61A Lecture 14

Friday, September 28

Testing for Identity

Demo

Implementing Dice

Implementing Dice

Random numbers are useful for experimentation

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They also appear in lots of algorithms, e.g.,

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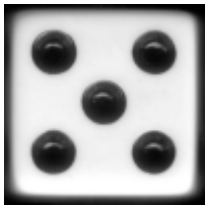


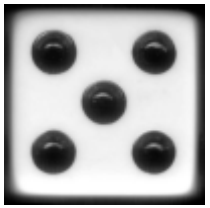
They also appear in lots of algorithms, e.g.,

- Primality tests
- Machine learning techniques

```
def make_dice(sides=6):
    seed = 1
    multiplier = pow(7, 5)
    big_prime = pow(2, 31) - 1
    def dice():
        nonlocal seed
        seed = (multiplier * seed) % big_prime
        return (sides*seed) // big_prime + 1
    return dice
```

Implementing Dice

Random numbers are useful for experimentation



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16807

Implementing Dice

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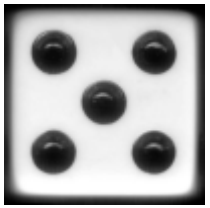

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2147483647

Implementing Dice

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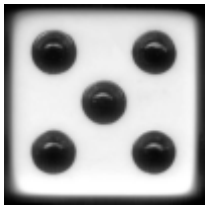

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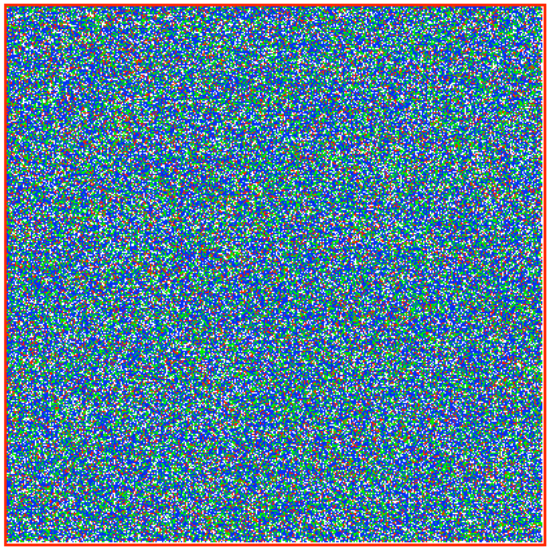
    return dice
```

16807

2147483647

P1 = 16807, P2 = 0, N = 2147483647



100000 dots drawn, seed = 1

http://www.math.utah.edu/~pa/Random/Random.html

S.K. Park and K.W. Miller, " Random Number Generators: Good Ones Are Hard To Find", Communications of the ACM, October 1988, pp. 1192-1201.

Implementing a Mutable Container Object

Demo

Dispatch Functions

A technique for packing multiple behaviors into one function

Dispatch Functions

A technique for packing multiple behaviors into one function

```
def pair(x, y):
    """Return a function that behaves like a pair."""
    def dispatch(m):
        if m == 0:
            return x
        elif m == 1:
            return y
    return dispatch
```

Dispatch Functions

A technique for packing multiple behaviors into one function

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Message argument can be anything, but strings are most common

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Message argument can be anything, but strings are most common

The body of a dispatch function is always the same:

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Message argument can be anything, but strings are most common

The body of a dispatch function is always the same:

- One conditional statement with several clauses

Dispatch Functions

A technique for packing multiple behaviors into one function

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```

Message argument can be anything, but strings are most common

The body of a dispatch function is always the same:

- One conditional statement with several clauses
- Headers perform equality tests on the message

Message Passing

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An approach to organizing the relationship among different pieces of a program

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Different objects pass messages to each other

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- What is your fourth element?

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Encapsulates the behavior of all operations on a piece of data

Message Passing

An approach to organizing the relationship among different pieces of a program

Different objects pass messages to each other

- What is your fourth element?
- Change your third element to this new value. (please?)

Encapsulates the behavior of all operations on a piece of data

Important historical role:
The message passing approach strongly influenced object-oriented programming
(next lecture)

A Mutable Container That Uses Message Passing

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```
def container_dispatch(contents):
```

