** of students in each section

Input:

- CS220 Information survey

Output:

- Average age within each section

Example:

SEC001: 19
SEC002: 19.5
SEC003: 25

Today's Outline

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Table Representation (list of dict)

Probability Tables and Markov Chains (dict of dict)

Table Representation

name	x	y
Alice	30	20
Bob	5	11
Cindy	-2	50

list of list representation

```
header = ["name", "x", "y"]
rows = [
     ["Alice", 30, 20],
     ["Bob",    5, 11],
2 →  ["Cindy", -2, 50],
]                 ↑
                  2
```

rows[2][header.index("y")]

list of dict representation

```
[
     {"name":"Alice", "x":30, "y":20},
     {"name":"Bob",   "x":5,  "y":11},
2 →  {"name":"Cindy", "x":-2, "y":50},
]                                ↑
                                "y"
```

rows[2]["y"]

Demo 2: Table Transform

Goal: create function that transforms list of lists table
to a list of dicts table

Input:

- List of lists (from a CSV)

Output:

- List of dicts

Example:

```
>>> header = [“x”,”y”]
>>> rows = [[1,2], [3,4]]
>>> transform(header, rows)
[{“x”:1, “y”:2}, {“x”:3, “y”:4}]
```

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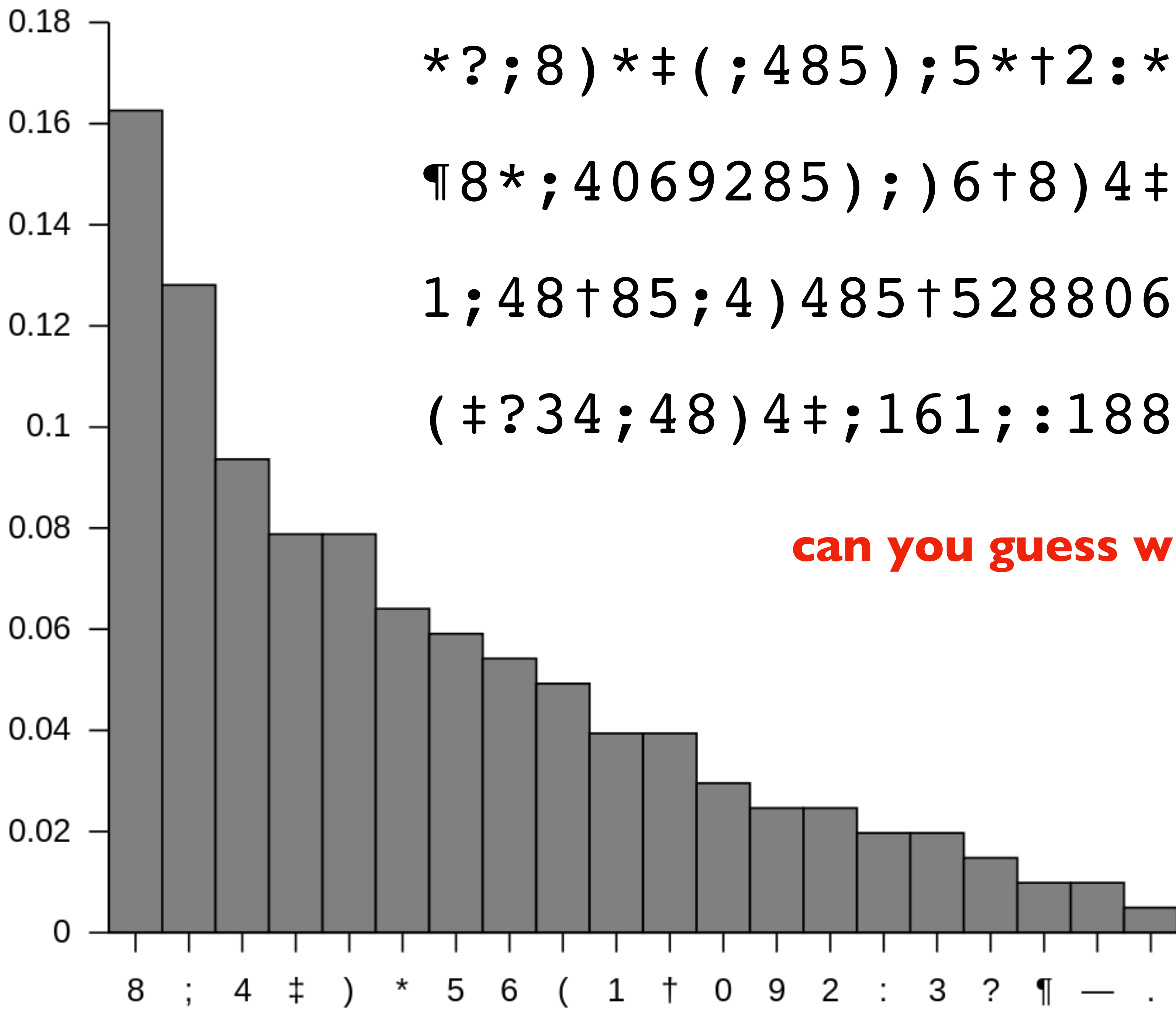
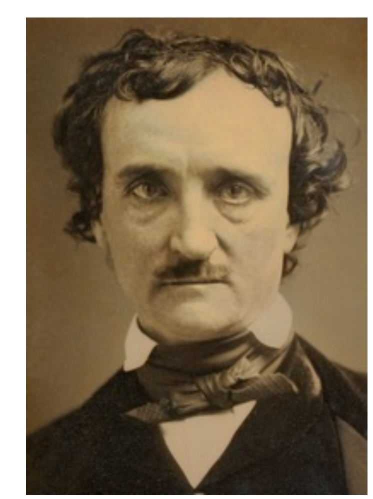
Challenge: Letter Frequency

```
53‡‡†305))6*;4826)4‡.)4‡);806*;48†8
¶60))85;;]8*;:‡*8†83(88)5*†;46(;88*96
*?;8)*‡(;485);5*†2:*‡(;4956*2(5*—4)8
¶8*;4069285);)6†8)4‡‡;1(‡9;48081;8:8‡
1;48†85;4)485†528806*81(‡9;48;(88;4
(‡?34;48)4‡;161;:188;‡?;
```

