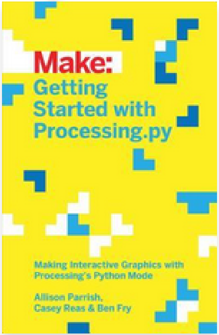
Physics 9 — Wednesday, November 21, 2018

- HW10 due Friday, November 30.
- For Monday, read Giancoli chapter 19 (DC circuits).
- Today: a tutorial of the "Processing.py" computer programming language — whose purpose is to learn how to code within the context of the visual arts. It makes coding fun and visual. Processing.py is a Python-based version of the (Java-based) Processing programming environment that I described last year in Physics 8.
- Extra-credit options (if you're interested):
  - Learn to use Mathematica (ask me how), which is a system for doing mathematics by computer. (It is the brains behind Wolfram Alpha.) Penn's site license makes Mathematica free-of-charge for SAS and Wharton students.
  - Use "Processing.py" (or ordinary "Processing") to write a program to draw or animate something that interests you. (Not necessarily physics-related.)
  - Knowing "how to code" is empowering & enlightening. So I offer you an excuse to give it a try, for extra credit, if you wish.
- Today's examples online at

http://positron.hep.upenn.edu/wja/p009/2018/files/pyprocessing/



Want to Read

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Getting Started with Processing.Py: Making Interactive Graphics with Processing's Python Mode

by Allison Parrish, Ben Fry, Casey Reas

★★★★★ 4.88 · Rating details · 8 Ratings · 3 Reviews

Processing opened up the world of programming to artists, designers, educators, and beginners. The Processing.py Python implementation of Processing reinterprets it for today's web. This short book gently introduces the core concepts of computer programming and working with Processing. Written by the co-founders of the Processing project, Reas and Fry, along with co-author Allison Parrish, Getting Started with Processing.py is your fast track to using Python's Processing mode. (less)

The software is free & open-source. Runs on Mac, Windows, Linux. The "getting started" book will set you back about $15.

or start with the in-browser video tutorial (no download needed): `http://hello.processing.org` (Processing, **not** Processing.py) https://processing.org

Processing | p5.js | Processing.py | Processing for Android | Processing for Pi | Processing Foundation

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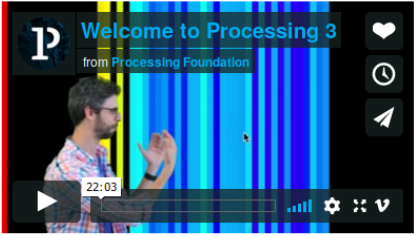

Welcome to Processing 3! Dan explains the new features and changes; the links Dan mentions are on the Vimeo page.

» Download Processing
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Processing is a flexible software sketchbook and a language for learning how to code within the context of the visual arts. Since 2001, Processing has promoted software literacy within the visual arts and visual literacy within technology. There are tens of thousands of students, artists, designers, researchers, and hobbyists who use Processing for learning and prototyping.

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komorebi
by Leslie Nooteboom

Particle Flow
by NEOANALOG

https://py.processing.org

Processing.py

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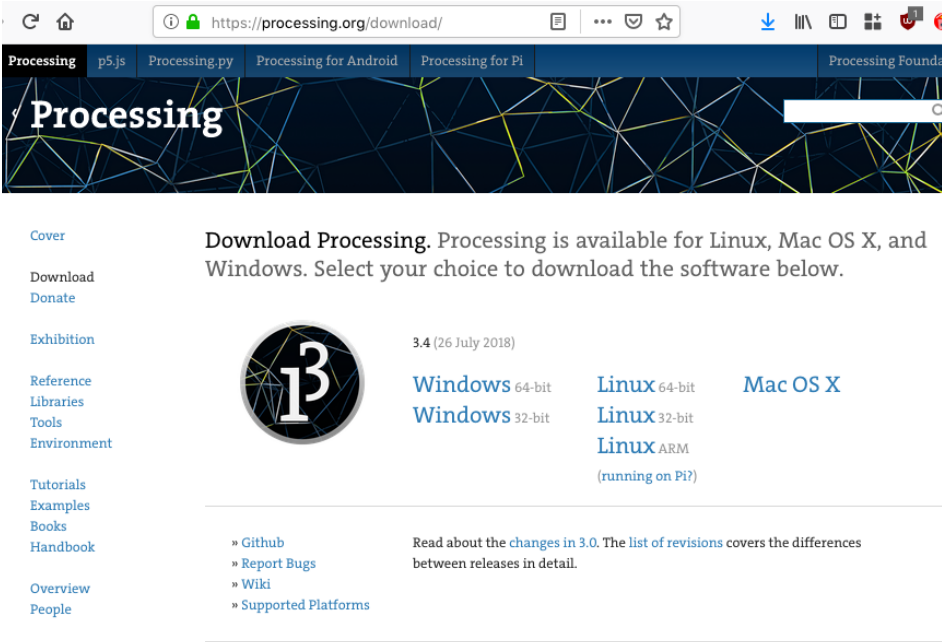
Python Mode for Processing

