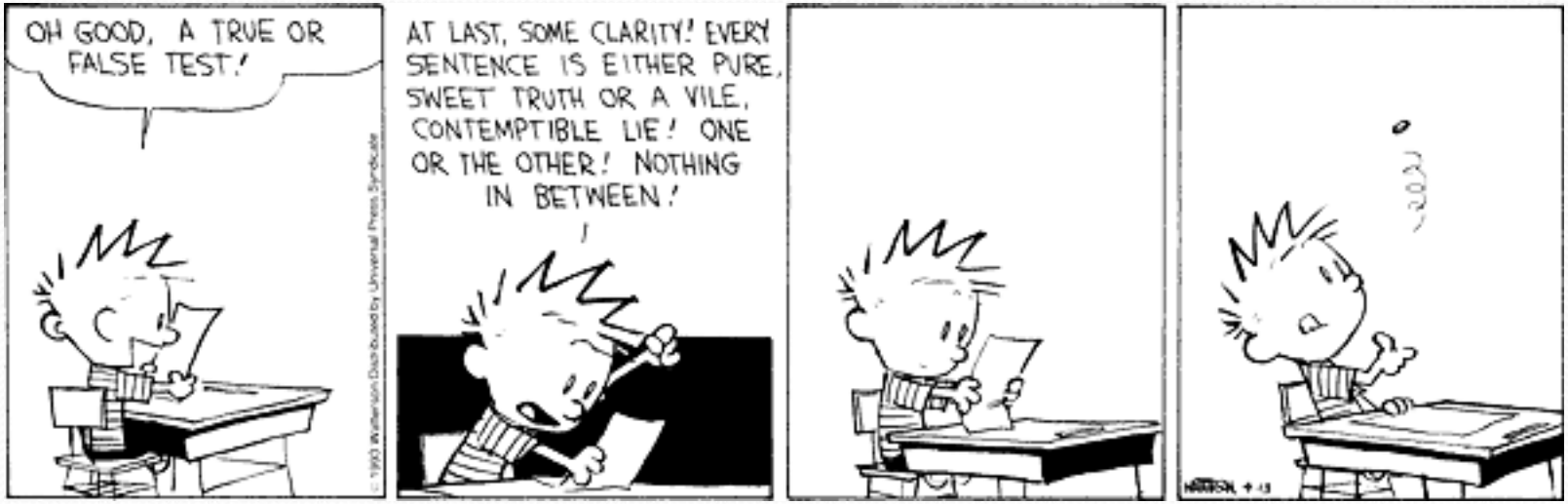
CS 115, Autumn 2021

Lecture 13: `if` / `else` and Boolean logic

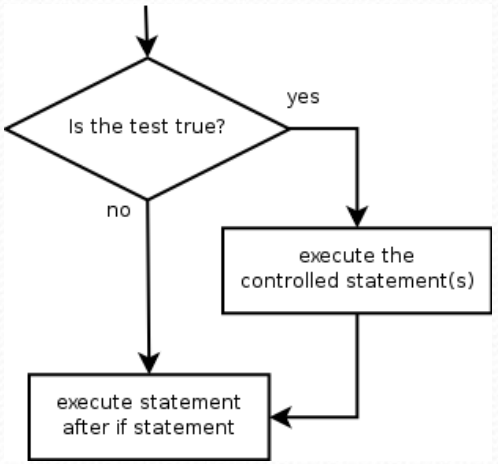


Thanks to Marty Stepp and Stuart Reges for parts of these slides

The `if` statement

Executes a block of statements only if a test is true

```
if test:
    statement
    ...
    statement
```



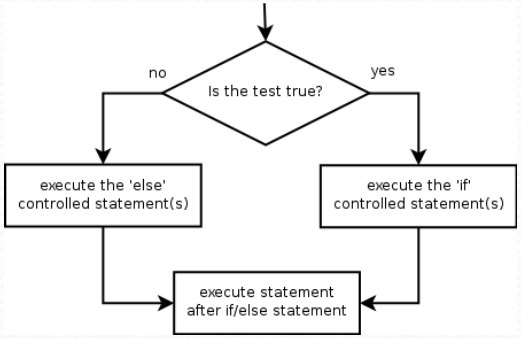
- Example:

```
gpa = float(input("gpa? "))
if gpa >= 2.0:
    print("Application accepted.")
```