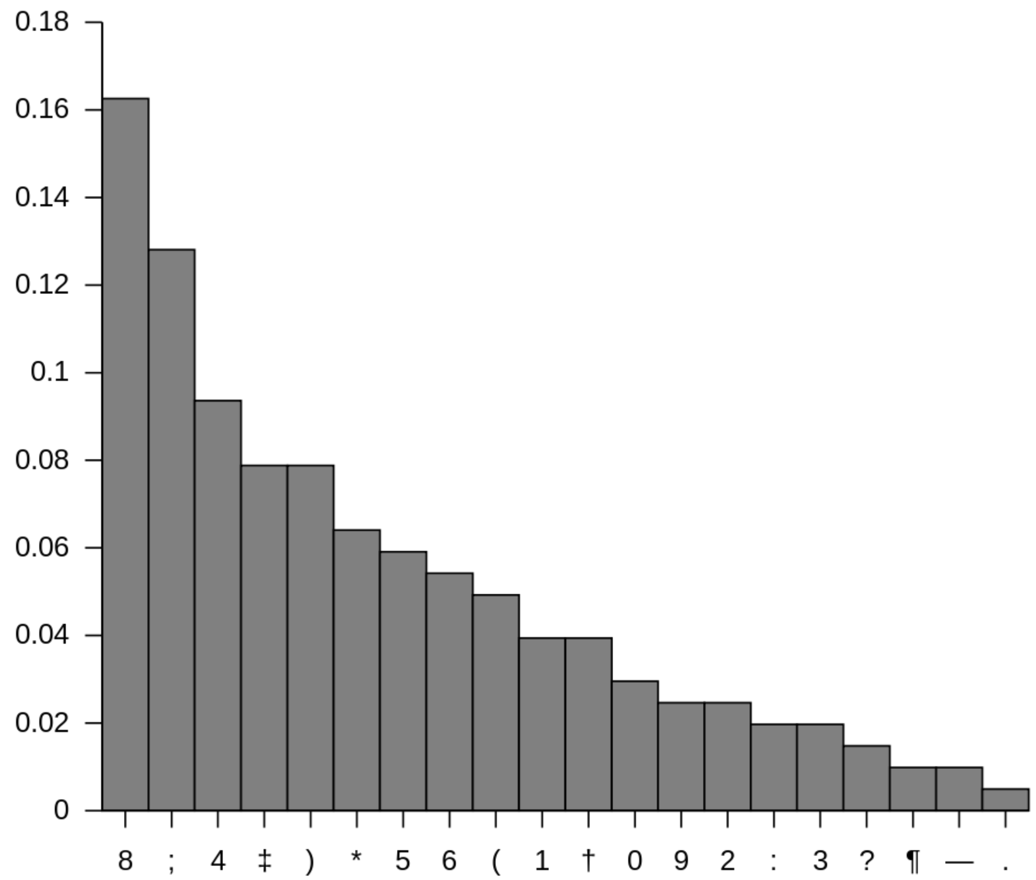


can you guess what 8 represents?

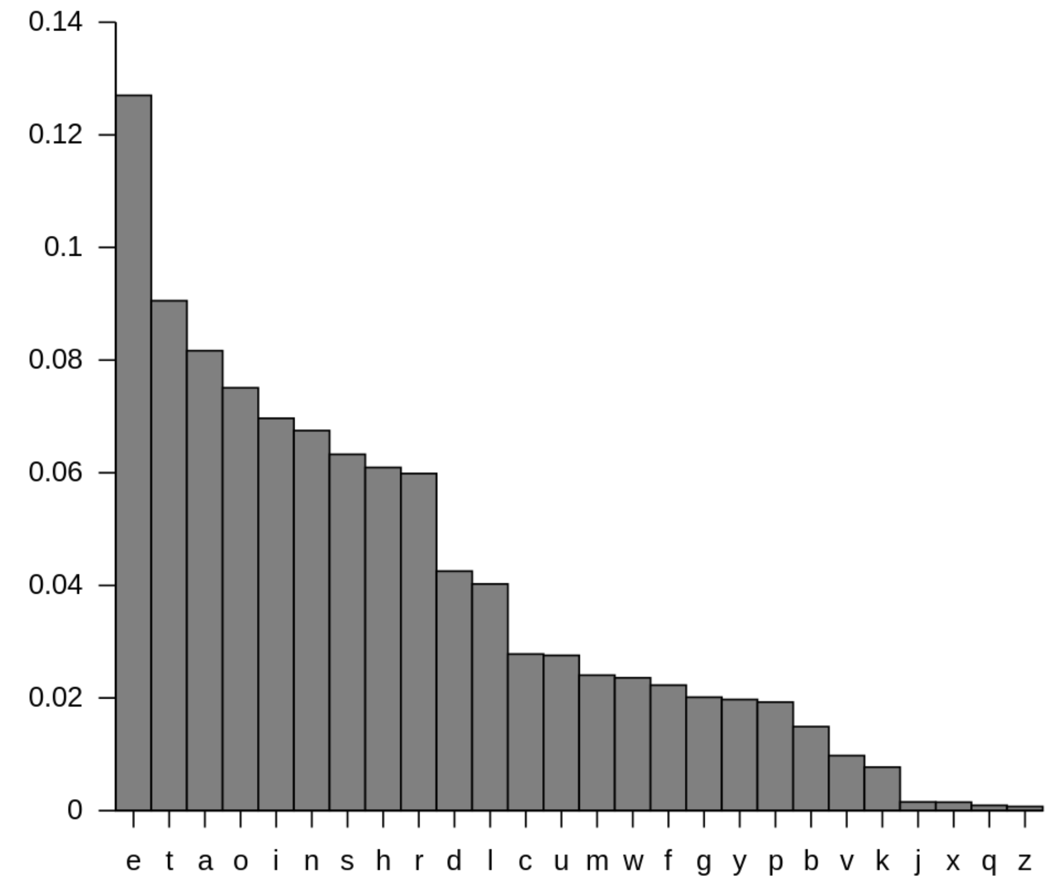


https://en.wikipedia.org/wiki/The_Gold-Bug

Challenge: Letter Frequency

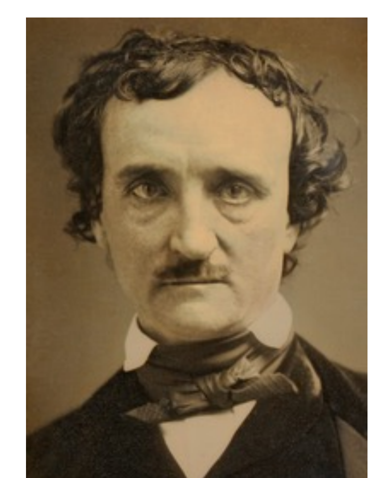


letters



symbols

how to compute these?



https://en.wikipedia.org/wiki/The_Gold-Bug

Challenge: Letter Frequency

Goal: if we randomly pick a word in a text, what is the probability that it will be a given letter?