You write Processing code. In Python.

Processing is a programming language, development environment, and online community. Since 2001, Processing has promoted software literacy within the visual arts and visual literacy within technology. Today, there are tens of thousands of students, artists, designers, researchers, and hobbyists who use Processing for learning, prototyping, and production.

Processing was initially released with a Java-based syntax, and with a lexicon of graphical primitives that took inspiration from OpenGL, Postscript, Design by Numbers, and other sources. With the gradual addition of alternative progamming interfaces — including JavaScript, Python, and Ruby — it has become increasingly clear that Processing is not a single language, but rather, an arts-oriented approach to learning, teaching, and making things with code.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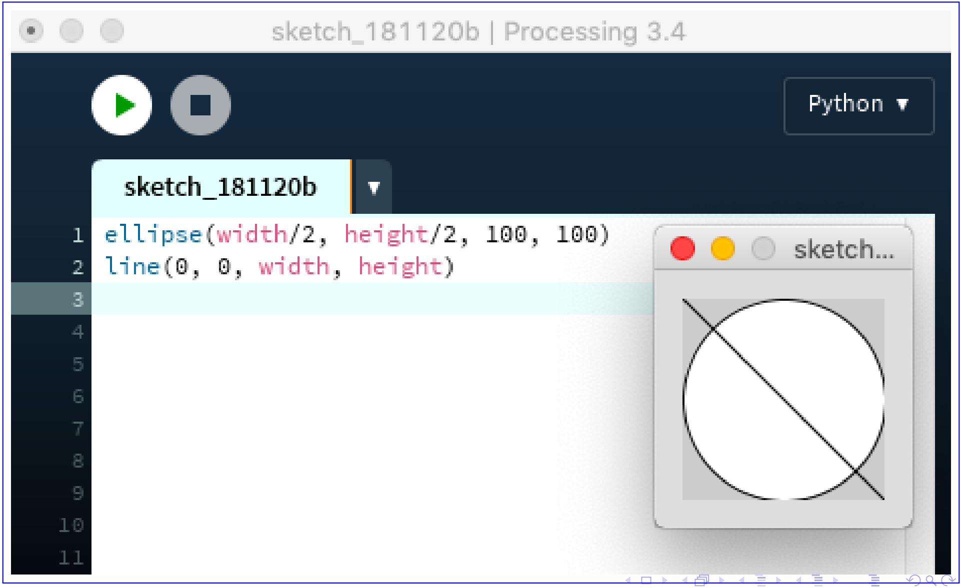
Download Processing. Processing is available for Linux, Mac OS X, and Windows. Select your choice to download the software below.
3.4 (26 July 2018)
Windows 64-bit
Windows 32-bit
Linux 64-bit
Linux 32-bit
Linux ARM
(running on Pi?)
Mac OS X
» Github
» Report Bugs
» Wiki
» Supported Platforms
Read about the changes in 3.0. The list of revisions covers the differences between releases in detail.

“hello world” program

Let’s draw a circle and a line.



More commonly, a Processing program has a function called `setup()` that runs once when the program starts, and another function called `draw()` that runs once per frame.

```
def setup():
  # this function runs once when the program starts up
  size(900, 450)  # sets width & height of window (in pixels)

def draw():
  # this function runs once per frame of the animation
  line(0, frameCount, width, height-frameCount)
```

Let's make it do something repetitive

```
def setup():
  # this function runs once when the program starts up
  size(900, 450)  # sets width & height of window (in pixels)

def draw():
  # this function runs once per frame of the animation
  dy = 0.5*height + 0.5*height*sin(0.01*frameCount)
  line(0, dy, width, height-dy)
```

