Creating Data Types

Outline

Basic Elements of a Data Type

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By convention, the first parameter of a method is named `self`

When a client calls a method, the `self` parameter variable references the object to be manipulated, ie, the object that was used to invoke the method; in the case of `__init__()`, it is a reference to the newly created object

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A client should access a data type only through the methods in its API

Examples of Data Types

Examples of Data Types

Stopwatch	
`Stopwatch()`	Constructs a new stopwatch
`elapsedTime()`	Returns the elapsed time (in seconds) since creation

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```
>_ ~/workspace/ipp/programs
```

```
$ python3 timeops.py 10000000
math.sqrt() is 2.05 times faster than math.pow()
$
```

Examples of Data Types

Examples of Data Types

timeops.py

```
from stopwatch import Stopwatch
import math
import stdio
import sys

def main():
    n = int(sys.argv[1])
    watch1 = Stopwatch()
    total = 0.0
    for i in range(1, n + 1):
        total += math.sqrt(i)
    time1 = watch1.elapsedTime()
    watch2 = Stopwatch()
    total = 0.0
    for i in range(1, n + 1):
        total += math.pow(i, 0.5)
    time2 = watch2.elapsedTime()
    stdio.writef('math.sqrt() is %.2f times faster than math.pow()\n', time2 / time1)

if __name__ == '__main__':
    main()
```

Examples of Data Types

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stopwatch.py

```
import stdio
import sys
import time

class Stopwatch:
    def __init__(self):
        self.creationTime = time.time()

    def elapsedTime(self):
        return time.time() - self.creationTime

def _main():
    n = int(sys.argv[1])
    watch = Stopwatch()
    primes = 0
    for i in range(2, n + 1):
        j = 2
        while j <= i / j:
            if i % j == 0:
                break
            j += 1
        if j > i / j:
            primes += 1
    time = watch.elapsedTime()
    stdio.writef('pi(%d) = %d computed in %.5f seconds\n', n, primes, time)

if __name__ == '__main__':
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```

Examples of Data Types

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Histogram	
`Histogram(n)`	constructs a new histogram from the integer values in $0, 1, \ldots, n-1$
`addDataPoint(i)`	adds an occurrence of integer i to the histogram
`draw()`	draw the histogram to standard draw

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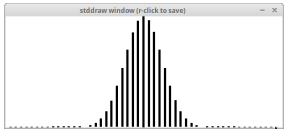
$ python3 bernoulli.py 50 0.5 1000000
```



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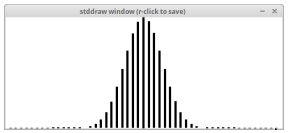
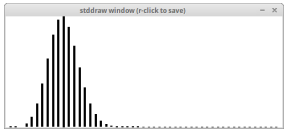



```
>_ ~/workspace/ipp/programs
$ python3 bernoulli.py 50 0.2 1000000
```



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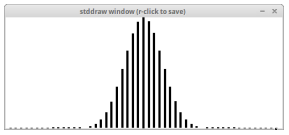


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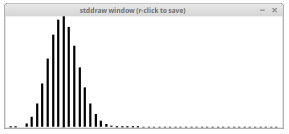
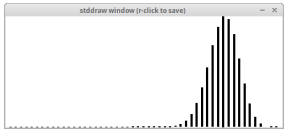



```
>_ ~/workspace/ipp/programs
$ python3 bernoulli.py 50 0.8 1000000
```



Examples of Data Types

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bernoulli.py

```
from histogram import Histogram
import stddraw
import stdrandom
import sys

def main():
    n = int(sys.argv[1])
    p = float(sys.argv[2])
    trials = int(sys.argv[3])
    histogram = Histogram(n + 1)
    for t in range(trials):
        heads = stdrandom.binomial(n, p)
        histogram.addDataPoint(heads)
    stddraw.setCanvasSize(500, 200)
    histogram.draw()
    stddraw.show()

if __name__ == '__main__':
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Examples of Data Types

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histogram.py

```
import stdarray
import stddraw
import stdrandom
import stdstats
import sys

class Histogram:
    def __init__(self, n):
        self.freq = stdarray.create1D(n, 0)

    def addDataPoint(self, i):
        self.freq[i] += 1

    def draw(self):
        stddraw.setYscale(-1, max(self.freq) + 1)
        stdstats.plotBars(self.freq)

def _main():
    trials = int(sys.argv[1])
    histogram = Histogram(6)
    for t in range(trials):
        roll = stdrandom.uniformInt(0, 6)
        histogram.addDataPoint(roll)
    stddraw.setCanvasSize(500, 200)
    histogram.draw()
    stddraw.show()

if __name__ == '__main__':
    _main()
```

Examples of Data Types

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A data type `Turtle` for producing turtle graphics[1]

`Turtle`	
`Turtle(x0, y0, a0)`	constructs a new turtle at (x_0, y_0) facing a_0 degrees from the x-axis
`turnLeft(delta)`	instructs the turtle to turn left (conterclockwise) by *delta* degrees
`goForward(step)`	instructs the turtle to move forward distance *step*, drawing a line

[1] Turtle graphics was part of the original Logo programming language developed by Wally Feurzig and Seymour Papert in 1966 for introducing programming to kids

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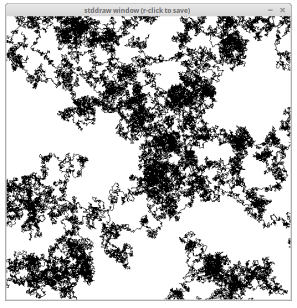
>_ ~/workspace/ipp/programs
$ python3 drunks.py 20 5000 .005
```



Examples of Data Types

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drunks.py

```
from turtle import Turtle
import stdarray
import stddraw
import stdrandom
import sys

def main():
    n = int(sys.argv[1])
    steps = int(sys.argv[2])
    stepSize = float(sys.argv[3])
    turtles = stdarray.create1D(n, None)
    for i in range(n):
        x = stdrandom.uniformFloat(0.0, 1.0)
        y = stdrandom.uniformFloat(0.0, 1.0)
        theta = stdrandom.uniformFloat(0.0, 360.0)
        turtles[i] = Turtle(x, y, theta)
    stddraw.setPenRadius(0.0)
    for i in range(steps):
        for turtle in turtles:
            theta = stdrandom.uniformFloat(0.0, 360.0)
            turtle.turnLeft(theta)
            turtle.goForward(stepSize)
            stddraw.show(0.0)
    stddraw.show()

if __name__ == '__main__':
    main()
```

Examples of Data Types

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turtle.py

```
import math
import stddraw
import sys


class Turtle:
    def __init__(self, x, y, theta):
        self.x = x
        self.y = y
        self.theta = theta

    def turnLeft(self, theta):
        self.theta += theta

    def goForward(self, stepSize):
        xOld = self.x
        yOld = self.y
        self.x += stepSize * math.cos(math.radians(self.theta))
        self.y += stepSize * math.sin(math.radians(self.theta))
        stddraw.line(xOld, yOld, self.x, self.y)

def _main():
    n = int(sys.argv[1])
    turtle = Turtle(0.5, 0.0, 180.0 / n)
    stepSize = math.sin(math.radians(180.0 / n))
    stddraw.setPenRadius(0.0)
    for i in range(n):
        turtle.goForward(stepSize)
        turtle.turnLeft(360.0 / n)
    stddraw.show()

if __name__ == '__main__':
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```