COMP110: Principles of Computing

10: References

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  - With reference to appropriate academic sources

Marking rubric

See assignment brief on LearningSpace/GitHub

Timeline

- **Peer review** next week! (4th December)
- **Deadline** shortly after! (check MyFalmouth)

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- Our picture of a variable: a labelled box containing a value
- For "plain old data" (e.g. numbers), this is accurate
- For **objects** (i.e. instances of classes), variables actually hold **references** (a.k.a. **pointers**)
- It is possible (indeed common) to have **multiple references** to the same underlying object

The wrong picture

```python
class Thing:
    def __init__(self,
                 a, b):
        self.a = a
        self.b = b

x = Thing(30, 40)
y = Thing(50, 60)
z = y
```

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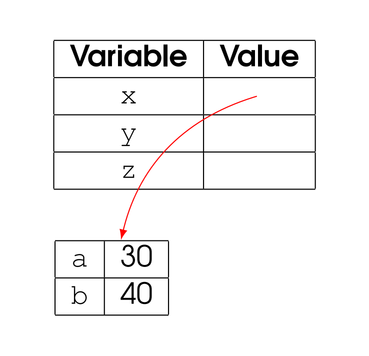

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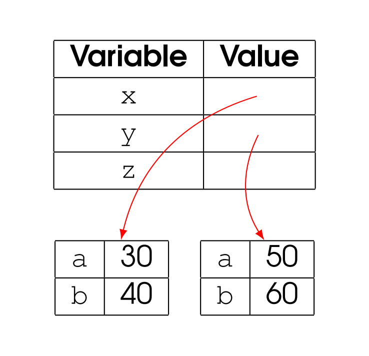

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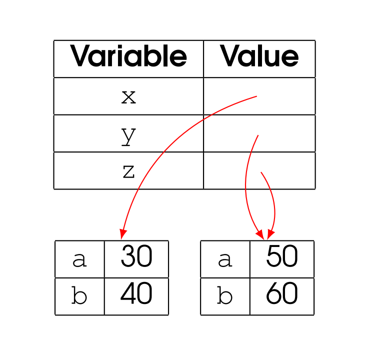

Values and references

Socrative room code: `FALCOMPED`

```
a = 10
b = a
a = 20
print("a:", a)
print("b:", b)
```

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```
class X:
    def __init__(self, value):
        self.value = value

a = X(10)
b = a
a.value = 20
print("a:", a.value)
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```

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class X:
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    x *= 2

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def double(x):
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`double` does not actually do anything, as `x` is just a local copy of whatever is passed in!

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However, instances are passed by **reference**

```
class Box:
    def __init__(self, v):
        self.value = v

def double(x):
    x.value *= 2

a = Box(7)
double(a)
print(a.value)
```

Pass by reference

However, instances are passed by **reference**

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class Box:
    def __init__(self, v):
        self.value = v

def double(x):
    x.value *= 2

a = Box(7)
double(a)
print(a.value)
```

`double` now has an effect, as `x` gets a reference to the `Box` instance

Lists are objects too

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a = ["Hello"]
b = a
b.append("world")
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... which means you should be careful when passing lists into functions, because the function might actually change the list!

References can be circular

```python
class X:
    pass

foo = X()
foo.x = foo
foo.y = "Hello"