How about repeating something more exciting?

```
def setup():
  # this function runs once when the program starts up
  size(900, 450)  # sets width & height of window (in pixels)

def draw():
  # this function runs once per frame of the animation
  dy = 0.5*height + 0.5*height*sin(0.01*frameCount)
  line(0, dy, width, height-dy)
  t = 0.02*frameCount
  x = 0.5*width + 200*cos(t)
  y = 0.5*height + 200*sin(t)
  ellipse(x, y, 20, 20)
```

Did you ever have a Spirograph toy when you were a kid?

```
def setup():
  size(900, 450)

def draw():
  t = 0.02*frameCount
  x = 0.5*width + 200*cos(t) + 30*cos(11*t)
  y = 0.5*height + 200*sin(t) - 30*sin(11*t)
  ellipse(x, y, 5, 5)
```

How about something that starts to resemble physics? A really, really low-tech animation of an planet orbiting a star.

```
def setup():
  size(900, 450)

def draw():
  t = 0.01*frameCount
  xsun = 0.5*width
  ysun = 0.5*height
  ellipse(xsun, ysun, 20, 20)
  rplanet = 200
  xplanet = xsun + rplanet*cos(t)
  yplanet = ysun + rplanet*sin(t)
  ellipse(xplanet, yplanet, 10, 10)
```

Let's add a moon in orbit around the planet.

```
def draw():
  t = 0.01*frameCount
  xsun = 0.5*width
  ysun = 0.5*height
  # clear screen before each new frame
  background(128)
  # draw sun
  ellipse(xsun, ysun, 20, 20)
  rplanet = 200
  xplanet = xsun + rplanet*cos(t)
  yplanet = ysun + rplanet*sin(t)
  # draw planet
  ellipse(xplanet, yplanet, 10, 10)
  rmoon = 30
  xmoon = xplanet + rmoon*cos(t*365/27.3)
  ymoon = yplanet + rmoon*sin(t*365/27.3)
  # draw moon
  ellipse(xmoon, ymoon, 5, 5)
```

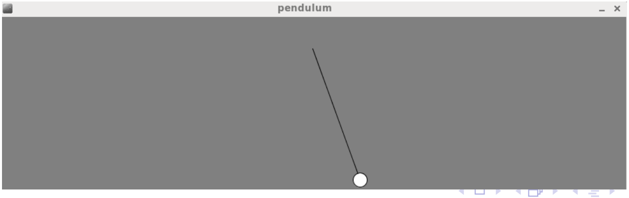
How about adding an inner planet?

```
def draw():
  ... other stuff suppressed ...
  # draw moon
  ellipse(xmoon, ymoon, 5, 5)
  # add second planet
  year_mercury_days = 115.88  # from Wikipedia
  T_ratio = year_mercury_days/365.25
  R_ratio = T_ratio**(2.0/3)
  xplanet = xsun + R_ratio*rplanet*cos(t/T_ratio)
  yplanet = ysun + R_ratio*rplanet*sin(t/T_ratio)
  ellipse(xplanet, yplanet, 7, 7)
```

Animate a pendulum (skip?)

```
def setup():
  size(900, 450)

def draw():
  t = 0.01*frameCount
  g = 9.8
  L = 2.0
  degree = PI/180
  amplitude = 20*degree
  omega = sqrt(g/L)
  theta = amplitude * sin(omega*t)
  xbob = L * sin(theta)
  ybob = L * cos(theta)
  # convert coordinates into pixel coordinates
  ... continued on next slide ...
```

```
def draw():
  ... continued from previous slide ...
  # convert coordinates into pixel coordinates
  xpixel_pivot = 0.5*width
  ypixel_pivot = 0.1*height
  scale = 100.0  # pixels per meter
  xpixel_bob = xpixel_pivot + scale*xbob
  ypixel_bob = ypixel_pivot + scale*ybob
  # clear the screen for each new frame of animation
  background(128)
  # draw the string
  line(xpixel_pivot, ypixel_pivot, xpixel_bob, ypixel_bob)
  # draw the bob
  ellipse(xpixel_bob, ypixel_bob, 20, 20)
```