Input:

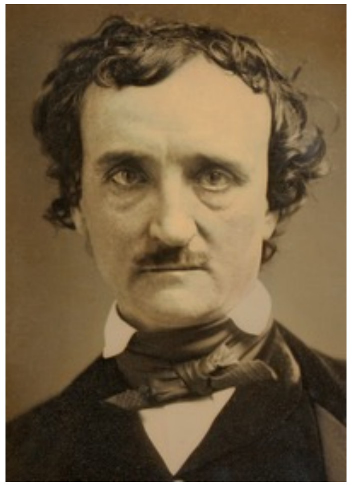
- Plaintext of book (from Project Gutenberg)

Output:

- The portion of letters in the text that are that letter

Example:

text: AAAAABBCCC
A: 50%
B: 20%
C: 30%



https://en.wikipedia.org/wiki/The_Gold-Bug

Sequence Data

Consider this sequence: `“the quick tiger is quiet”`

What letter likely comes after “t” in this text?

Next Letter	Probability
h	50%
i	50%
a	0%
...	0%

dict for “t”:
`{“h”: 0.5, “i”: 0.5}`

What letter likely comes after “q” in this text?

Next Letter	Probability
u	100%
...	0%

dict for “q”:
`{“u”: 1.0}`

Sequence Data

Organize all the dicts with a dict:

```
probs = {
  “u”: {“i”: 1.0},



}
```

Imagine a next-letter probability dictionary for every letter

dict for “u”:

```
{“i”: 1.0}
```

dict for “t”:

```
{“h”: 0.5, “i”: 0.5}
```

dict for “i”:

```
{“c”: 0.25, “g”: 0.25,
“s”: 0.25, “e”: 0.25}
```

dict for “q”:

```
{“u”: 1.0}
```

•••

Sequence Data

Organize all the dicts with a dict:

```
probs = {
   “u”: {“i”: 1.0},
   “t”: {“h”: 0.5, “i”: 0.5}
   “i”: {“c”: 0.25, “g”: 0.25,
         “s”: 0.25, “e”: 0.25},
   “q”: {“u”: 1.0},
   …
}
```

```
probs[“i”]
```

Imagine a next-letter probability dictionary for every letter

dict for “u”:

`{“i”: 1.0}`

dict for “t”:

`{“h”: 0.5, “i”: 0.5}`

dict for “i”:

```
{“c”: 0.25, “g”: 0.25,
“s”: 0.25, “e”: 0.25}
```

dict for “q”:

`{“u”: 1.0}`

•••

Sequence Data

Organize all the dicts with a dict:

```
probs = {
  “u”: {“i”: 1.0},
  “t”: {“h”: 0.5, “i”: 0.5}
  “i”: {“c”: 0.25, “g”: 0.25,
        “s”: 0.25, “e”: 0.25},
  “q”: {“u”: 1.0},
  …
}
```

```
probs[“i”][“e”] → 0.25
```

There is a 25% probability that the letter following an “i” is an “e”

Imagine a next-letter probability dictionary for every letter

dict for “u”:

```
{“i”: 1.0}
```

dict for “t”:

```
{“h”: 0.5, “i”: 0.5}
```

dict for “i”:

```
{“c”: 0.25, “g”: 0.25,
“s”: 0.25, “e”: 0.25}
```

dict for “q”:

```
{“u”: 1.0}
```

•••

Vocabulary

```
probs = {
  "u": {"i": 1.0},
  "t": {"h": 0.5, "i": 0.5}
  "i": {"c": 0.25, "g": 0.25,
        "s": 0.25, "e": 0.25},
  "q": {"u": 1.0},
  …
}
```

The collection of transition probabilities like this is sometimes called a "stochastic matrix"

Processes that make probabilistic transitions like this (e.g., from one letter to the next) are called "Markov chains"

Random Text Generation

which looks closest to English?

1. XFOML RXKHRJFFJUJ ZLPWCFWKCYJ FFJEYVKCQSGHYD QPAAMKBZAACIBZLHJQD.

2. OCRO HLI RGWR NMIELWIS EU LL NBNESEBYA TH EEI ALHENHTTPA OOBTTVA NAH BRL.

3. ON IE ANTSOUTINYS ARE T INCTORE ST BE S DEAMY ACHIN D ILONASIVE TUCOOWE AT TEASONARE FUSO TIZIN ANDY TOBE SEACE CTISBE.

Examples from *A Mind at Play*, by Soni and Goodman

Random Text Generation

all letters equally likely

XFOML RXKHRJFFJUJ
ZLPWCFWKCYJ FFJEYVKCQSGHYD
QPAAMKBZAACIBZLHJQD.

weighted random, based on frequency in a text
(implement with dict)

OCRO HLI RGWR NMIELWIS EU LL
NBNESEBYA TH EEI ALHENHTTPA
OOBTTVA NAH BRL.

probability of each letter based on previous letter
(implement with dict of dicts)

ON IE ANTSOUTINYS ARE T
INCTORE ST BE S DEAMY ACHIN D
ILONASIVE TUCOOWE AT
TEASONARE FUSO TIZIN ANDY
TOBE SEACE CTISBE.

Examples from *A Mind at Play*, by Soni and Goodman

Hypothetical Use Case

DNA sequences

GATACAGATACAGATACA

GCTATAGCTATAGCGCGC

AAAATTTTAAAATTTTAAAA

stochastic model

CATCATC?TC?TCATC?TCAT
CATCATCATCATCATCATCAT

synthetic sequences, filling in gaps

BIOINFORMATICS APPLICATIONS NOTE Vol. 22 no. 12 2006, pages 1534–1535
doi:10.1093/bioinformatics/btl113

Sequence analysis

GenRGenS: software for generating random genomic sequences and structures

Yann Ponty[1], Michel Termier[2] and Alain Denise[1,*]
[1]LRI, UMR CNRS 8623, Université Paris-Sud 11, F91405 Orsay cedex, France and [2]IGM, UMR CNRS 8621, Université Paris-Sud 11, F91405 Orsay cedex, France

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Associate Editor: Martin Bishop