The `if/else` statement

Executes one block if a test is true, another if false

```
if test:
    statement(s)
else:
    statement(s)
```

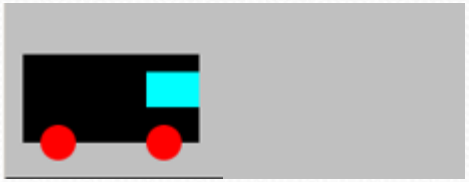


- Example:

```
gpa = float(input("gpa? "))
if gpa >= 2.0:
    print("Welcome to Mars University!")
else:
    print("Application denied.")
```

Moving in a pattern

- How can we move a shape in a specific pattern?
  - Example: make the car appear to drive across the panel
  - We will need to keep track of the x location of the car and make it increase a little each time we draw the car
    - How can we keep track of this?



```
def repeat():
    x = 10
    y = 30
    panel.fill_rect(x, y, 100, 50, "black")
    panel.fill_oval(x + 10, y + 40, 20, 20, "red")
    panel.fill_oval(x + 70, y + 40, 20, 20, "red")
    panel.fill_rect(x + 70, y + 10, 30, 20, "cyan")

panel = drawing_panel(260, 100, "gray")
panel.animate(50, repeat)
```

Relational expressions

- `if` statements use logical tests.

```
if i <= 10: ...
```

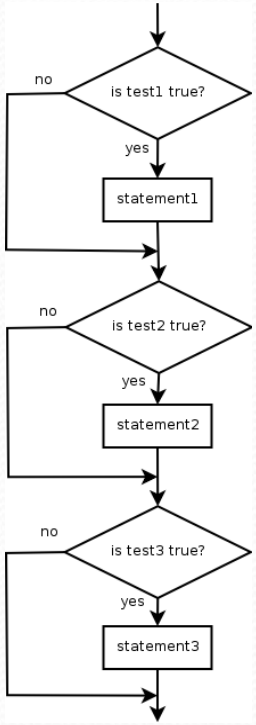
  - These are `boolean` expressions
- Tests use *relational operators*:

Operator	Meaning	Example	Value
==	equals	1 + 1 == 2	True
!=	does not equal	3.2 != 2.5	True
<	less than	10 < 5	False
>	greater than	10 > 5	True
<=	less than or equal to	126 <= 100	False
>=	greater than or equal to	5.0 >= 5.0	True

Misuse of `if`

- What's wrong with the following code?

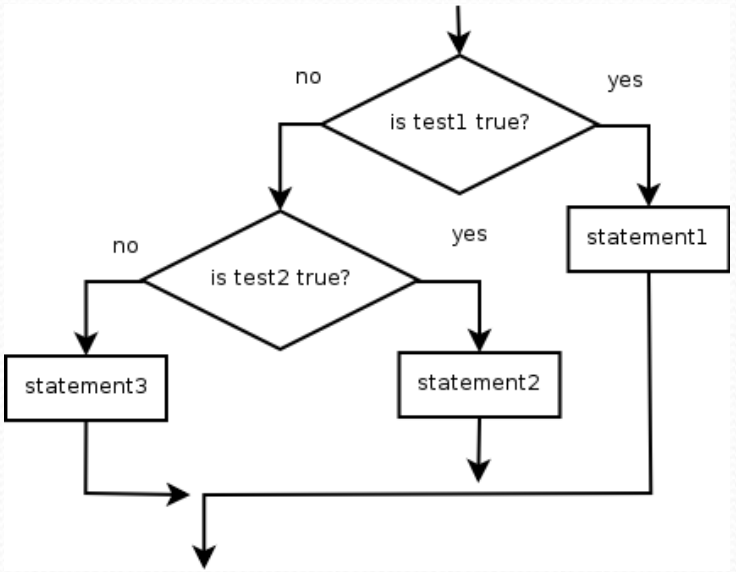
```
percent = float(input("What percentage did you earn? "))

if percent >= 90:
    print("You got an A!")

if percent >= 80:
    print("You got a B!")

if percent >= 70:
    print("You got a C!")

if percent >= 60:
    print("You got a D!")

if percent < 60:
    print("You got an F!")

...
```



