Control structures direct the flow of logic in a program. For example, conditionals (if-elif-else) allow a program to skip sections of code, while iteration (while), allows a program to repeat a section.

1.1 If statements

Conditional statements let programs execute different lines of code depending on certain conditions. Let’s review the if-elif-else syntax:

\[
\begin{align*}
\text{if} & \ <\text{conditional expression}>: \\
& \quad <\text{suite of statements}> \\
\text{elif} & \ <\text{conditional expression}>: \\
& \quad <\text{suite of statements}> \\
\text{else} & : \\
& \quad <\text{suite of statements}>
\end{align*}
\]

Recall the following points:

- The else and elif clauses are optional, and you can have any number of elif clauses.

- A conditional expression is a expression that evaluates to either a true value (True, a non-zero integer, etc.) or a false value (False, 0, None, ".", [], etc.).

- Only the suite that is indented under the first if/elif with a conditional expression evaluating to a true value will be executed.
• If none of the conditional expressions evaluate to a true value, then the else suite is executed. There can only be one else clause in a conditional statement!

1.2 Boolean Operators

Python also includes the boolean operators and, or, and not. These operators are used to combine and manipulate boolean values.

• `not` returns the opposite truth value of the following expression.

• `and` stops evaluating any more expressions (short-circuits) once it reaches the first false value and returns it. If all values evaluate to a true value, the last value is returned.

• `or` short-circuits at the first true value and returns it. If all values evaluate to a false value, the last value is returned.

```python
>>> not None
True
>>> not True
False
>>> -1 and 0 and 1
0
>>> False or 9999 or 1/0
9999
```

1.3 Questions

1. Alfonso will only wear a jacket outside if it is below 60 degrees or it is raining. Fill in the function `wears_jacket` which takes in the current temperature and a Boolean value telling if it is raining and returns True if Alfonso will wear a jacket and False otherwise.

This should only take one line of code!

```python
def wears_jacket(temp, raining):
    ""
    >>> rain = False
    >>> wears_jacket(90, rain)
    False
    >>> wears_jacket(40, rain)
    True
    >>> wears_jacket(100, True)
    True
    """
```
2. To handle discussion section overflow, TAs may direct students to a more empty section that is happening at the same time. Write the function handle_overflow, which takes in the number of students at two sections and prints out what to do if either section exceeds 30 students. Note: Don’t worry about printing “spot” for singular values and “spots” for multiple values.

```python
def handle_overflow(s1, s2):
    """
    >>> handle_overflow(27, 15)
    No overflow.
    >>> handle_overflow(35, 29)
    1 spot left in Section 2.
    >>> handle_overflow(20, 32)
    10 spots left in Section 1.
    >>> handle_overflow(35, 30)
    No space left in either section.
    """
```

1.4 While loops

Iteration lets a program repeat statements multiple times. A common iterative block of code is the **while loop**:

```python
while <conditional clause>:
    <body of statements>
```

As long as <conditional clause> evaluates to a true value, <body of statements> will continue to be executed. The conditional clause gets evaluated each time the body finishes executing.
1.5 Questions

1. What is the result of evaluating the following code?

```python
def square(x):
    return x * x

def so_slow(num):
    x = num
    while x > 0:
        x = x + 1
    return x / 0

square(so_slow(5))
```

2. Fill in the `is_prime` function, which returns `True` if `n` is a prime number and `False` otherwise. After you have a working solution, think about potential ways to make your solution more efficient.

**Hint:** use the `%` operator: `x % y` returns the remainder of `x` when divided by `y`.

```python
def is_prime(n):
```
2 Environment Diagrams

An environment diagram keeps track of all the variables that have been defined and the values they are bound to.

\[ x = 3 \]

```python
def square(x):
    return x ** 2
```

\[ \text{square}(2) \]

When you execute assignment statements in an environment diagram (like \( x = 3 \)), you need to record the variable name and the value:

1. Evaluate the expression on the right side of the = sign
2. Write the variable name and the expression's value in the current frame.

