Control Structures: if, while, for

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CMPT140
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Outline for today

- Formatted output
- abs(), +=, string.capitalize()
- Qualified import
- Selection: if, if..else.., if..elif..else
- Loops: while
- Sentinel variables
- Loop counters
- Using mathematical closed forms instead of loops
- For loops

Formatted output: print with %

- The built-in print can accept a format string:
  - **print "You have %d apples." % 7**
    - **→ "You have 7 apples."**
  - It can take a list of arguments:
    - **print "%d apples and %d oranges." % (7, 10)**
      - **→ "7 apples and 10 oranges."**
  - Format codes:
    - %d: integer
    - %f: float
    - %s: string

Formatting: %d, %f

- You can specify the field width:
- **print "%3d apples" % 5**
  - **" 5 apples" (note two leading spaces)**
- **print "%-3d apples" % 5**
  - **"5 apples" (left-aligned: two trailing spc)**
- **print "%03d apples" % 5**
  - **"005 apples" (padded with zeros)**
- **print "%4.1f apples" % 5.273**
  - **" 5.3 apples": 4 is the total field width, including the decimal**
  - **1 is the number of digits after the decimal**

String concat, repetition

- The plus operator (+) is overloaded to work with strings: concatenation
  - "Hello" + "World!" → "HelloWorld!"
  - Overloading is when one operator or function can do different things depending on the type of its arguments:
    - 2 + 3 → integer addition
    - 2 + 3.0 → float addition
    - "A" + "B" → string concatenation
- Python also has string repetition:
  - "Hi!" * 3 → "Hi!Hi!Hi!"

String concatenation vs. print

- print converts each of its arguments to a string, and puts spaces between them:
  - **print “Hello”, “dear”, “World!”**
    - **→ Hello dear World!**
- String concatenation doesn't insert spaces:
  - **print “Hello” + “dear” + “World!”**
    - **→ HellodearWorld!**

A few misc nifty tricks

- Absolute value built-in: abs(-5.0) → 5.0
- Increment/decrement, etc:
  - count += 1 # count = count + 1
  - numApples *= 2 # nA = nA * 2
  - No builtin "++" operator as in C++/Java
- Turn strings into all-caps:
  - import string
  - string.upper("Hello") # "HELLO"

Qualified import

- The usual way to import a library:

```
import string
string.capitalize("Hello!")
```

- Import individual functions from a library:

```
from string import capitalize
capitalize("Hello!")
```

- Or import an entire library (don't do this):

```
from string import *
capitalize("Hello!")
```

- We'll learn later about namespaces

Program Structure

- Five basic program structure/flow abstractions:
  - Sequence (newline)
  - Selection (if ... elif ... else)
  - Repetition/loops (while, for)
  - Composition (subroutines)
  - Parallelism
- Today covers the first three program structure abstractions

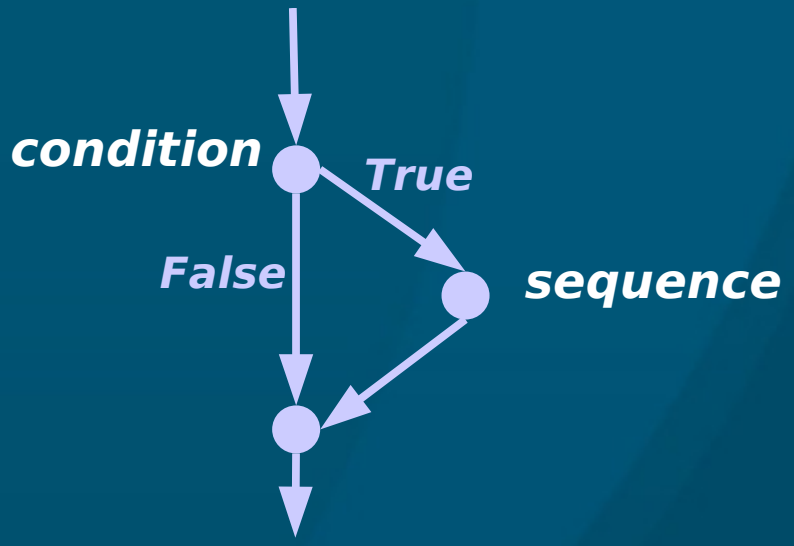
Statement sequences

- A sequence of statements is executed in order:
  - Successive statements are not executed until the preceding statement is completed

```
print “Running really_slow_function() ...”
really_slow_function()
print “done!”
```