A Mutable Container That Uses Message Passing

```
def container_dispatch(contents):

    def dispatch(message, value=None):
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    def dispatch(message, value=None):

        nonlocal contents
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def container_dispatch(contents):

    def dispatch(message, value=None):

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        if message == 'get':
```

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    def dispatch(message, value=None):

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        if message == 'get':

            return contents
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A Mutable Container That Uses Message Passing

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def container_dispatch(contents):

    def dispatch(message, value=None):

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        if message == 'get':

            return contents

        if message == 'put':
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A Mutable Container That Uses Message Passing

```
def container_dispatch(contents):

    def dispatch(message, value=None):

        nonlocal contents

        if message == 'get':

            return contents

        if message == 'put':

            contents = value
```

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```
def container_dispatch(contents):

    def dispatch(message, value=None):

        nonlocal contents

        if message == 'get':

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            contents = value



 return dispatch
```

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def container_dispatch(contents):

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        if message == 'get':

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```

```
def container(contents):

    def get():

        return contents

    def put(value):

        nonlocal contents

        contents = value

    return get, put
```

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def container_dispatch(contents):

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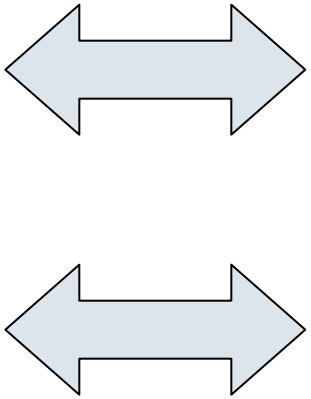

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        if message == 'get':

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 return dispatch
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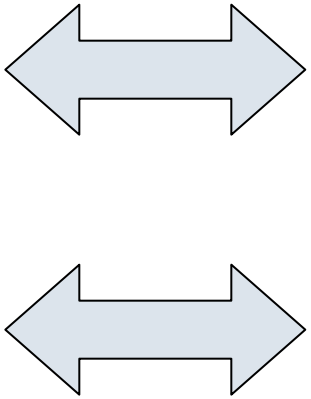

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    def get():

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        contents = value

    return get, put
```

Demo

Implementing Mutable Recursive Lists

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Recursive List
Refresher Demo

Implementing Mutable Recursive Lists

```
def mutable_rlist():
```

Recursive List
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def mutable_rlist():
    contents = empty_rlist
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Recursive List Refresher Demo

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Recursive List Refresher Demo

Implementing Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
```

Recursive List Refresher Demo

Implementing Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
        nonlocal contents
        if message == 'len':
            return len_rlist(contents)
```

Recursive List Refresher Demo

Implementing Mutable Recursive Lists

```
def mutable_rlist():
    contents = empty_rlist
    def dispatch(message, value=None):
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        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
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    def dispatch(message, value=None):
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            return getitem_rlist(contents, value)
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    contents = empty_rlist
    def dispatch(message, value=None):
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        if message == 'len':
            return len_rlist(contents)
        elif message == 'getitem':
            return getitem_rlist(contents, value)
        elif message == 'push_first':
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        elif message == 'pop_first':
            f = first(contents)
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        elif message == 'push_first':
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        elif message == 'pop_first':
            f = first(contents)
            contents = rest(contents)
            return f
        elif message == 'str':
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Recursive List Refresher Demo

Demo

Implementing Dictionaries

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    """Return a functional implementation of a dictionary."""
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    def setitem(key, value):
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        for item in records:
            if item[0] == key:
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        for item in records:
            if item[0] == key:
                item[1] = value
                return
        records.append([key, value])
```

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    def dispatch(message, key=None, value=None):
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        records.append([key, value])

    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
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        records.append([key, value])

    def dispatch(message, key=None, value=None):
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            return getitem(key)
        elif message == 'setitem':
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        records.append([key, value])

    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
        elif message == 'setitem':
            setitem(key, value)
        elif message == 'keys':
            return tuple(k for k, _ in records)
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    def dispatch(message, key=None, value=None):
        if message == 'getitem':
            return getitem(key)
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            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)
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        records.append([key, value])

    def dispatch(message, key=None, value=None):
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        elif message == 'setitem':
            setitem(key, value)
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            return tuple(k for k, _ in records)
        elif message == 'values':
            return tuple(v for _, v in records)

    return dispatch
```

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            return tuple(k for k, _ in records)
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    return dispatch
```

Question: Do we need a nonlocal statement here?