print(foo.x.x.x.x.x.y)
```

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- Pointers are a type of reference, and have the same semantics
- C++ also has something called references...

Vectors

2D vectors

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- General form: $\begin{pmatrix} x \\ y \end{pmatrix}$
- Can also have $3, 4, 5, \ldots$ dimensional vectors

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  - In computer graphics, sometimes y points down instead of up

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- Multiplication by a **scalar** (a number) also works element-wise
  - $c \times \begin{pmatrix} x \\ y \end{pmatrix} = \begin{pmatrix} c \times x \\ c \times y \end{pmatrix}$

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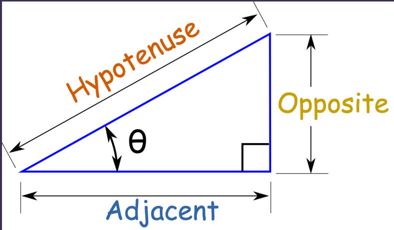
- Addition: if u and v are offsets, then $u + v$ is the combined offset

Trigonometry



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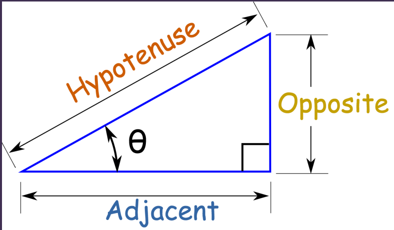

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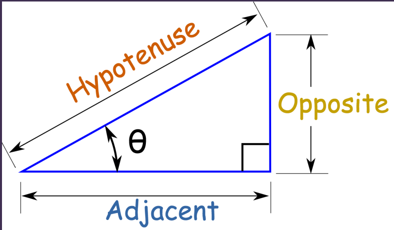

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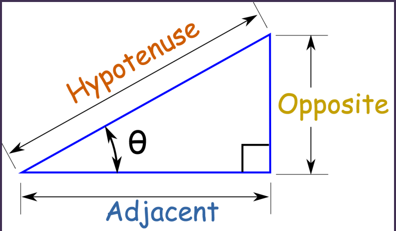

- $\sin\theta = \frac{\text{opposite}}{\text{hypotenuse}}$
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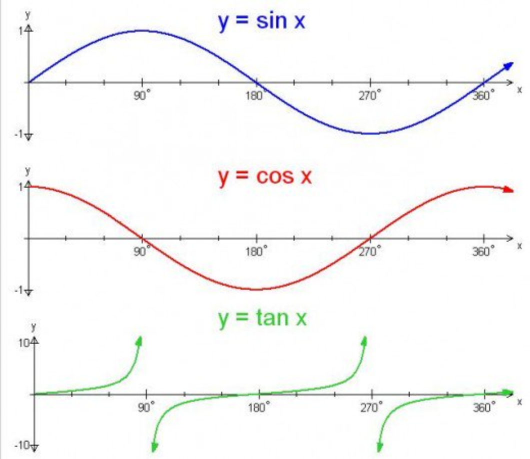
- $\tan\theta = \frac{\text{opposite}}{\text{adjacent}}$

Sine, cosine and tangent



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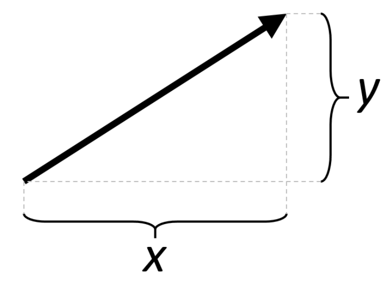

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A vector also has **direction** and **magnitude** (or **length**)

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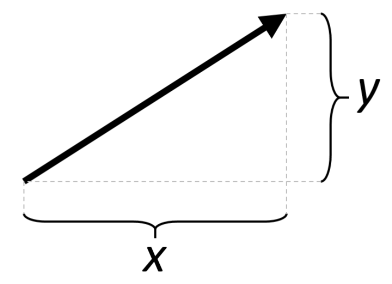

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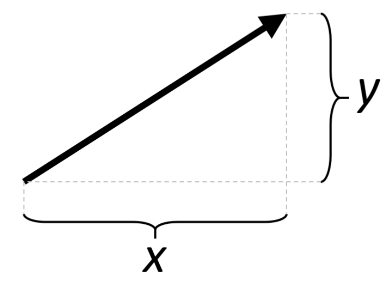

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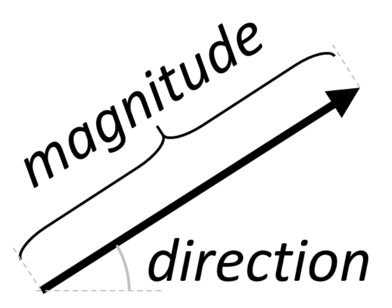

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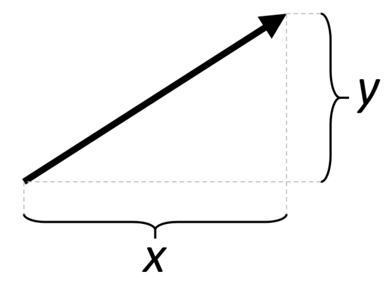

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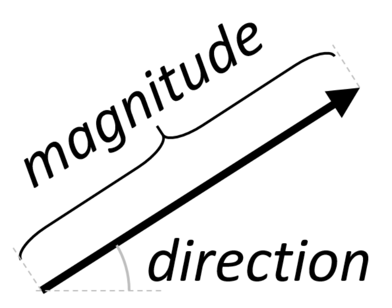

(Direction is measured as an angle from the positive *x*-axis)

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- The vector with magnitude r and direction θ is $\begin{pmatrix} r\cos\theta \\ r\sin\theta \end{pmatrix}$
- Multiplication: if u is a vector with magnitude r and direction θ, then $c \times u$ has magnitude $c \times r$ and direction θ

Worksheet D