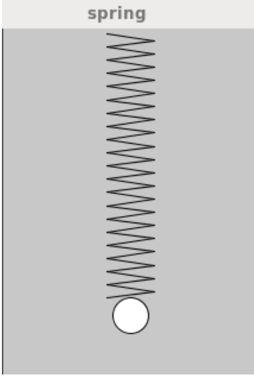


Animate a mass bobbing on a spring

```
def draw():
  t = 0.01*frameCount
  omega = 1.0
  amplitude = 0.5
  Lequilibrium = 2.0
  xbob = 0
  ybob = Lequilibrium + amplitude * cos(omega*t)
  xpixel_anchor = 0.5*width
  ypixel_anchor = 0.01*height
  scale = 100.0
  xpixel_bob = xpixel_anchor + scale*xbob
  ypixel_bob = ypixel_anchor + scale*ybob
  // draw the bob
  rbob = 15
  ellipse(xpixel_bob, ypixel_bob, 2*rbob, 2*rbob)
```

Clear screen between frames; draw the spring

```
def draw():
  ... other stuff suppressed ...
  # clear the screen for each new frame
  background(200)
  # draw the bob
  rbob = 15
  ellipse(xpixel_bob, ypixel_bob, 2*rbob, 2*rbob)
  # draw the spring as a series of zig-zag lines
  nzigzag = 20
  for i in range(nzigzag):
    spring_top = ypixel_anchor
    spring_bottom = ypixel_bob - rbob
    dy = (spring_bottom-spring_top)/nzigzag
    xzig = xpixel_anchor - 20
    yzig = ypixel_anchor + i*dy
    xzag = xpixel_anchor + 20
    ymid = yzig + 0.5*dy
    yzag = yzig + dy
    line(xzig, yzig, xzag, ymid)
    line(xzag, ymid, xzig, yzag)
```

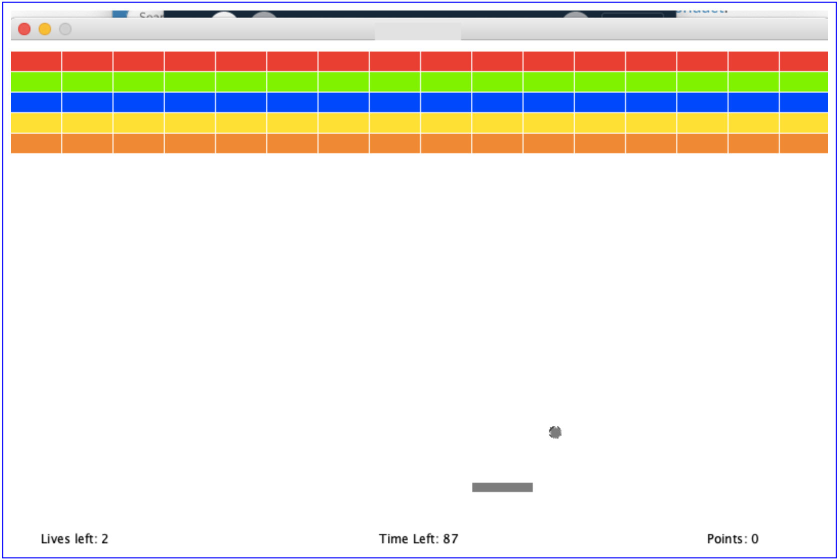


Let's add some "physics" to the spring.

```
# we will update position & velocity frame-by-frame,
# so we store them in these "global" variables
y = 1.49  # need to change this to make anything happen!
vy = 0.0

def draw():
  dt = 0.01
  k = 20.0
  m = 1.0
  g = 9.8
  Lrelaxed = 1.0
  y = y + vy*dt
  Fy = m*g - k*(y-Lrelaxed)
  vy = vy + (Fy/m)*dt
  xbob = 0
  ybob = Lrelaxed + y
  ... the rest is unchanged ...
```

https://en.wikipedia.org/wiki/Leapfrog_integration

A "breakout" game coded by a Fall 2017 (and Fall 2018) student.