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Question: Do we need a nonlocal statement here?

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A dispatch dictionary has messages as keys and functions (or data objects) as values.

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- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dictionaries handle the message look-up logic; we concentrate on implementing useful behavior.

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dictionaries handle the message look-up logic; we concentrate on implementing useful behavior.

In Javascript, all objects are just dictionaries

Dispatch Dictionaries

Enumerating different messages in a conditional statement isn't very convenient:

- Equality tests are repetitive
- We can't add new messages without writing new code

A dispatch dictionary has messages as keys and functions (or data objects) as values.

Dictionaries handle the message look-up logic; we concentrate on implementing useful behavior.

Demo

In Javascript, all objects are just dictionaries

Example: Constraint Programming

Bonus Material

Example: Constraint Programming

Bonus Material

```
a + b = c
```

Example: Constraint Programming

Bonus Material

```
a + b = c

a = c - b
```

Example: Constraint Programming

Bonus Material

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a + b = c

a = c - b

b = c - a
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Algebraic equations are *declarative*. They describe a relation among different quantities.

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Python functions are *procedural*. They describe how to compute a result from a set of input arguments.

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Constraint programming:

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Constraint programming:

- We define the relationship between quantities

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Constraint programming:

- We define the relationship between quantities
- We provide values for the "known" quantities

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Challenge: We want a general means of combination.

Example: Constraint Programming

Bonus Material

```
a + b = c

a = c - b                    p * v = n * k * t

b = c - a
```

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Boltzmann's constant

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Example: Constraint Programming

Bonus Material

```
a + b = c
a = c - b
b = c - a
```

Boltzmann's constant

```
p * v = n * k * t
9 * c = 5 * (f - 32)
```

Algebraic equations are *declarative*. They describe a relation among different quantities.

ONE WAY Python functions are *procedural*. They describe how to compute a result from a set of input arguments.

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A Constraint Network for Temperature Conversion