Challenge: Conditional Letter Frequency

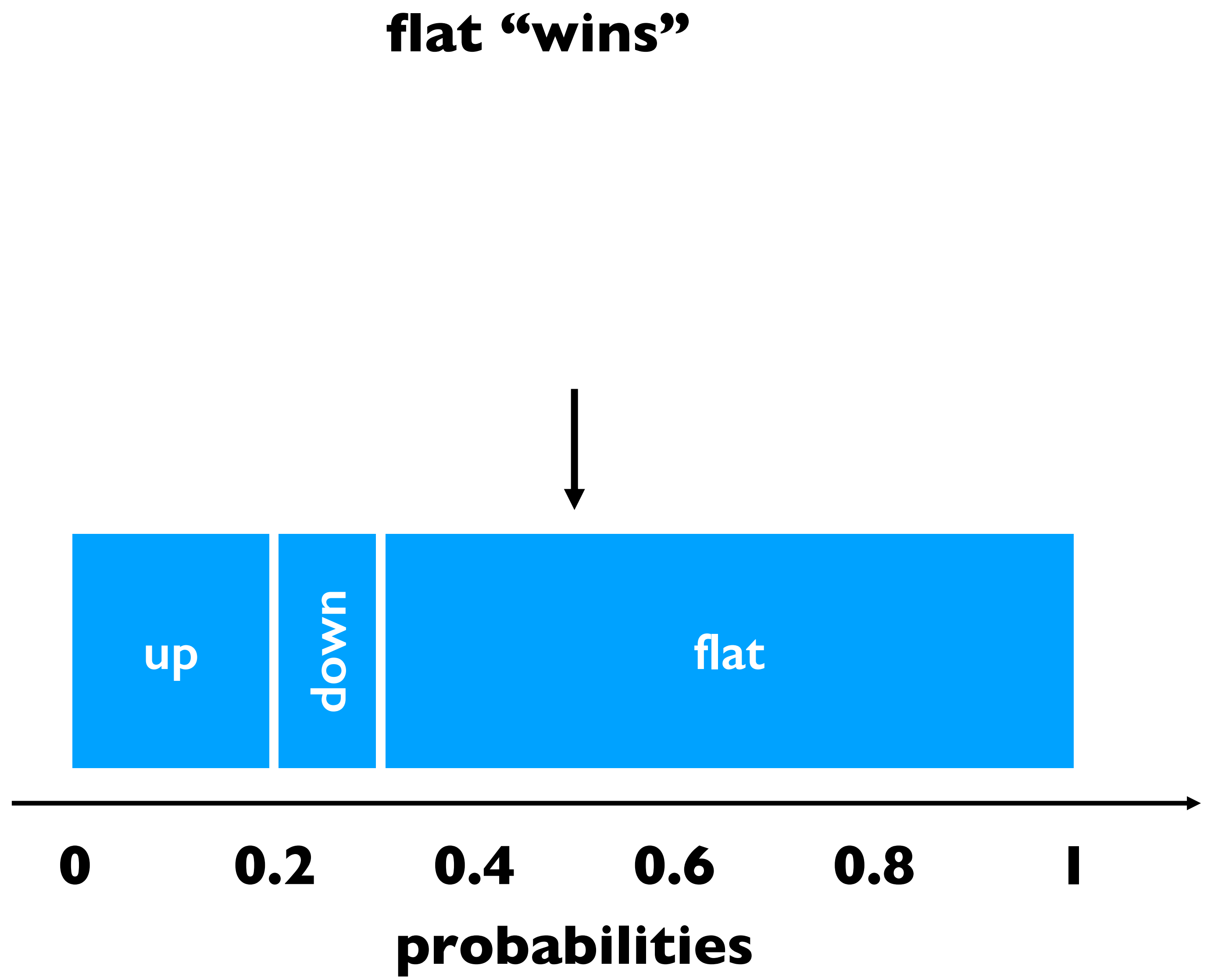
Goal: if we look at given letter, what is the next letter likely to be?

Input:
- Plaintext of book (from Project Gutenberg)

Output:
- Transition probabilities
- Randomly generated text, based on probabilities

Weighted Random

```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}

x = random.random()
# assume 0.5
```

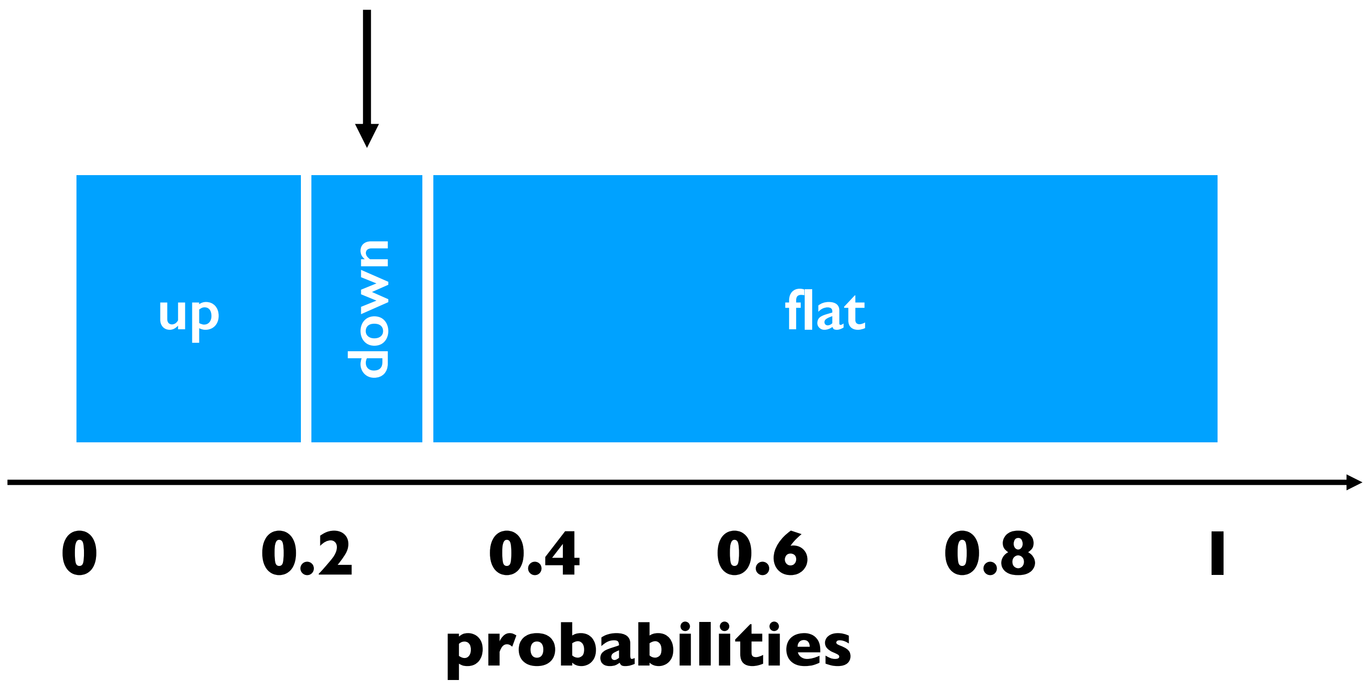


Weighted Random

```
transitions = {
    "up": 0.2,
    "down": 0.1,
    "flat": 0.7
}
```