- Separate statements are on separate lines
  - Whitespace and newlines matter in Python
  - In most other languages, semicolon (;) separates statements, and newlines don't matter

Simple selection: if



if *condition* :

statement sequence

- Indentation (tab) indicates what's part of the statement sequence
- Condition is a Boolean expression evaluating to either True or False
- Conditional execution: if condition evaluates to False, then the statement sequence is skipped over and not executed

Example: if

```
if numApples > 12:
        print “Okay, that's waay too many apples!”
print “Let's eat some apples!”
```

- Observe indentation (it matters in Python!)
- Parentheses () not needed around condition
  - But if condition is complex, parentheses may be useful to clarify precedence:
  - **if (numApples > 5) and (numApples < 12)**

Branching: if ... else ...

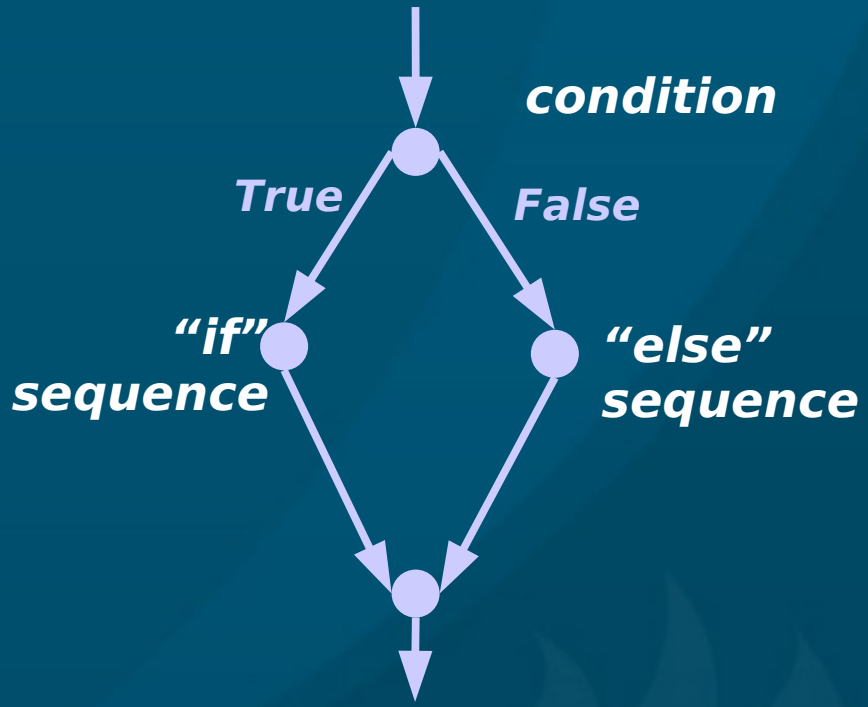
if *condition* :

statement sequence

else :

statement sequence

- Only one of the two statement sequences is executed



Example: if ... else ...

```
if numFriends > 0:
        applesPerFriend = numApples / numFriends
else:
        print “Awww, you need some friends!”
```

- Would the division work if numFriends == 0?
- Will this code generate an error if numFriends == 0?

Branching: if ... elif ... else ...

if *condition* :