Bonus Material

```
9 * celsius = 5 * (fahrenheit - 32)
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A Constraint Network for Temperature Conversion

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Combination idea: All intermediate quantities have values too.

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This quantity relates directly to **celsius**

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A Constraint Network for Temperature Conversion

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This quantity relates directly to **fahrenheit**

A Constraint Network for Temperature Conversion

Bonus Material

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u

v

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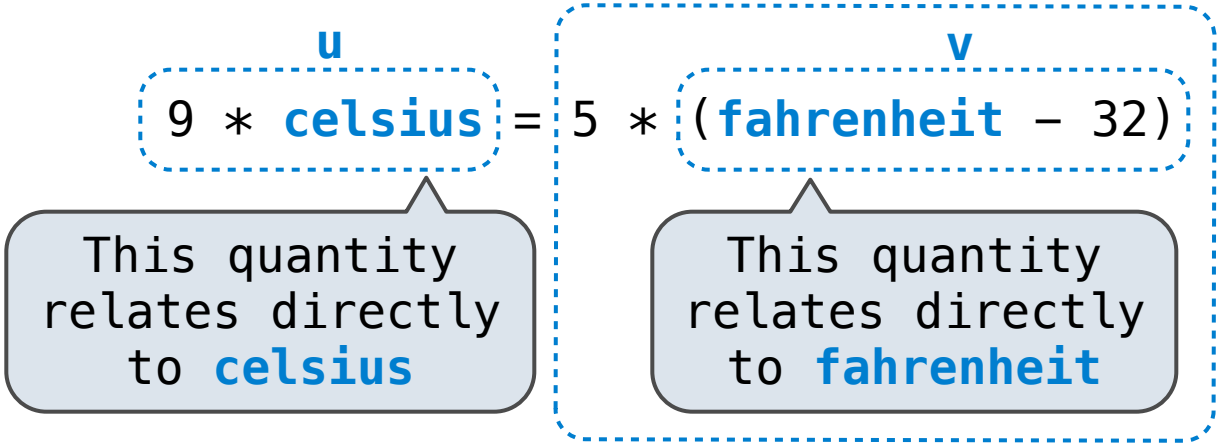
This quantity relates directly to **celsius**

This quantity relates directly to **fahrenheit**

A Constraint Network for Temperature Conversion

Bonus Material

Combination idea: All intermediate quantities have values too.