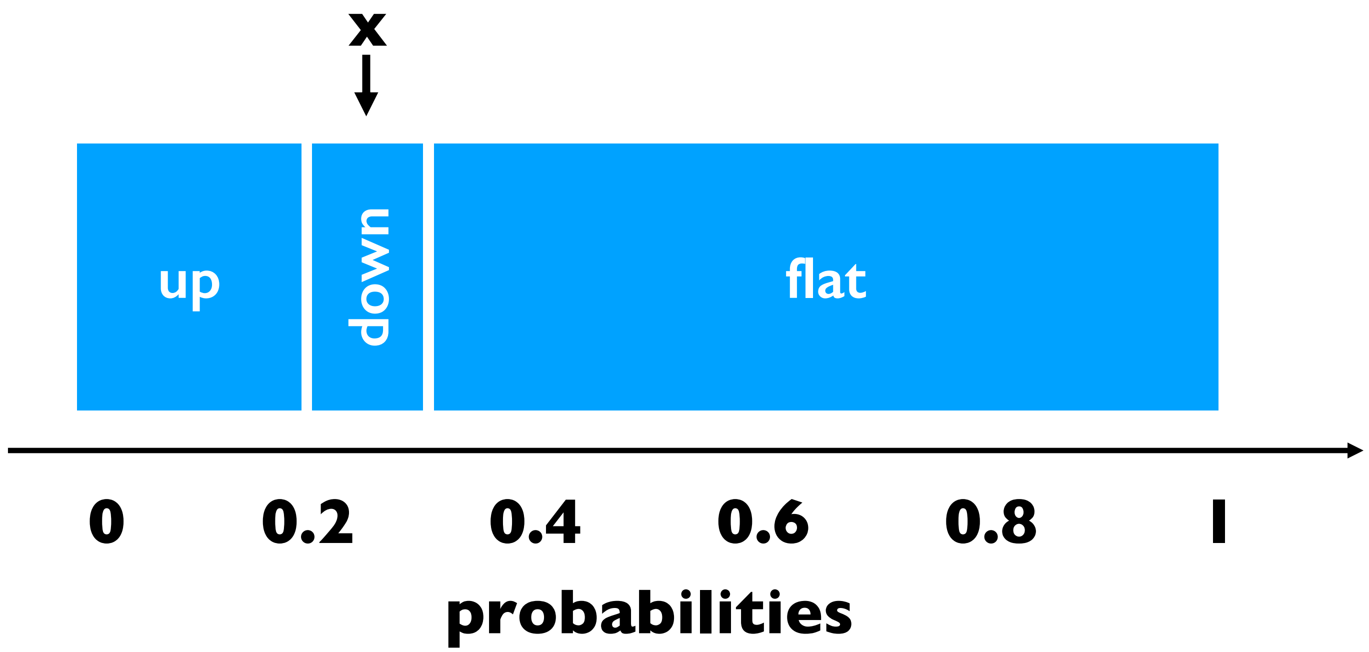
```
x = random.random()
# assume 0.25
```

down "wins"