When you execute `def` statements, you need to record the function name and bind the function object to the name.

1. Write the function name (e.g., `square`) in the frame and point it to a function object (e.g., `func square(x) [parent=Global]`). The `[parent=Global]` denotes the frame in which the function was defined.

When you execute a call expression (like `square(2)`), you need to create a new frame to keep track of local variables.

1. Draw a new frame. Label it with
   
   • a unique index (f1, f2, f3 and so on)
   • the intrinsic name of the function (square), which is the name of the function object itself. For example, if the function object is `func square(x) [parent=Global]`, the intrinsic name is `square`.
   • the parent frame ([parent=Global])
2. Bind the formal parameters to the arguments passed in (e.g. bind \( x \) to 3).
3. Evaluate the body of the function.

If a function does not have a return value, it implicitly returns `None`. Thus, the “Return value” box should contain `None`.

---

\(^a\)Since we do not know how built-in functions like `add(...)` or `min(...)` are implemented, we do not draw a new frame when we call built-in functions.
1. Draw the environment diagram that results from running the following code.
   
   ```python
   a = 1
   def b(b):
       return a + b
   a = b(a)
   a = b(a)
   ```
2. Draw the environment diagram so we can visualize exactly how Python evaluates the
code. What is the output of running this code in the interpreter?

```python
>>> from operator import add
>>> def sub(a, b):
...     sub = add
...     return a - b
>>> add = sub
>>> sub = min
>>> print(add(2, sub(2, 3)))
```
3 Higher Order Functions

A higher order function (HOF) is a function that manipulates other functions by taking in functions as arguments, returning a function, or both.

3.1 Functions as Arguments

One way a higher order function can manipulate other functions is by taking functions as input (an argument). Consider this higher order function called negate.

```python
def negate(f, x):
    return -f(x)
```

negate takes in a function \( f \) and a number \( x \). It doesn’t care what exactly \( f \) does, as long as \( f \) is a function, takes in a number and returns a number. Its job is simple: call \( f \) on \( x \) and return the negation of that value.

3.2 Questions

1. Implement a function `keep_ints`, which takes in a function `cond` and a number \( n \), and only prints a number from 1 to \( n \) if calling `cond` on that number returns `True`:

```python
def keep_ints(cond, n):
    """Print out all integers 1..i..n where cond(i) is true""

    >>> def is_even(x):
    ...     # Even numbers have remainder 0 when divided by 2.
    ...     return x % 2 == 0
    >>> keep_ints(is_even, 5)
    2
    4
    """
```
3.3 Functions as Return Values

Often, we will need to write a function that returns another function. One way to do this is to define a function inside of a function:

```python
def outer(x):
    def inner(y):
        ...
    return inner
```

The return value of `outer` is the function `inner`. This is a case of a function returning a function. In this example, `inner` is defined inside of `outer`. Although this is a common pattern, we can also define `inner` outside of `outer` and still use the same `return` statement. However, note that in this second example (unlike the first example), `inner` doesn't have access to variables defined within the `outer` function, like `x`.

```python
def inner(y):
    ...

def outer(x):
    ...
    return inner
```

3.4 Questions

1. Use this definition of `outer` to fill in what Python would display when the following lines are evaluated.

```python
def outer(n):
    def inner(m):
        return n - m
    return inner

>>> outer(61)

>>> f = outer(10)

>>> f(4)

>>> outer(5)(4)
```
2. Implement a function `keep_ints` like before, but now it takes in a number `n` and returns a function that has one parameter `cond`. The returned function prints out all numbers from 1..i..n where calling `cond(i)` returns True.

```python
def keep_ints(n):
    """Returns a function which takes one parameter cond and prints out all integers 1..i..n where calling cond(i) returns True."
    >>>
    def is_even(x):
        ...    # Even numbers have remainder 0 when divided by 2.
        ...    return x % 2 == 0
    >>> keep_ints(5)(is_even)
    2
    4
    """
```