Warmup (L4)

- Write a function `checkWithin(result, expected, tolerance, name)` that generalizes our assert-based tolerance checking
  - (That is, it **`assert`**s that `result` is within the `tolerance` of `expected`, with `name` as the name/message for the assertion)
- Note: Don't use this in your submissions; MarkUs won't detect the separate tests ☺

CS114

L4 (M2)

Making decisions

CS114 L4 (M2)

Assertions

- Remember “==” and “<” from our assertions?
- What do they actually do?

```
print(hypotenuse(4, 5) < 7)
True
```

Conditionals

- `hypotenuse(4, 5) < 7` is simply a fact: it is true
- We can *conditionalize code* based on facts
  - That is, rather than just asserting that something is true as a test, we check if it's true, then choose what to do next

Why?

- Remember:
  computation =
    calculation +
    repetition +
    decision making
- We did calculation in Module 1
- Conditions will give us *decision making*

Decision making

```
def pos(x: float) -> float:
    """
    If x is not zero, return the absolute value of x.
    Otherwise, return 1.
    """
    if x < 0:
        return -x
    elif x == 0:
        return 1
    else:
        return x

assert pos(42) == 42,
assert pos(-42) == 42,
assert pos(0) == 1, "Special case pos(0) is 1."
```

This code only runs if x < 0

This code only runs if x == 0

(`elif` means “else if”)

This code only runs if x > 0

That condition is implicit: it only runs if neither previous case matched.

Decision making

```
def pos(x: float) -> float:
    """
    If x is not zero, return the absolute value of x.
    Otherwise, return 1.
    """
    if x < 0:
        return -x
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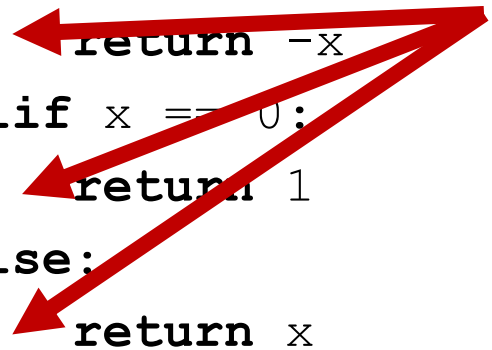
    else:
        return x
```



Indenting again to show what happens conditionally and what doesn't

```
assert pos(42) == 42, "Absolute value of positive is positive."
assert pos(-42) == 42, "Absolute value of negative is positive."
assert pos(0) == 1, "Special case pos(0) is 1."
```

Decision making

```
def clamp(x: float, minVal: float, maxVal: float) -> float:
    """
    If x is between minVal and maxVal, return x. Otherwise return minVal
    if x is below the range, or maxVal if it's above the range.
    """
    assert minVal <= maxVal, "minVal cannot be greater than maxVal"
    if x < minVal:
        return minVal
    if x > maxVal:
        return maxVal
    return x

assert clamp(-12, 0, 10) == 0, "Minimum value works (0)"
assert clamp(12, -15, -3) == -3, "Maximum value works (negative)"
assert clamp(4, -10, 10) == 4, "In-range value works (across 0)"
# ... more tests ...
```

Decision making

```
def clamp(x: float, minVal: float, maxVal: float) -> float:
    """
    If x is between minVal and maxVal, return x. Otherwise return minVal
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```

We write <= for ≤ and >= for ≥

Decision making

```
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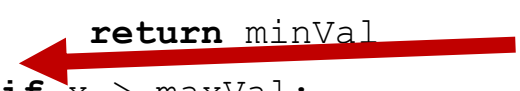

else/elif are not required

Still imperative

- Anything indented under **`if`** is executed conditionally
- Anything after **`if`** (unindented) is executed *unconditionally*. It's simply run in order.
  - Except for *early return*
- Let's add some `print`s to our `clamp` function in Jupyter to understand what is and isn't run

Decision making

```
def clamp(x: float, minVal: float, maxVal: float) -> float:
    """
    If x is between minVal and maxVal, return x. Otherwise return minVal
    if x is below the range, or maxVal if it's above the range.
    """
    assert minVal <= maxVal, "minVal cannot be greater than maxVal"
    if x < minVal:
        x = minVal
    if x > maxVal:
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    return x

assert clamp(-12, 0, 10) == 0, "Minimum value works (0)"
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# ... more tests ...
```

Variable naming aside

- I told you to use descriptive names, but I just named my parameter "`x`"
- Names are for what the variable means *to the function*, not to whoever calls the function
- In the case of `clamp`, `x` means nothing to us, so `x` is as good as any other name.