Weighted Random

```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}
```

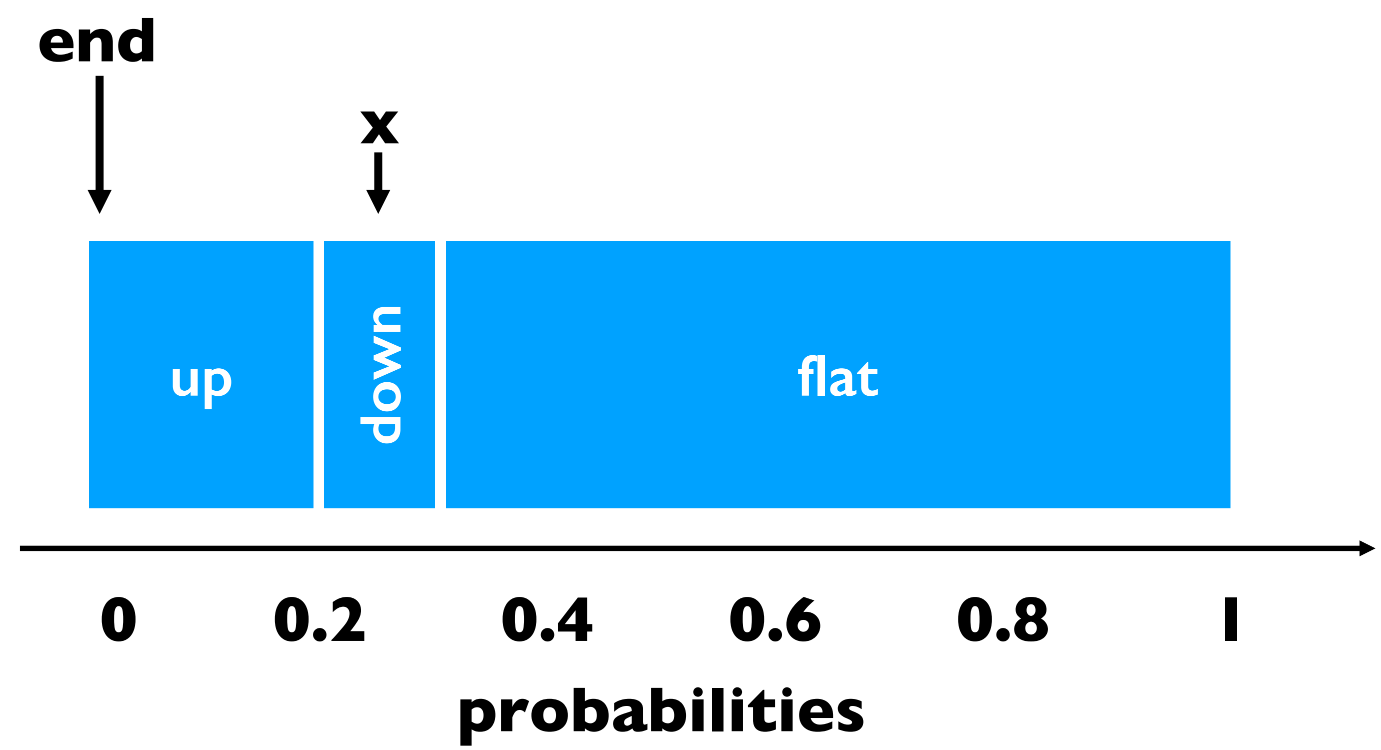


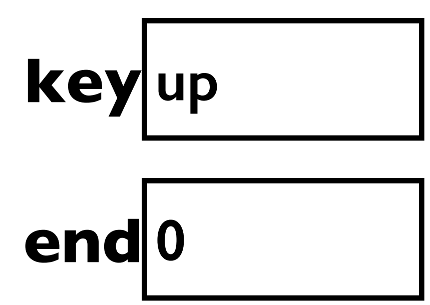

```
x = random.random()
# assume 0.25
```

```
end = 0
keys = [“up”, “down”, “flat”]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```

Weighted Random

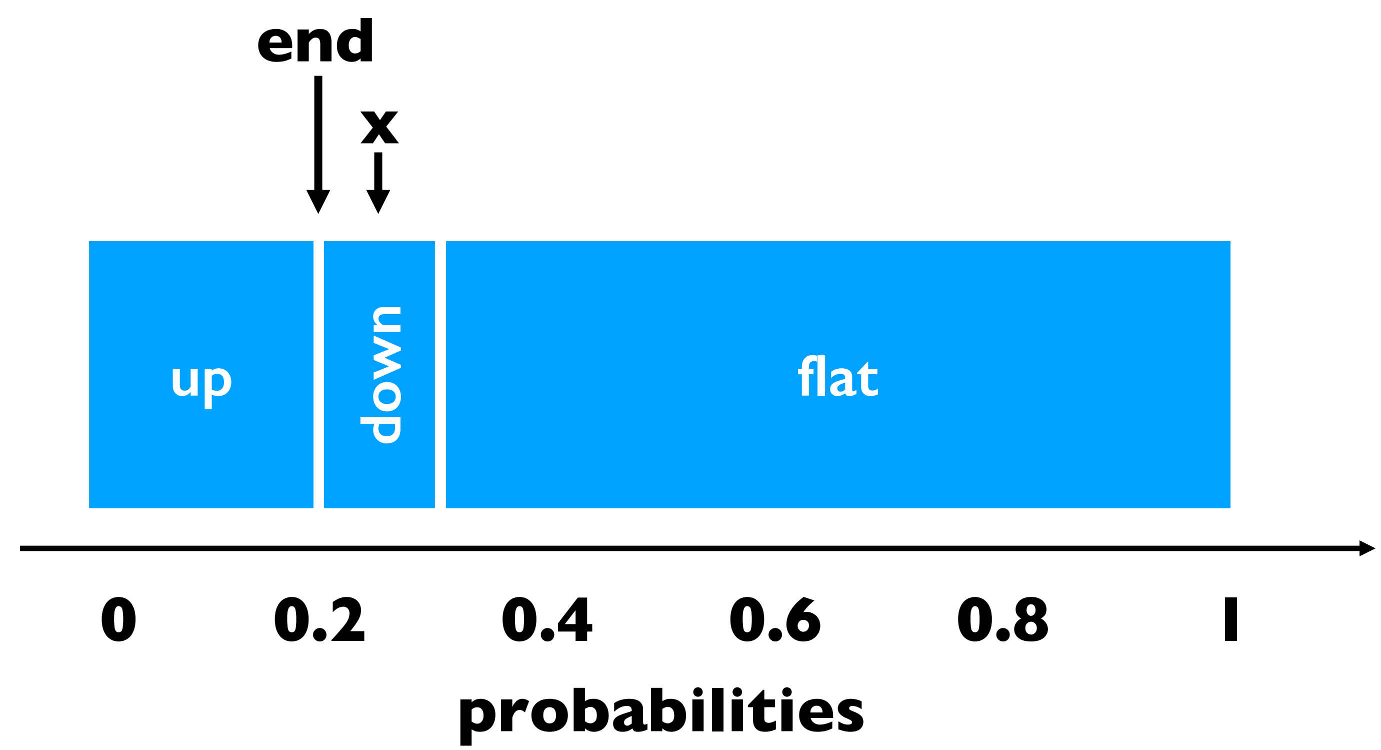
```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}

x = random.random()
# assume 0.25

end = 0
keys = [“up”, “down”, “flat”]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```





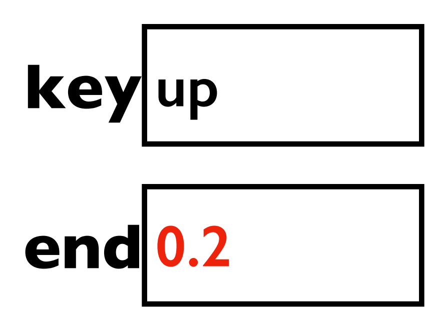
Weighted Random

```
transitions = {
    "up": 0.2,
    "down": 0.1,
    "flat": 0.7
}
```



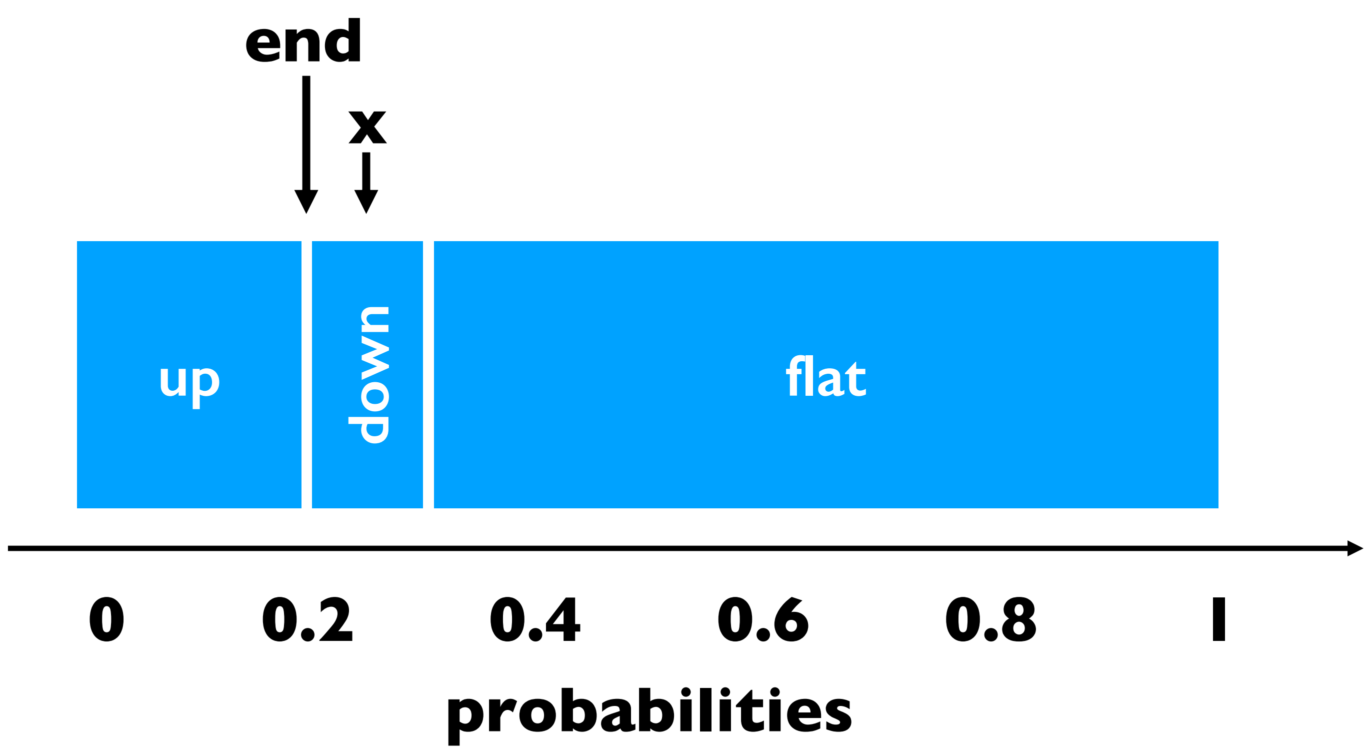

```
x = random.random()
# assume 0.25
```

```
end = 0
keys = ["up", "down", "flat"]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```



Weighted Random