This was done in Java Processing. Let's try to imitate it in Python!

```
def setup():
    size(900, 450)
    global b
    # Make rectangle location be its center position
    rectMode(CENTER)
    # Instantiate the state of the game board
    b = Breakout()

def draw():
    global b
    b.update()
    b.draw()

class Breakout:

    # "Constructor" for new Breakout object
    def __init__(self):
    ... continued on next slide ...
```

```
class Breakout:

    def __init__(self):
        # various screen boundaries
        self.ytop = 0.0
        self.ybot = height
        self.xleft = 0.0
        self.xright = width
        # ball's size, position, velocity
        self.rball = 7.0
        self.xball = 0.5*width
        self.yball = 0.5*height
        self.speed = 3.0
        self.vxball = self.speed/sqrt(2)
        self.vyball = self.speed/sqrt(2)

    def update(self):
        ... see next slide ...

    def draw(self):
        ... see next slide ...
```

```
class Breakout:

    def __init__(self):
        ... see previous slide ...

    def update(self):
        dt = 1.0
        # use ball velocity to update ball position
        self.xball += self.vxball*dt
        self.yball += self.vyball*dt
        # update ball velocity if it hits the game boundary
        if ((self.xball >= self.xright) or
            (self.xball <= self.xleft)):
            self.vxball *= -1.0
        if ((self.yball >= self.ybot) or
            (self.yball <= self.ytop)):
            self.vyball *= -1.0

    def draw(self):
        ... see next slide ...
```

```
class Breakout:

    def __init__(self):
        ... see earlier slide ...

    def update(self):
        ... see previous slide ...

    def draw(self):
        # clear the screen
        background(200)
        # draw the ball (black)
        fill(color(0, 0, 0))
        ellipse(self.xball, self.yball,
                2*self.rball, 2*self.rball)
```

```
... insert this into Breakout :: __init__
# paddle's location and x,y thickness
self.xpaddle = 0.5*width
self.ypaddle = 0.95*height
self.dxpaddle = 0.1*width
self.dypaddle = 0.02*height

... insert this into Breakout :: update
# make the paddle follow the horizontal mouse position
self.xpaddle = mouseX
# check for ball bouncing off of the paddle
if (abs(self.yball - self.ypaddle) < self.dypaddle/2 and
    abs(self.xball - self.xpaddle) < self.dxpaddle/2 and
        self.vyball > 0):
    self.vyball *= -1.0

... insert this into Breakout :: draw
# draw the paddle (white)
fill(color(255, 255, 255))
rect(self.xpaddle, self.ypaddle,
     self.dxpaddle, self.dypaddle)
```

```
class Brick:

    def __init__(self, x, y, dx, dy):
        self.x = x
        self.y = y
        self.dx = dx
        self.dy = dy
        self.rcolor = random(0, 255)
        self.gcolor = random(0, 255)
        self.bcolor = random(0, 255)

    def checkCollision(self, x, y):
        if abs(x-self.x) > 0.5*self.dx:
            return False
        if abs(y-self.y) > 0.5*self.dy:
            return False
        return True

    def draw(self):
        fill(color(self.rcolor, self.gcolor, self.bcolor))
        rect(self.x, self.y, self.dx, self.dy)
```

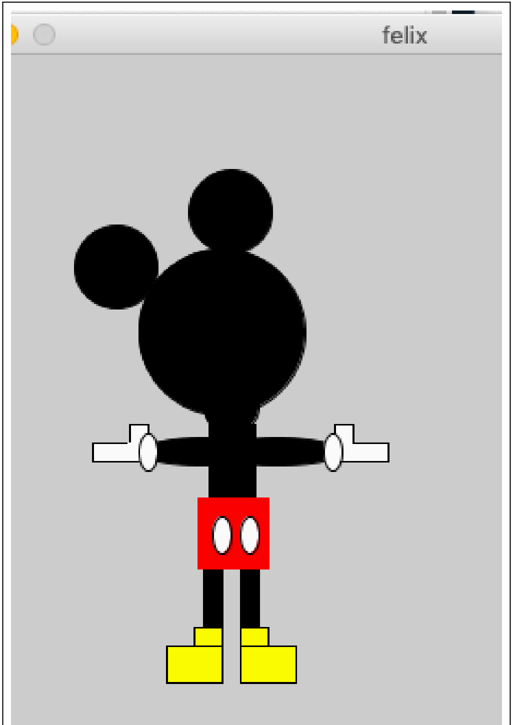
```
... insert into Breakout :: __init__
# make list of bricks
self.bricks = []
ncol = 10
for irow in range(5):
    for jcol in range(ncol):
        dxbrick = 1.0*width/ncol
        dybrick = 0.05*height
        xbrick = (jcol+0.5)*dxbrick
        if (irow % 2) != 0:
            xbrick += 0.5*dxbrick
        ybrick = 0.1*height + (irow+0.5)*dybrick
        self.bricks.append(Brick(x=xbrick, y=ybrick,
                                 dx=dxbrick, dy=dybrick))

... insert into Breakout :: draw
# draw the bricks
for b in self.bricks:
    b.draw()
```

```
... insert into Breakout :: update
# check for collisions with bricks
for i in range(len(self.bricks)):
    b = self.bricks[i]
    if b.checkCollision(self.xball, self.yball):
        # collision!  reverse the ball's velocity
        self.vxball *= -1.0
        self.vyball *= -1.0
        # delete the struck brick from the list!
        self.bricks.pop(i)
        # don't check any more bricks this frame,
        # as we modified the list of bricks
        break
```