A Constraint Network for Temperature Conversion

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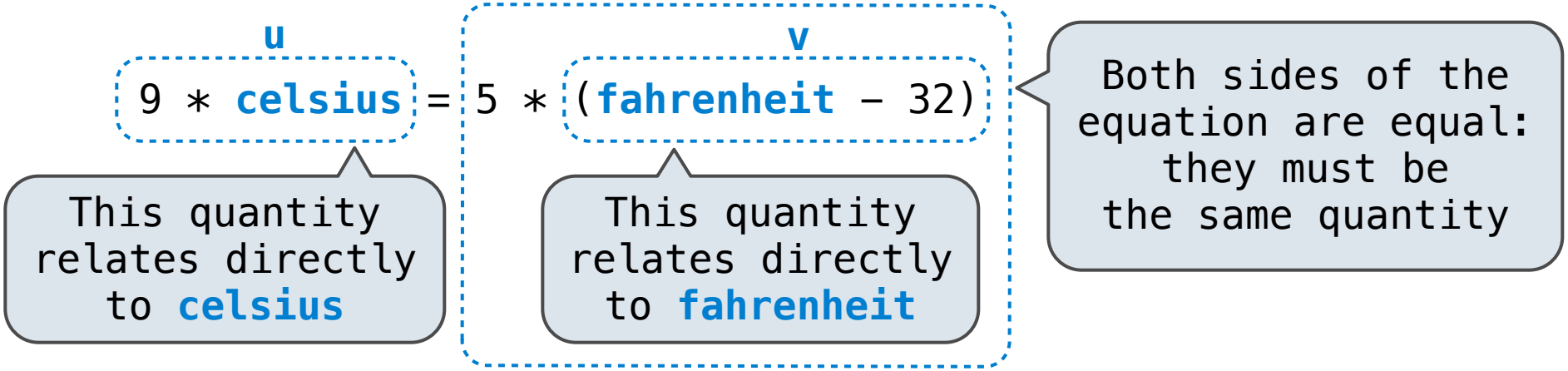

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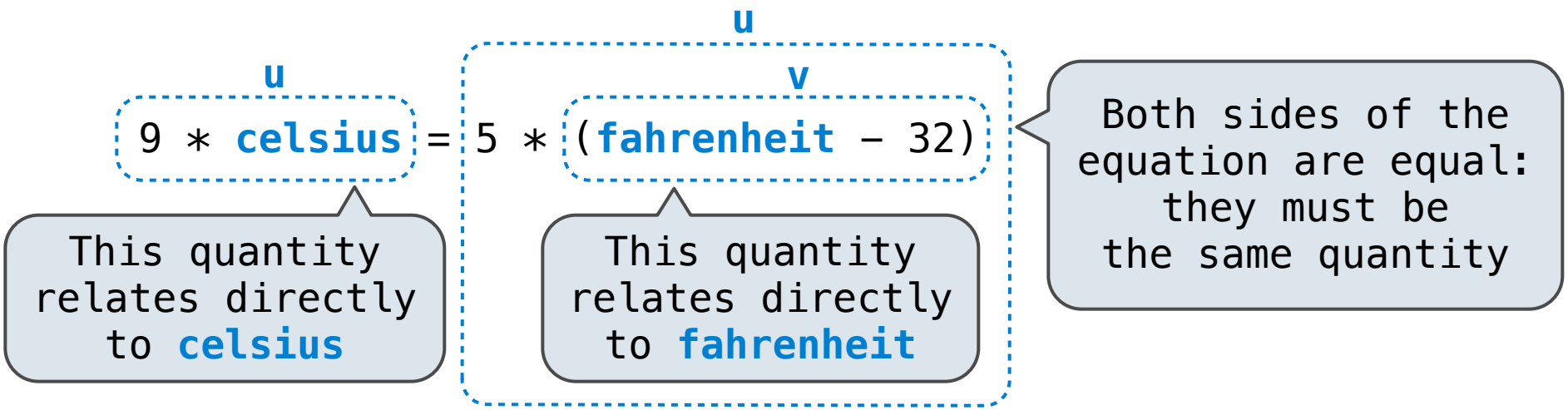

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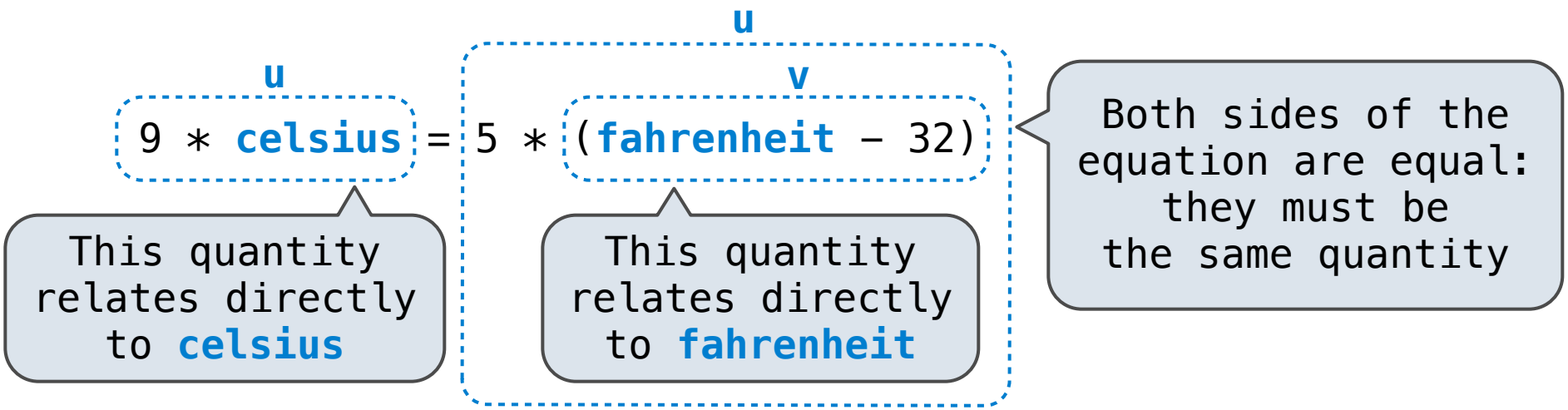

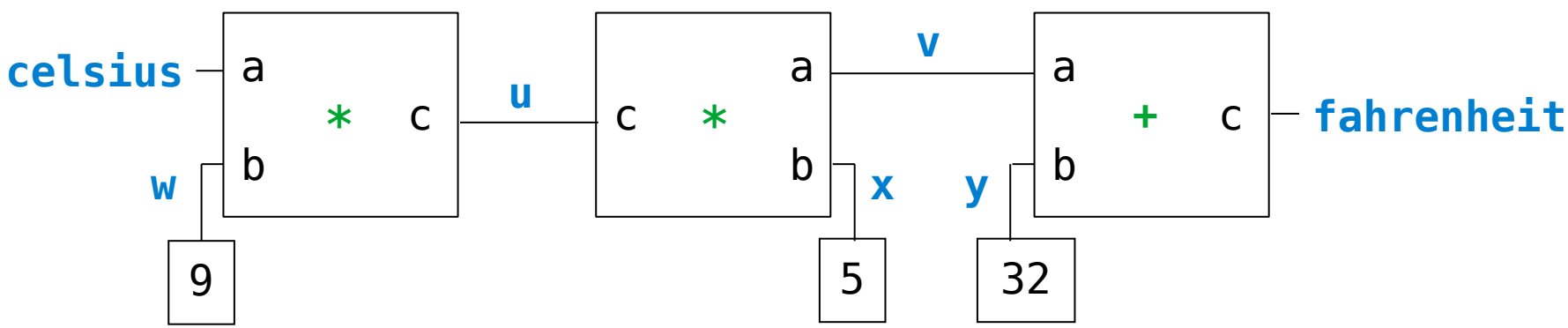

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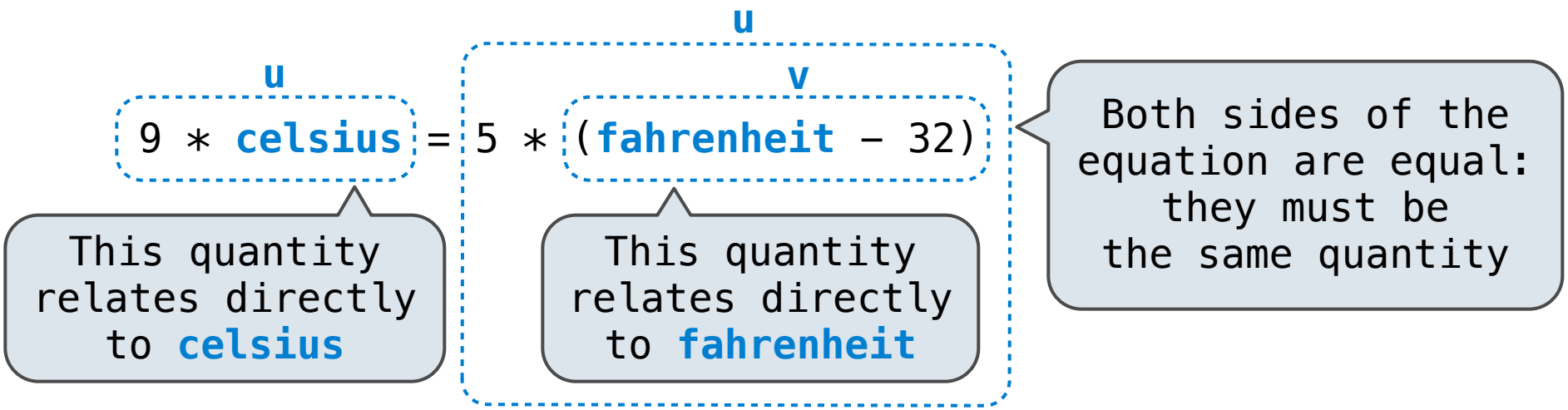

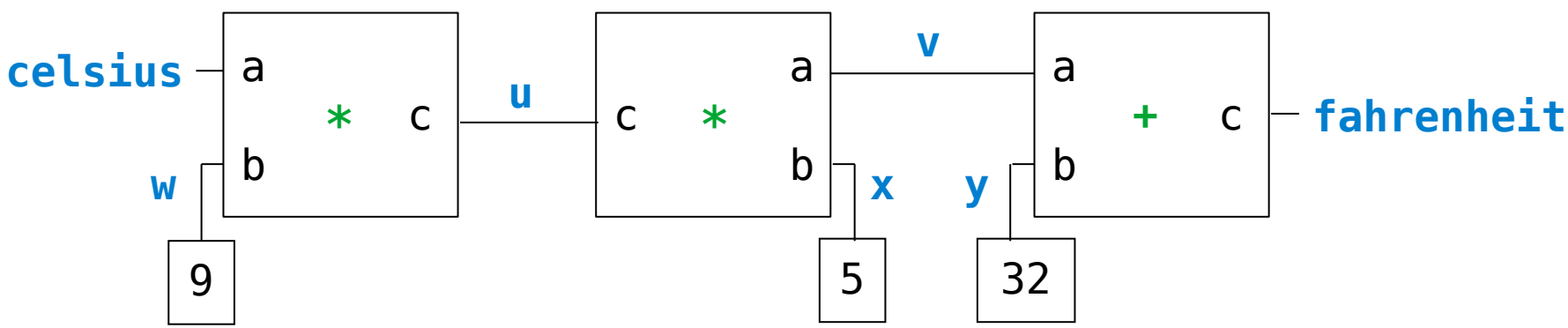

Demo