```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}
```




```
x = random.random()
# assume 0.25
```

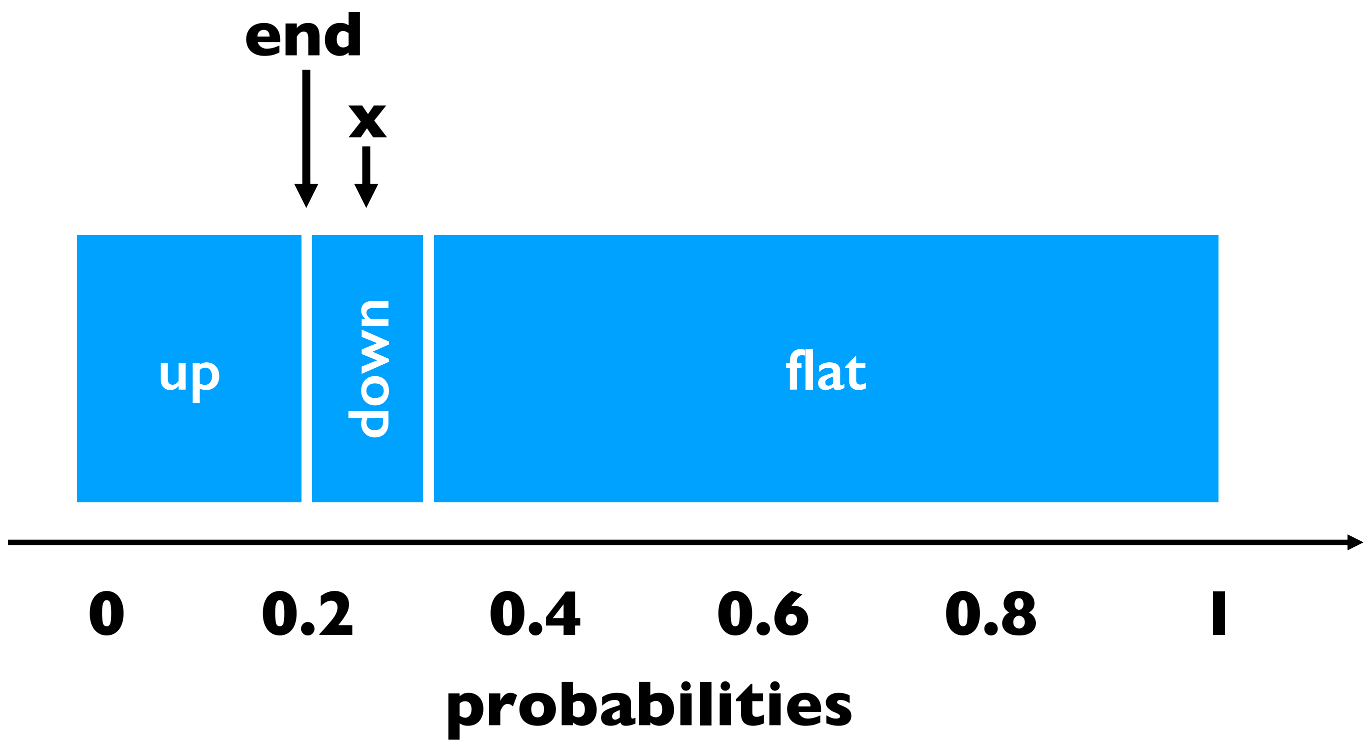
```
end = 0
keys = [“up”, “down”, “flat”]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```

key: up

end: 0.2

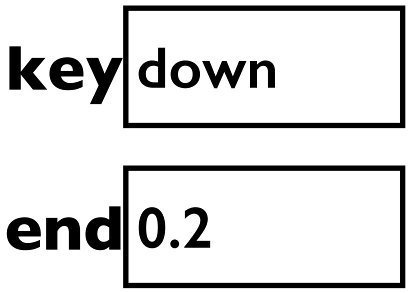
Weighted Random

```
transitions = {
    "up": 0.2,
    "down": 0.1,
    "flat": 0.7
}
```