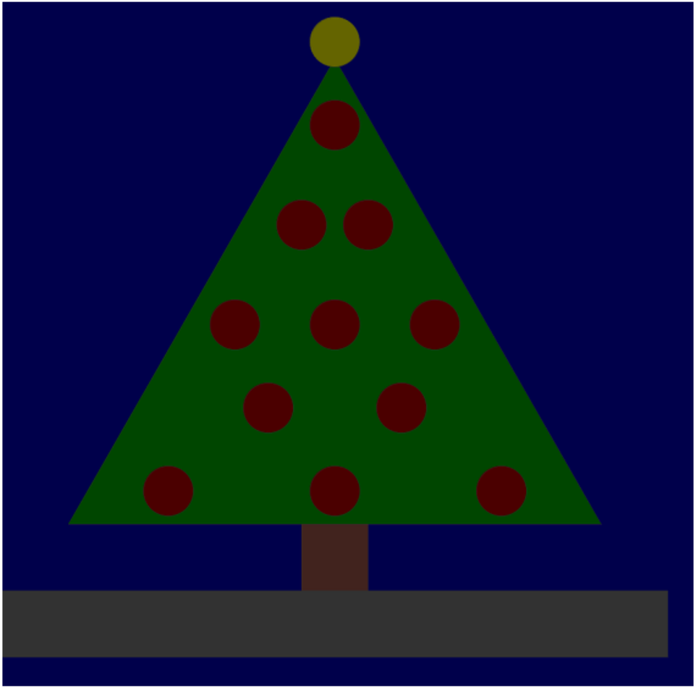
```
        ... in Breakout :: __init__
        self.previousMouseX = mouseX
...
        ... in Breakout :: update
        # estimate the horizontal velocity of the paddle
        vxpaddle = (mouseX - self.previousMouseX)/dt
        self.previousMouseX = mouseX
...
            ... upon detecting collision with paddle
            # allow paddle velocity to affect horizontal
            # ball velocity, since otherwise we can get
            # stuck with bricks that cannot be reached
            self.vxball += vxpaddle
            # don't let ball velocity become too horizontal
            minvh = 0.5*self.speed
            if abs(self.vyball) < minvh:
                self.vyball = -minvh
            # but keep the overall ball speed constant
            temp_speed = sqrt(self.vxball**2 + self.vyball**2)
            self.vxball *= self.speed/temp_speed
            self.vyball *= self.speed/temp_speed
```