Nested `if/else`

Chooses between outcomes using many tests

```
if test:
    statement(s)
elif test:
    statement(s)
else:
    statement(s)
```



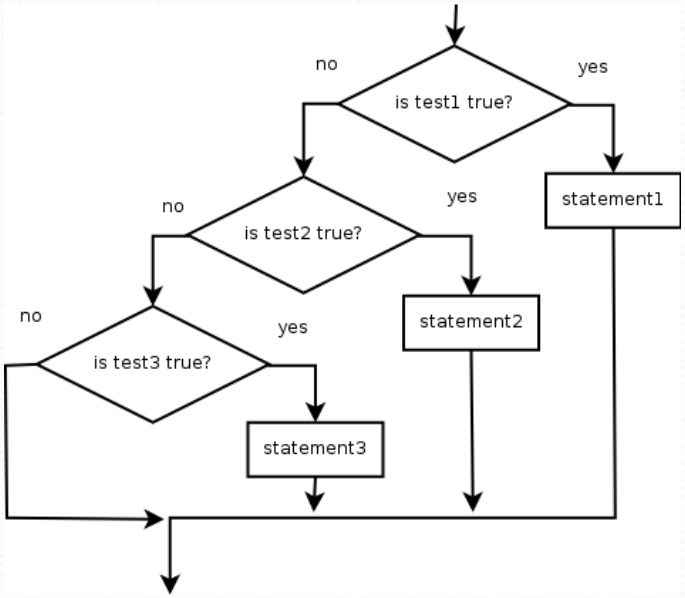
- Example:

```
if x > 0:
    print("Positive")
elif x < 0:
    print("Negative")
else:
    print("Zero")
```

Nested `if/elif/elif`

- If it ends with `else`, exactly one path must be taken.
- If it ends with `if`, the code might not execute any path.

```
if test:
    statement(s)
elif test:
    statement(s)
elif test:
    statement(s)
```



- Example:

```
if place == 1:
    print("Gold medal!")
elif place == 2:
    print("Silver medal!")
elif place == 3:
    print("Bronze medal.")
```

Nested `if` structures

- exactly 1 path *(mutually exclusive)*

```
if test:
    statement(s)
elif test:
    statement(s)
else:
    statement(s)
```

- 0 or 1 path *(mutually exclusive)*

```
if test:
    statement(s)
elif test:
    statement(s)
elif test:
    statement(s)
```

- 0, 1, or many paths *(independent tests; not exclusive)*

```
if test:
    statement(s)

if test:
    statement(s)

if test:
    statement(s)
```

Which nested `if/else`?

- **(1) if/if/if (2) nested if/else (3) nested if/elif/elif**
  - Whether a user is lower, middle, or upper-class based on income.
    - **(2)** nested `if / elif / else`
  - Whether you made the dean's list (GPA ≥ 3.8) or honor roll (3.5-3.8).
    - **(3)** nested `if / elif`
  - Whether a number is divisible by 2, 3, and/or 5.
    - **(1)** sequential `if / if / if`
  - Computing a grade of A, B, C, D, or F based on a percentage.
    - **(2)** nested `if / elif / elif / elif / else`

Exercise: bouncing ball

- Draw a ball on a `drawing_panel` and animate its path as it falls.
  - It should bounce when it hits the ground
  - Add a count for how many times the ball bounces
  - Can we make it fall with gravity?
    - displacement = velocity * time + ½ * acceleration * time^2

Relational expressions

- `if` statements use logical tests.

```
if i <= 10: ...
```

  - These are Boolean expressions.
- Tests use *relational operators*:

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<=	less than or equal to	126 <= 100	False
>=	greater than or equal to	5.0 >= 5.0	True

Logical operators

- Tests can be combined using *logical operators*:

Operator	Description	Example	Result
`and`	and	`(2 == 3) and (-1 < 5)`	`False`
`or`	or	`(2 == 3) or (-1 < 5)`	`True`
`not`	not	`not (2 == 3)`	`True`

- "Truth tables" for each, used with logical values *p* and *q*:

p	q	p and q	p or q
True	True	True	True
True	False	False	True
False	True	False	True
False	False	False	False

p	not p
True	False
False	True

Evaluating logical expressions

- Relational operators have lower precedence than math; logical operators have lower precedence than relational operators