    statement sequence

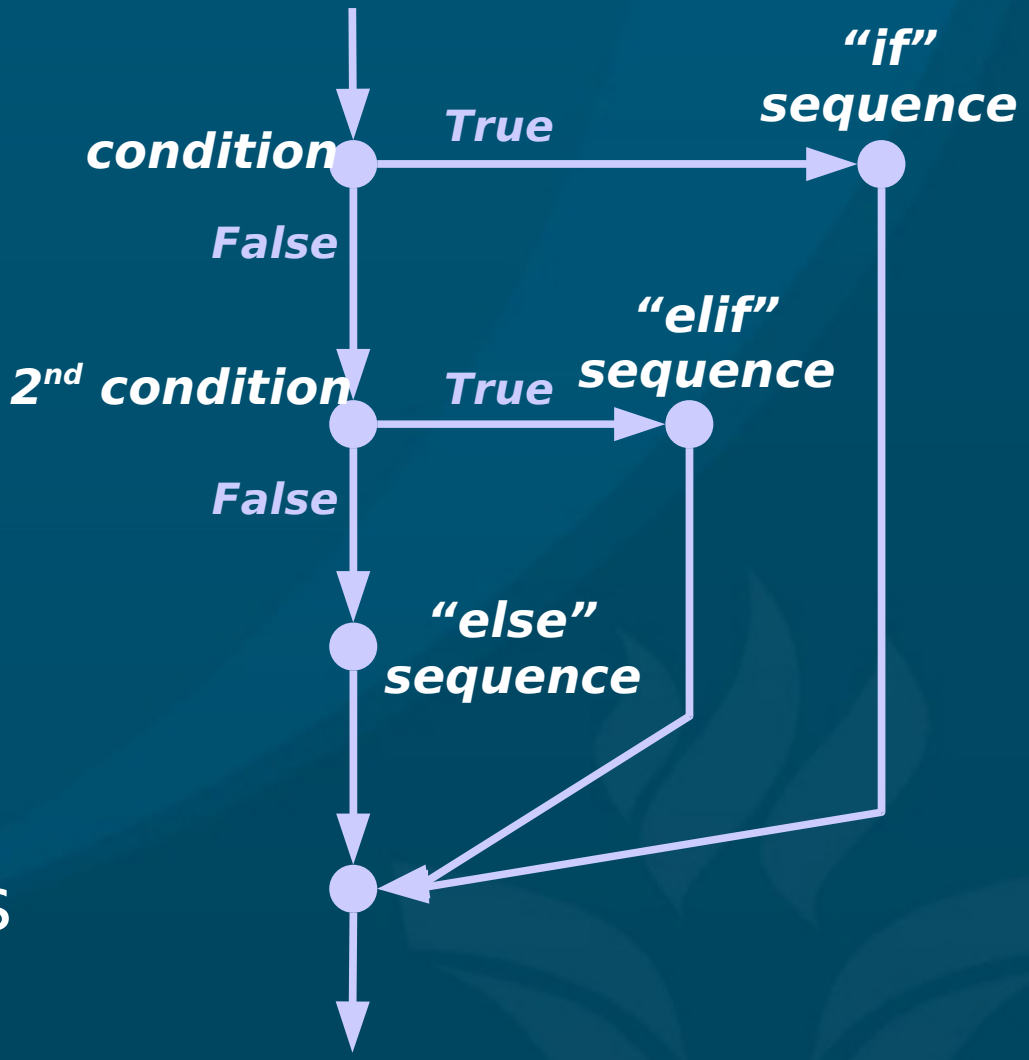
elif 2nd condition :

    statement sequence

else :

    statement sequence

- Only one of the statement sequences is executed



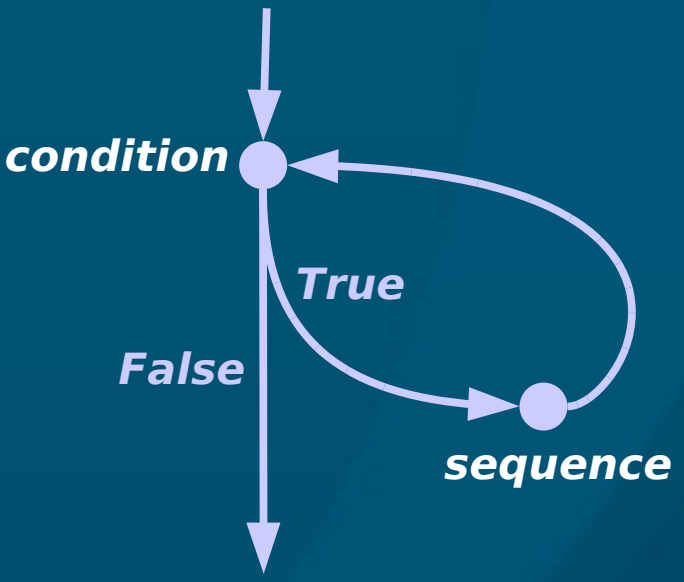
Example: if ... elif ... else ...

```
if numFriends <= 0:
        print “Awww, you need some friends!”
elif numFriends > 30:
        print “Wow, that's a lot of friends!”
else:
        applesPerFriend = numApples / numFriends
```

while loops

while *condition :*

statement sequence



- As with “if”, *condition* is a Boolean expression:
  - Evaluated once before entering the loop,
  - Re-evaluated each time through the loop:
    - Top-of-loop testing
- *Statement sequence* is run only if *condition* evaluates to True

Sentinel variables

- A sentinel variable controls whether a loop continues: the loop only exits when the sentinel variable has a certain value

```
answer = 0
while answer != 4:
    answer = input("Math quiz: 2 + 2 = ")
```