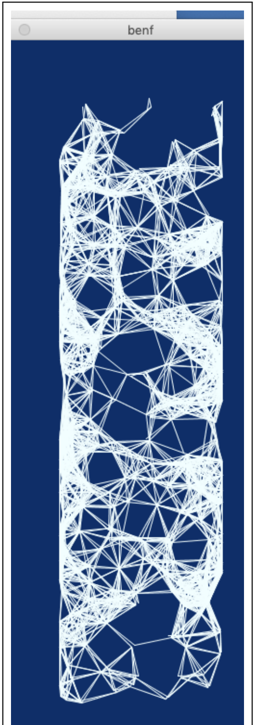

sketch_1121_breakout

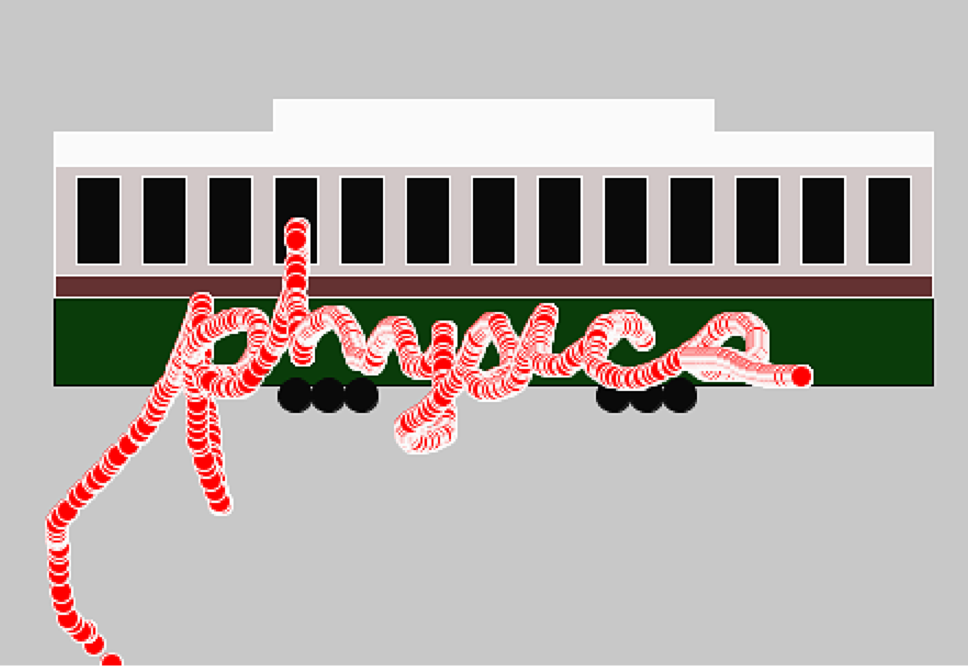
- The easiest way to get started with the original Java-based version of Processing is to start with this easy online video tutorial that will get you coding in Processing in about an hour! No download or software install is needed for this tutorial — you type your first programs directly into your web browser as you follow along with the video. `http://hello.processing.org`
- For the Python version, work through the first few tutorials at `http://py.processing.org/tutorials`
- If you're in Addams Hall often, you might ask Orkan Telhan if he has ideas — I believe he still teaches Processing in FNAR 264 / VLST 264, "Art, Design, and Digital Culture."
- There are also tons of examples at `http://processing.org` that you could use as starting points or for inspiration, though again these examples use the Java version of Processing.
- In Fall 2017, ten students sent me Processing sketches! I include a few screen captures on the next few slides.