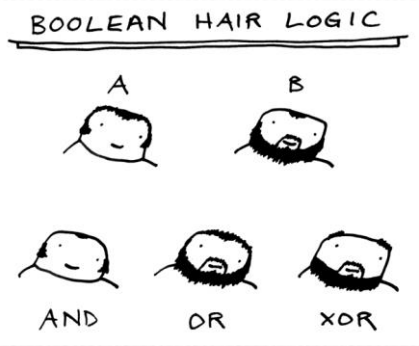
```
5 * 7 >= 3 + 5 * (7 - 1) and 7 <= 11
5 * 7 >= 3 + 5 * 6 and 7 <= 11
35    >= 3 + 30 and 7 <= 11
35    >= 33 and 7 <= 11
True and True
True
```

Logical questions

- What is the result of each of the following expressions?

```
x = 42
y = 17
z = 25
```

  - `y < x and y <= z`
  - `x % 2 == y % 2 or x % 2 == z % 2`
  - `x <= y + z and x >= y + z`
  - `not(x < y and x < z)`
  - `(x + y) % 2 == 0 or not((z - y) % 2 == 0)`

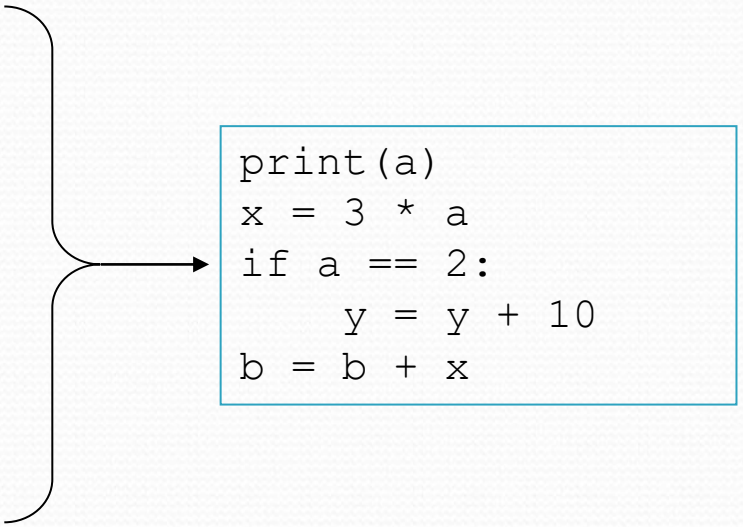


    - Answers: `True`, `False`, `True`, `True`, `False`

Factoring `if/else` code

- **factoring**: Extracting common/redundant code.
  - Can reduce or eliminate redundancy from `if/else` code.
- Example:

```
if a == 1:
    print(a)
    x = 3
    b = b + x
elif a == 2:
    print(a)
    x = 6
    y = y + 10
    b = b + x
else:          # a == 3
    print(a)
    x = 9
    b = b + x
```



```
print(a)
x = 3 * a
if a == 2:
    y = y + 10
b = b + x
```

Type `bool`

- **`bool`**: A logical type whose values are `True` and `False`.
  - A logical ***test*** is actually a Boolean expression.
  - Like other types, it is legal to:
    - create a `bool` variable

```
minor     = age < 21
is_prof   = "Prof" in name
loves_csc = True

# allow only CS-loving students over 21
if minor or is_prof or not loves_csc:
    print("Can't enter the club!")
```

Using `bool`

- Why is type `bool` useful?
  - Can capture a complex logical test result and use it later
  - Can write a function that does a complex test and returns it
  - Makes code more readable

```
good_age    = age >= 27 and age < 39
good_height = height >= 78 and height < 84
rich        = salary >= 100000.0
if (goodAge and goodHeight) or rich:
    print("Okay, let's go out!")
else:
    print("It's not you, it's me...")
```

De Morgan's Law

- **De Morgan's Law**: Rules used to negate boolean tests.
  - Useful when you want the opposite of an existing test.

Original Expression	Negated Expression	Alternative
`a and b`	`not a or not b`	`not(a and b)`
`a or b`	`not a and not b`	`not(a or b)`

  - Example:

Original Code	Negated Code
`if x == 7 and y > 3:` `    ...`	`if x != 7 or y <= 3:` `    ...`