  - Sentinel variable is answer
  - Sentinel value is 4

Counting loops

- A common form of loop uses a counter:

```
counter = 1
while counter <= max:
    sum = sum + counter
    counter = counter + 1
```

- What if we need to prematurely exit this loop?

```
counter = 1
while counter <= max:
    if need_to_exit_early():
        counter = max + 1
    ...
```

Closed forms instead of loops

- Sometimes with a bit of thought we can replace a loop with a single mathematical equation
  - "Work smarter, not harder"
- Example: Add the first *n* integers >0

```
sum = 0
counter = 1
while counter <= n:
    sum = sum + counter
    counter = counter + 1
print "Sum is %d." % sum
```

Closed form solution

- But observe the pattern:
  - 1 + 2 + 3 + ... + (n-2) + (n-1) + n

- Each pair makes n+1; there are n/2 pairs:
- Closed form solution:

  sum = n * (n+1) / 2

- (If n is type int, does the / cause problems?)

while loops: continue

- You can prematurely go to the next iteration of a while loop by using continue:
  - **counter = 0**
  - **while counter < 5:**
    - **counter += 1**
    - **if counter == 3:**
      - **continue**
    - **print counter,**
- Output:
  - **1 2 4 5**

while loops: break

- You can quit a while loop early by using break:

```
counter = 0
while counter < 5:
    counter += 1
    if counter == 3:
        break
    print counter,
```

- Output:

```
1 2
```

while loops: else

- The optional else clause of a while loop is executed when the loop condition is False:
  - **counter = 0**
  - **while counter < 5:**
    - **counter += 1**
    - **print counter,**
  - **else:**
    - **print “Loop is done!”**
- Output:
  - **1 2 3 4 5 Loop is done!**

while loops: break skips else

- If the loop is exited via break, the else clause is not performed:

```
counter = 0
while counter < 5:
    counter += 1
    if counter == 3:
        break
    print counter,
else:
    print "Loop is done!"
```

- Output: 1 2

Common errors with loops

- Print squares from 1^2 up to 10^2:
  - **counter = 0**
  - **while counter < 10:**
    - **print counter*counter,**
- What's wrong with this loop?
  - counter is never incremented!
- → Always make sure progress is being made in the loop!

Common errors with loops

- Count from 1 up to 10 by twos:
  - **counter = 1**
  - **while counter != 10:**
    - **print counter,**
    - **counter += 2**
- What's wrong with this loop? How to fix it?
  - **counter = 1**
  - **while counter < 10:**
    - **print counter,**
    - **counter += 2**

Common errors with loops

- Count from 1.1 up to 2.0 in increments of 0.1:
  - **counter = 1.1**
  - **while counter != 2.0:**
    - **print counter,**
    - **counter += 0.1**
- Seems like it should work, but it might not due to inaccuracies in floating-point arithmetic
  - **counter = 1.1**
  - **while counter < 2.0:**
    - **print counter,**
    - **counter += 0.1**

for loops

- Many loops do counting: the for loop is an easy construct that prevents many of these errors
- Syntax:
  - **for *target* in *expression list* :**
    - ***Statement sequence***
- Example:
  - **for counter in (0, 1, 2, 3, 4):**
    - **print counter,**
  - Output: **0 1 2 3 4**
- for loops can also take an else sequence, like while loops

range()

- The built-in function range() produces a list suitable for use in a for loop:
  - **range(10)** → **[0, 1, 2, 3, 4, 5, 6, 7, 8, 9]**
  - Note 0-based, and omits end of range
- Specify starting value:
  - **range(1, 10)** → **[1, 2, 3, 4, 5, 6, 7, 8, 9]**
- Specify increment:
  - **range(10, 0, -2)** → **[10, 8, 6, 4, 2]**

- *Technically, range() returns a list (mutable), rather than a tuple (immutable). More on this later.*

for loop examples

- Print squares from 1^2 up to 10^2:
  - **for counter in range(1, 11):**
    - **print counter * counter,**
- for loops can iterate over other lists:
  - **for appleVariety in (“Fuji”, “Braeburn”, “Gala”):**
    - **print “I like”, appleVariety, “apples!”**

- *Technically, the for loop uses an iterator to get the next item to loop over. Iterators are beyond the scope of CMPT140.*

TODO

- Lab1 due Wed/Thu!
  - 10pm upload to myCourses
  - #40: don't need looping; just run for 3 purchases
- Read ch3
- HW2 posted, due next Mon (ch2,3)
- Lab2 posted, due next week Wed/Thu
  - Uses selection(if) and/or looping
  - Short writeup ok