In-lecture quiz (L4)

- https://student.cs.uwaterloo.ca/~cs114/F25/quiz/
- Q1: Which of these Python function definitions is valid?
  -
```
def return(x: int) -> int:                    # A
    return x
```
  -
```
def roundBadly(x: float) -> int:              # B
    if x < 0:
        return int(x) - 1
    return int(x)
```
  -
```
def greater(x: float, y: float) -> float:     # C
    if x > y:
    return x
    return y
```
  -
```
void iGotLost(const std::string &user) {      # D
    cout << "Aren't you glad you're learning "
            "Python instead of C++?" <<std::endl;
}
```

In-lecture quiz (L4)

- https://student.cs.uwaterloo.ca/~cs114/F25/quiz/
- Q2: What will this code print?

```
def f(x: int) -> None:
    if x > 5:
        print("Big")
    print("Small")
f(42)
```

  - Big **A**
  - Small **B**
  - Big
Small **C**
  - Nothing **D**

Boolean logic

CS114 L4 (M2)

Booleans

- `True` and `False` are *values*
- Although it's weird, you can, e.g., store it in a variable:

```
x = hypotenuse(4, 5) < 7
```

- Just as `True` is a value, so is `False`:

```
print(hypotenuse(4, 5) > 7)
False
```

Booleans

- These are called *boolean values*, named for logician George Boole
  - For the type checker, "`bool`"
- Math with booleans is called *boolean logic*
- We get booleans with our comparators:

`==`, `!=`, `<`, `<=`, `>`, `>=`

!= for ≠ (not equal to)

Multiple conditions

- You can nest conditions

```
if x >= minVal:
    if x <= maxVal:
        return x
    else:
        return maxVal
else:
    return minVal
```

- Let's add some `print`s to understand this

Multiple conditions

- There are also operators to combine conditions:

```
if x >= minVal and x <= maxVal:
    return x
elif x < minVal:
    return minVal
else: # x > maxVal
    return maxVal
```

It's sometimes useful to comment an else to make it clear when it happens.

- **and** for both, **or** for either

Nesting vs. combining

- When you put an **`if`** inside of another **`if`**, that's called *nesting conditionals*
- Sometimes it's unavoidable (or would be ugly to avoid)
  - In particular, when you need to nest a condition *and* do something else
- When you can avoid it, you usually should. It results in *pyramids of doom* (code so nested that it gets indented so far that it's annoying to read)

A note on or

- In common use, "`or`" can be ambiguous
  - If CS114 is my favorite class *or* I fail it, I'll remember it well.
  - What if CS114 is your favorite class *and* you fail it?
- In CS, "`or`" always means "and/or", so, e.g., "`1 == 1 or 2 == 2`" is true.

Complex combos

- You can also invert a condition with not, and group things with parentheses just like in numerical math

```
if not (x < minVal or x > maxVal):
    return x
elif x < minVal:
    return minVal
else: # x > maxVal
    return maxVal
```

Mind your precedence

- BEDMAS is now BEDMASCN&O

  (pronounced bed-masc-nando)

  - Brackets/parentheses, exponents, division and multiplication, addition and subtraction, …
  - Conditionals (`==`, `!=`, `<`, `<=`, `>`, `>=`)
  - **`not`**
  - **`and`**
  - **`or`**

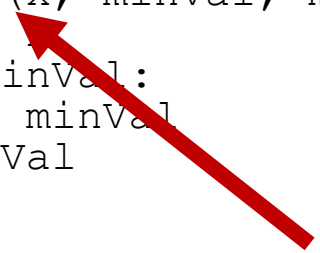
Mind your precedence

- Confused?
- When in doubt, just use parentheses to make it clear
- Don’t double up (e.g., `((a<b))`). Otherwise, it’s never bad style.
  - (Using parentheses around `assert` isn’t bad style, it’s just incorrect.)

Booleans are *values*

- Here's a new version of clamp:

```
def clamp(x: float, minVal: float, maxVal: float) -> float:
    """
    If x is between minVal and maxVal, return x. Otherwise
    return minVal if x is below the range, or maxVal if it's
    above the range.
    """
    if inRange(x, minVal, maxVal):
        return x
    elif x < minVal:
        return minVal
    return maxVal
```



There's no comparison here (at least, not directly!). We got a `bool` because that's what `inRange` returned!

- Let's write `inRange` to work with it.

Booleans are *values*

- Here's a new version of clamp:

```
def clamp(x: float, minVal: float, maxVal: float) -> float:
    """
    If x is between minVal and maxVal, return x. Otherwise
    return minVal if x is below the range, or maxVal if it's
    above the range.
    """
    if inRange(x, minVal, maxVal):
        return x
    elif x < minVal:
        return minVal
    return maxVal
```

Making the `x > maxVal` condition totally implicit is poor style, because it's unclear. I did it here just to show an `elif` without an `else`.

- Let's write `inRange` to work with it.

The power of abstraction

CS114 L4 (M2)

Nonobvious conditions

- Let's write a function `isEven` to check if an integer is even.
- None of our comparators look like "is even" or "divisible by"...
- New operator! `%`
  - Remainder after division, e.g., `5%2==1`
  - Called "modulo"

Modulo and quotient

- In math, remainder after division is usually paired with *quotient* to keep division in integers
- We can do the same to keep division in `int`s.
- Quotient is `//` (two slashes)

Modulo

- Wait, remainder after division still isn't "is even" or "divisible by"…
- A number is even if it's divisible by 2…
- A number is divisible by *y* if the remainder after division by *y* is 0…
- So, we can use ==: `x%y==0`

isEven

- With modulo in mind, let's write our `isEven` function.

```
def isEven(v: int) -> bool:
    """
    Returns True if v is even,
    False otherwise.
    """
    return v%2==0
```