List comprehensions

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Three Ways to Define a List

• Explicitly write out the whole thing:
  
  squares = [0, 1, 4, 9, 16, 25, 36, 49, 64, 81, 100]

• Write a loop to create it:
  
  squares = []
  for i in range(11):
      squares.append(i * i)

• Write a list comprehension:
  
  squares = [i * i for i in range(11)]

• A list comprehension is a concise description of a list
• A list comprehension is shorthand for a loop
Two ways to convert Centigrade to Fahrenheit

ctemps = [17.1, 22.3, 18.4, 19.1]

With a loop:

ftemps = []
for c in ctemps:
    f = celsius_to_farenheit(c)
    ftemps.append(f)

With a list comprehension:

ftemps = [celsius_to_farenheit(c) for c in ctemps]

The comprehension is usually shorter, more readable, and more efficient
Syntax of a comprehension

```
[(x, y) for x in seq1 for y in seq2 if sim(x, y) > threshold]
```

- **expression**: something that can be iterated
- **for clause (required)**: assigns value to the variable x
- **zero or more additional for clauses**
- **zero or more if clauses**
result = [(x, y) for x in seq1 for y in seq2 if sim(x, y) > threshold]

result = []
for x in seq1:
    for y in seq2:
        if sim(x, y) > threshold:
            result.append((x, y))

... use result ...

Semantics of a comprehension
Types of comprehensions

List

\[ [i \times 2 \text{ for } i \text{ in } \text{range}(3)] \]

Set

\{i \times 2 \text{ for } i \text{ in } \text{range}(3) \}

Dictionary

\{ key: value \text{ for } item \text{ in } \text{sequence} ... \}
\{i: i \times 2 \text{ for } i \text{ in } \text{range}(3) \}
Cubes of the first 10 natural numbers

Goal:
    Produce: [0, 1, 8, 27, 64, 125, 216, 343, 512, 729]

With a loop:

cubes = []
for x in range(10):
    cubes.append(x ** 3)

With a list comprehension:

cubes = [x ** 3 for x in range(10)]
Powers of 2: ( $2^0$ through $2^{10}$ )

Goal: [1, 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024]

powers = [2 ** i for i in range(11)]
Lengths of elements of a list

Goal: Write a list comprehension that computes the length of each string in the list colors.

colors = ["red", "blue", "purple", "gold", "orange"]
lengths = [**your expression goes here**]

⇒ [3, 4, 6, 4, 6]
Even elements of a list

Goal: Given an input list \texttt{nums}, produce a list of the even numbers in \texttt{nums}

\texttt{nums} = [3, 1, 4, 1, 5, 9, 2, 6, 5]
\texttt{evens} = [**your expression goes here**]

⇒ [4, 2, 6]
Dictionary of squares

Goal: Given an input list nums, produce a dictionary that maps each number to the square of that number.

nums = [3, 1, 4, 5, 9, 2, 6, 7]
square_dict = {[**your expression goes here**]}
Normalize a list

num_list = [6, 4, 2, 8, 9, 10, 3, 2, 1, 3]
total = sum(num_list)

With a loop:

for i in range(len(num_list)):
    num_list[i] = num_list[i] / total

With a list comprehension:

num_list = [num / total for num in num_list]
**Dice Rolls**

**Goal:** A list of all possible dice rolls.

**With a loop:**
```python
rolls = []
for r1 in range(1, 7):
    for r2 in range(1, 7):
        rolls.append((r1, r2))
```

**With a list comprehension:**
```python
rolls = [(r1, r2) for r1 in range(1, 7) for r2 in range(1, 7)]
```
All above-average 2-die rolls

Goal: Result list should be a list of 2-tuples:
[(2, 6), (3, 5), (3, 6), (4, 4), (4, 5), (4, 6), (5, 3), (5, 4), (5, 5), (5, 6),
(6, 2), (6, 3), (6, 4), (6, 5), (6, 6)]

[(r1, r2) for r1 in range(1, 7)
    for r2 in range(1, 7)
    if r1 + r2 > 7]

OR

[(r1, r2) for r1 in range(1, 7)
    for r2 in range(8 - r1, 7)]
**Sum of above-average 2-die rolls**

**Goal:** Result list should be a list of integers:

\[
[\text{r}_1 + \text{r}_2 \text{ for } \text{r}_1 \text{ in range}(1, 7) \\
\text{    for } \text{r}_2 \text{ in range}(1, 7) \\
\text{    if } \text{r}_1 + \text{r}_2 > 7]
\]

\[\Rightarrow [8, 8, 9, 8, 9, 10, 8, 9, 10, 11, 8, 9, 10, 11, 12]\]

**Remove Duplicates: Use Set Comprehensions**

\[
\{\text{r}_1 + \text{r}_2 \text{ for } \text{r}_1 \text{ in range}(1, 7) \\
\text{    for } \text{r}_2 \text{ in range}(1, 7) \\
\text{    if } \text{r}_1 + \text{r}_2 > 7}\}
\]

\[\Rightarrow \{8, 9, 10, 11, 12\}\]
Making a Grid

Goal: A grid were each element is the sum of it's row # and column #.
(e.g. \([[0, 1, 2], [1, 2, 3]]\))

With a loop:

grid = []
for i in range(2):
    row = []
    for j in range(3):
        row.append(i + j)
    grid.append(row)

With a list comprehension:

grid = [[i + j for j in range(3)] for i in range(2)]
A word of caution

List comprehensions are great, but they can get confusing. Err on the side of readability.

```python
nums = [n for n in range(100) if 
    sum([int(j) for j in str(n)]) % 7 == 0]
```
or

```python
nums = []
for n in range(100):
    digit_sum = sum([int(j) for j in str(n)])
    if digit_sum % 7 == 0:
        nums.append(n)
```
A word of caution

List comprehensions are great, but they can get confusing. Err on the side of readability.

```python
nums = [n for n in range(100) if sum([int(j) for j in str(n)]) % 7 == 0]
```
or

```python
def sum_digits(n):
    digit_list = [int(i) for i in str(n)]
    return sum(digit_list)

ums = [n for n in range(100) if sum_digits(n) % 7 == 0]
```