felix

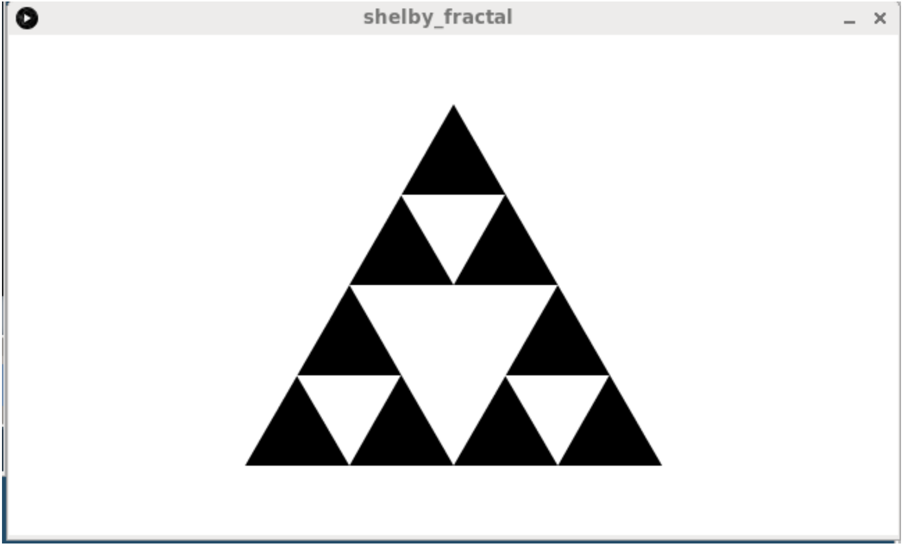

galena



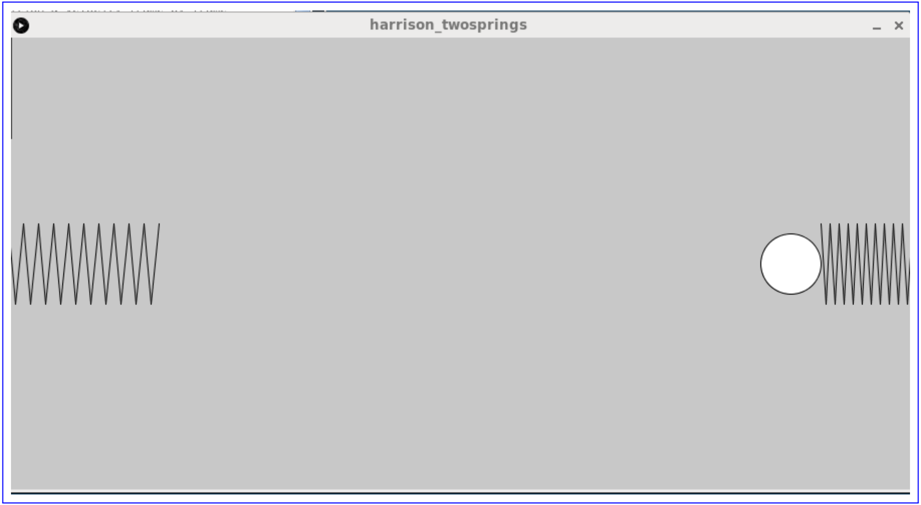

benf



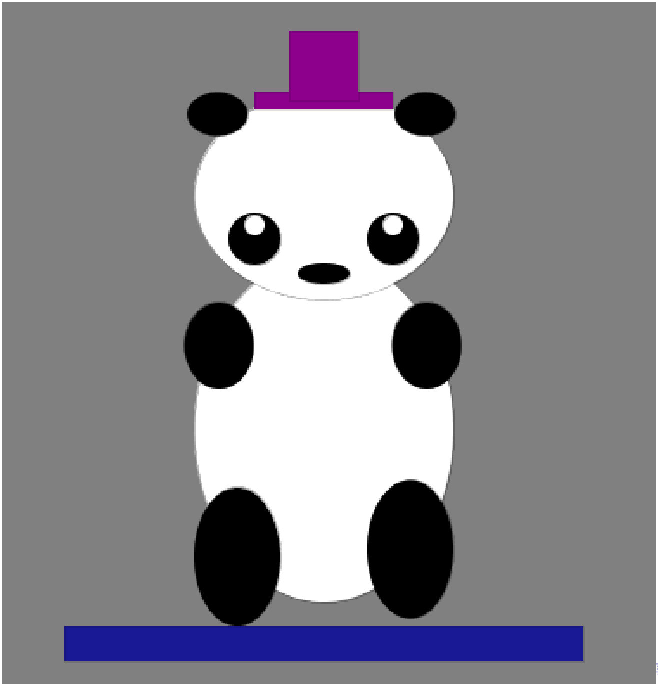
An example from a Fall 2013 student: drawing a fractal.



Another Fall 2013 student: ball bouncing between two springs

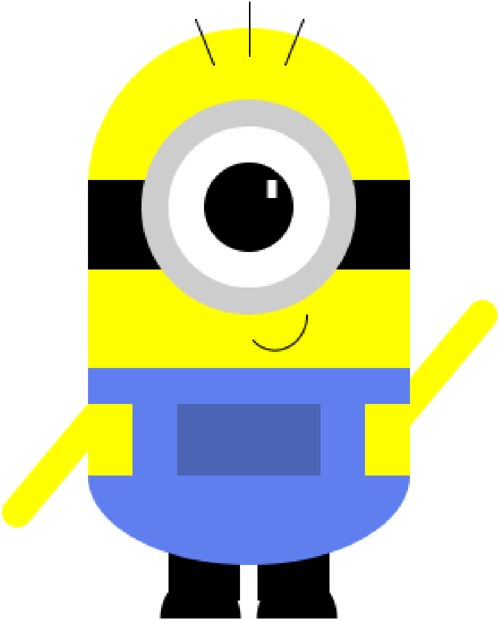


An example from a Fall 2015 student: an animated panda.



An example from a Fall 2015 student: a rotating fractal.

An example from a Fall 2015 student: a minion.



Fall 2015 student: bird moves where you move the mouse pointer.

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  - Use "Processing.py" (or ordinary "Processing") to write a program to draw or animate something that interests you. (Not necessarily physics-related.)
  - Knowing "how to code" is empowering & enlightening. So I offer you an excuse to give it a try, for extra credit, if you wish.
- Today's examples online at

http://positron.hep.upenn.edu/wja/p009/2018/files/pyprocessing/