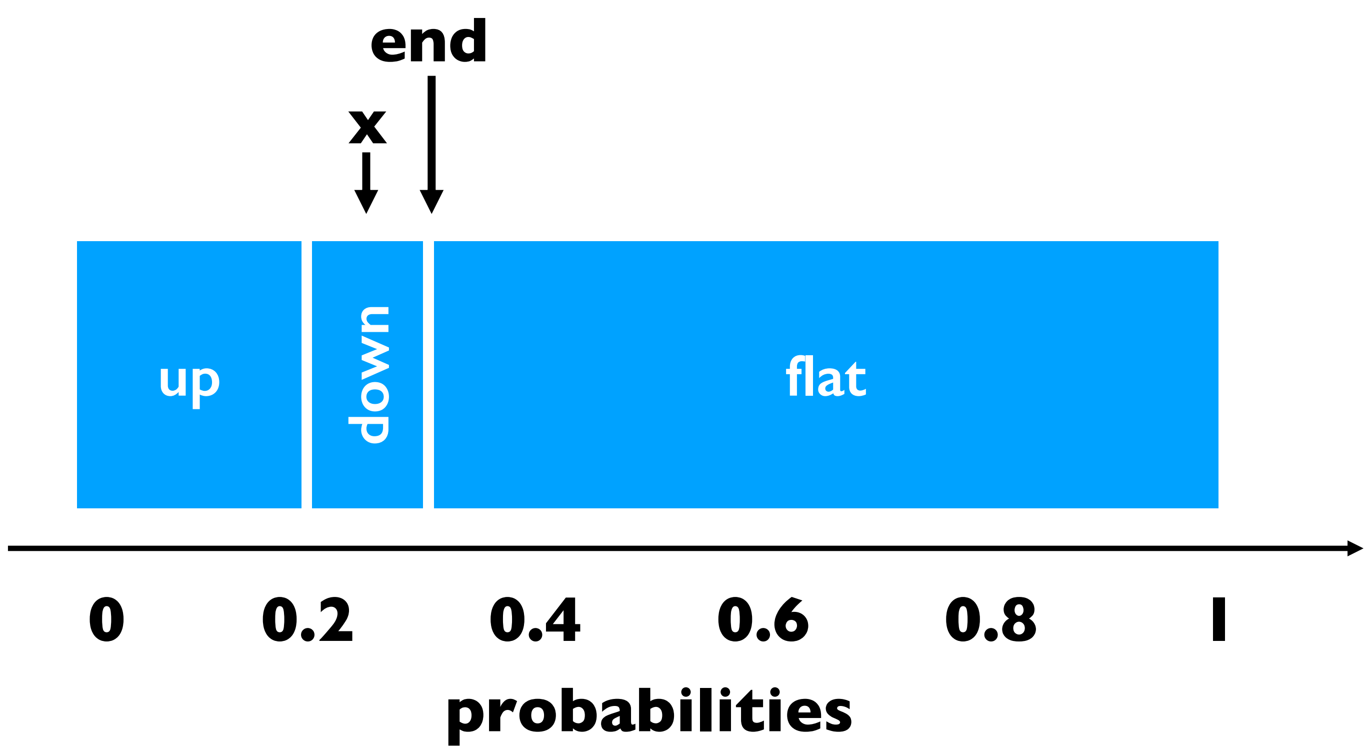

```
x = random.random()
# assume 0.25
```

```
end = 0
keys = ["up", "down", "flat"]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```



Weighted Random

```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}

x = random.random()
# assume 0.25

end = 0
keys = [“up”, “down”, “flat”]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```

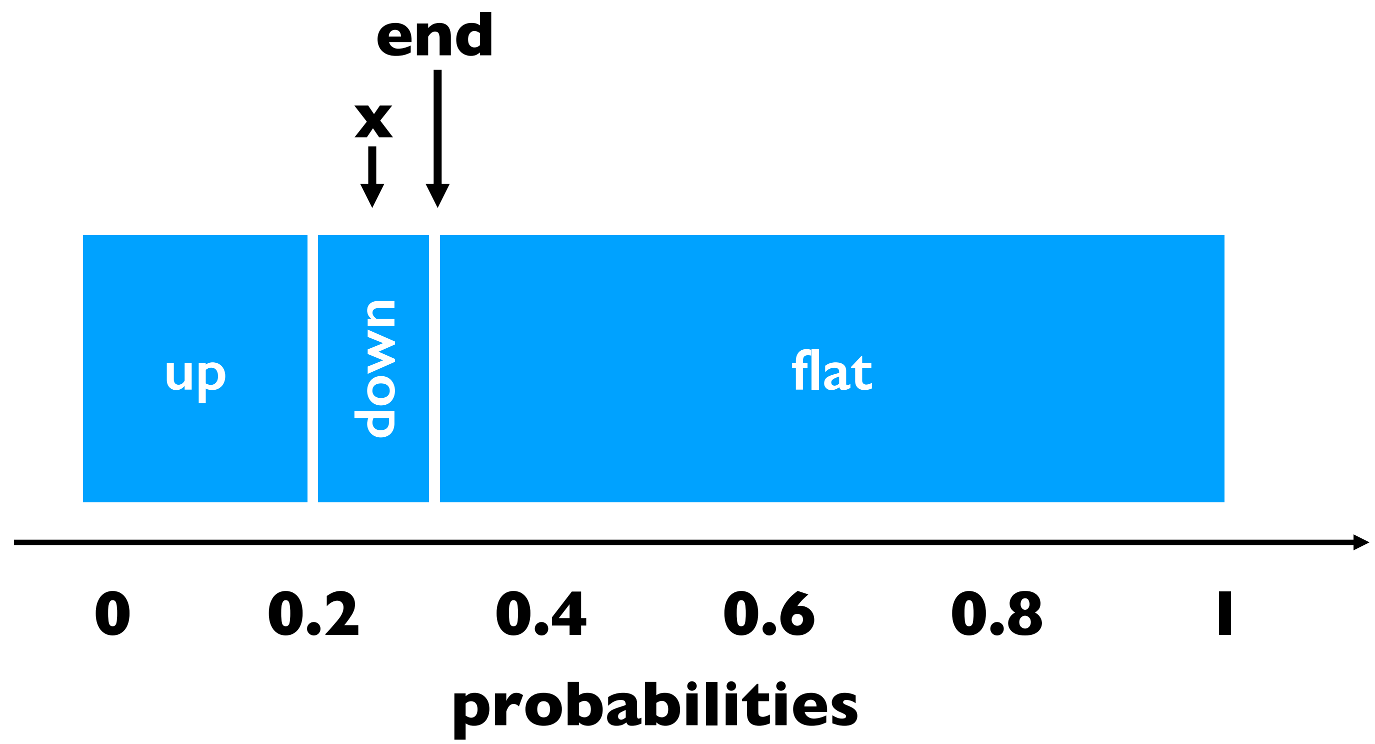


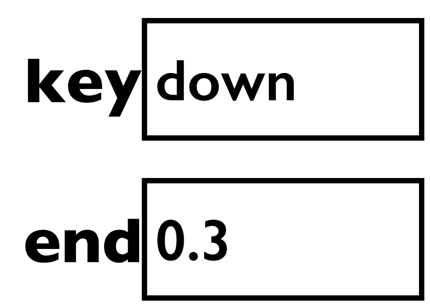
key: down

end: 0.3

Weighted Random

```
transitions = {
    “up”: 0.2,
    “down”: 0.1,
    “flat”: 0.7
}

x = random.random()
# assume 0.25

end = 0
keys = [“up”, “down”, “flat”]
winner = None
for key in keys:
    end += transitions[key]
    if end >= x:
        winner = key
        break
```





we randomly chose “down”