1. List Comprehension in Python

List comprehension is a concise way to create lists in Python. It provides a more syntactically elegant way of writing loops that would normally generate lists.

Syntax:

```
[expression for item in iterable if condition]
```

- `expression`: The value or operation that will be added to the list.
- `item`: The current item from the iterable.
- `iterable`: An iterable like a list, tuple, or string.
- `condition`: Optional filter that decides whether or not to include the item in the list.

Example 1: Basic List Comprehension

```
# Create a list of squares of numbers
squares = [x ** 2 for x in range(10)]
print(squares)
```

Output:

```
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

Example 2: List Comprehension with a Condition

```
# Create a list of even squares
even_squares = [x ** 2 for x in range(10) if x % 2 == 0]
print(even_squares)
```

Output:

```
[0, 4, 16, 36, 64]
```

Example 3: Nested List Comprehension

```
# Create a 3x3 matrix using list comprehension
matrix = [[1, 2, 3], [4, 5, 6], [7, 8, 9]]
flattened = [element for row in matrix for element in row]
print(flattened)
```

Output:

```
[1, 2, 3, 4, 5, 6, 7, 8, 9]
```

2. Lambda (Anonymous) Functions in Python

A **lambda function** is a small, anonymous function defined using the `lambda` keyword. It is useful when you need a short function for a short period and don't want to define a full function using `def`.

Syntax:

```
lambda arguments: expression
```

- `arguments`: The parameters that the function takes (can be more than one).
- `expression`: A single expression that the function evaluates and returns.

Example 1: Basic Lambda Function

```
# A lambda function to add two numbers
add = lambda x, y: x + y
print(add(5, 3))  # Output: 8
```

Example 2: Lambda with `sorted` function

Lambda functions are commonly used with functions like `sorted()`, `filter()`, and `map()`.

```
# Sorting a list of tuples based on the second element
pairs = [(1, 2), (3, 1), (5, 0)]
pairs_sorted = sorted(pairs, key=lambda pair: pair[1])
print(pairs_sorted)
```

Output:

```
 [(5, 0), (3, 1), (1, 2)]
```

Example 3: Using `lambda` with `filter()`

```
# Filter even numbers using lambda
numbers = [1, 2, 3, 4, 5, 6, 7, 8, 9]
even_numbers = list(filter(lambda x: x % 2 == 0, numbers))
print(even_numbers)
```

Output:

```
 [2, 4, 6, 8]
```

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3. Python Iterators

An **iterator** in Python is an object that represents a stream of data; it produces the data one element at a time. An iterator must implement two methods:

1. `__iter__()` - Returns the iterator object itself. This is required to use the object in a loop.
2. `__next__()` - Returns the next item from the collection. When there are no more items, it raises the `StopIteration` exception.

Example 1: Creating an Iterator Class

```
class Counter:
    def __init__(self, low, high):
        self.current = low
        self.high = high

    def __iter__(self):
        return self

    def __next__(self):
        if self.current > self.high:
            raise StopIteration
        else:
            self.current += 1
            return self.current - 1

# Using the iterator
counter = Counter(1, 5)
for num in counter:
    print(num)
```

Output:

```
1
2
3
4
5
```

Example 2: Using Built-in Iterator (List)

```
# Iterating through a list using an iterator
numbers = [10, 20, 30]
iterator = iter(numbers)
print(next(iterator))  # Output: 10
print(next(iterator))  # Output: 20
print(next(iterator))  # Output: 30
```

If you call `next()` after exhausting the iterator, it will raise a `StopIteration` exception.

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4. Python Generators

A **generator** is a type of iterable that generates items on the fly. It's implemented using a function with the `yield` keyword, rather than returning all items at once. When `yield` is called, it pauses the function and returns a value, but it remembers the state of the function and continues where it left off when the generator is called again.

Syntax:

```
def generator_function():
    yield value
```

Example 1: Simple Generator Function

```
def count_up_to(max):
    count = 1
    while count <= max:
        yield count
        count += 1

# Using the generator
counter = count_up_to(3)
for number in counter:
    print(number)
```

Output:

```
1
2
3
```

Example 2: Generator for Fibonacci Numbers

```
def fibonacci(n):
    a, b = 0, 1
    for _ in range(n):
        yield a
        a, b = b, a + b

# Using the generator
fib = fibonacci(5)
for num in fib:
    print(num)
```

Output:

```
0
1
1
2
3
```

Example 3: Generator Expression (Similar to List Comprehension)

```
# Generator expression to create a sequence of squares
squares_gen = (x ** 2 for x in range(10))
for square in squares_gen:
    print(square)
```

Output:

```
0
1
4
9
16
25
36
49
64
81
```

Key Differences between Iterators and Generators

Feature	**Iterators**	**Generators**
Definition	Objects that implement `__iter__` and `__next__` methods.	Functions that use `yield` to return values one at a time.
Memory	An iterator can store all its elements in memory.	A generator produces items one by one and doesn't store them.
Performance	Slower if elements are large and numerous.	More memory-efficient because they yield items one by one.
Creation	Created using classes or `iter()` on an object.	Created using a function with `yield` or generator expressions.

Conclusion

- **List Comprehension**: Provides a concise way to create lists, with optional conditions and expressions.
- **Lambda Functions**: Anonymous, small functions used for short-term use, typically with higher-order functions.
- **Iterators**: Objects that iterate over a sequence, implementing `__iter__()` and `__next__()` methods.
- **Generators**: Functions that generate items on the fly using `yield`, offering efficient memory usage for large datasets.