Randomness in NumPy!

Pro tip

Always check your production environment before you deploy. Otherwise you might, as a hypothetical example, end up trying to give a presentation and find out the libraries you need aren't installed.

Announcements

- All future assignments and lessons will be on `Prairielearn` now.
- For your labs, you will log in to https://prairietest.org (https://prairietest.org) to get started.
- We are creating a canvas site for the course; main use will be as a gradebook.

In [ ]:

```
```

Randomness

Why do we want random numbers?

In [26]:

```
import numpy.random as rand
import numpy as np
from matplotlib.pyplot import imshow,show,plot
import matplotlib.pyplot as plt
```

In [4]:

```
rand.randint(1,100,3)
```

Out[4]:

```
array([84, 64, 78])
```

```
In [5]: print(rand.randint.__doc__)
```

```
randint(low, high=None, size=None, dtype=int)

Return random integers from `low` (inclusive) to `high` (exclusive).

Return random integers from the "discrete uniform" distribution of
the specified dtype in the "half-open" interval [`low`, `high`). If
`high` is None (the default), then results are from [0, `low`).

.. note::
    New code should use the ``integers`` method of a ``default_rng()``
    instance instead; please see the :ref:`random-quick-start`.

Parameters
----------
low : int or array-like of ints
    Lowest (signed) integers to be drawn from the distribution (unless
    ``high=None``, in which case this parameter is one above the
    *highest* such integer).
high : int or array-like of ints, optional
    If provided, one above the largest (signed) integer to be drawn
    from the distribution (see above for behavior if ``high=None``).
    If array-like, must contain integer values
size : int or tuple of ints, optional
    Output shape.  If the given shape is, e.g., ``(m, n, k)``, then
    ``m * n * k`` samples are drawn.  Default is None, in which case a
    single value is returned.
dtype : dtype, optional
    Desired dtype of the result. Byteorder must be native.
    The default value is int.

    .. versionadded:: 1.11.0

Returns
-------
out : int or ndarray of ints
    `size`-shaped array of random integers from the appropriate
    distribution, or a single such random int if `size` not provided.

See Also
--------
random_integers : similar to `randint`, only for the closed
    interval [`low`, `high`], and 1 is the lowest value if `high` is
    omitted.
random.Generator.integers: which should be used for new code.

Examples
--------
>>> np.random.randint(2, size=10)
array([1, 0, 0, 0, 1, 1, 0, 0, 1, 0]) # random
>>> np.random.randint(1, size=10)
array([0, 0, 0, 0, 0, 0, 0, 0, 0, 0])

Generate a 2 x 4 array of ints between 0 and 4, inclusive:

>>> np.random.randint(5, size=(2, 4))
array([[4, 0, 2, 1], # random
       [3, 2, 2, 0]])

Generate a 1 x 3 array with 3 different upper bounds

>>> np.random.randint(1, [3, 5, 10])
array([2, 2, 9]) # random

Generate a 1 by 3 array with 3 different lower bounds

>>> np.random.randint([1, 5, 7], 10)
array([9, 8, 7]) # random

Generate a 2 by 4 array using broadcasting with dtype of uint8
```

```
>>> np.random.randint([1, 3, 5, 7], [[10], [20]], dtype=np.uint8)
array([[ 8,  6,  9,  7], # random
       [ 1, 16,  9, 12]], dtype=uint8)
```

```
In [ ]:
```

Reminder of a couple of utilities

```
In [6]: "5,20".split(",")
```

```
Out[6]: ['5', '20']
```

```
In [7]: "3d20".split("d")
```

```
Out[7]: ['3', '20']
```

```
In [10]: sum(np.array([2,5,9]))
```

```
Out[10]: 16
```

Try this!

Anyone play tabletop games like Dungeons and Dragons? Make a dice rolling function.

Call `roll("3d6")` to roll 3 6-sided dices and return the sum.

```
In [13]: "2d20".split("d")
```

```
Out[13]: ['2', '20']
```

```
In [14]: rand.randint(1,21,2)
```

```
Out[14]: array([ 1, 11])
```

```
In [21]: def roll(spec):
             times = 1
             size = 1
             try:
                 [times,size] = spec.split("d")
             except:
                 print("Invalid format.")
                 return 0
             result = sum(rand.randint(1,int(size)+1,int(times)))
             return result
```

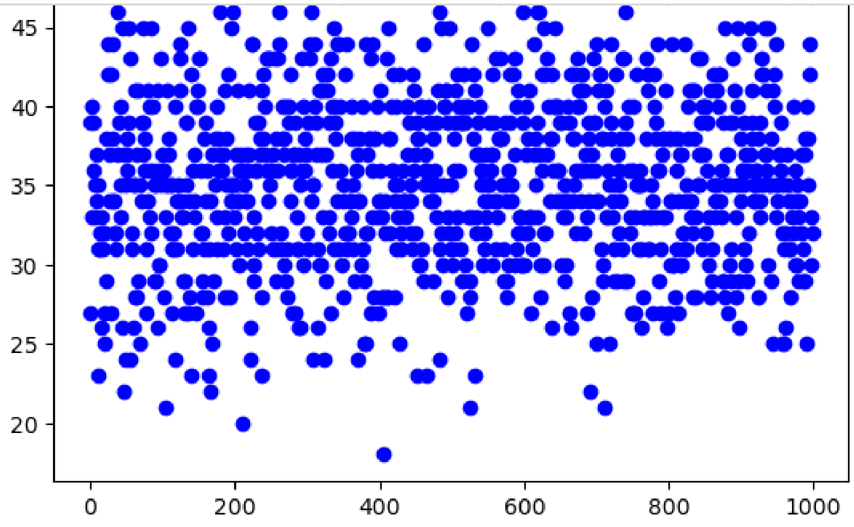
```
In [25]: roll("3d6")
```

```
Out[25]: 8
```

```
In [12]: sum(rand.randint(1,7,3))
```

```
Out[12]: 12
```

In [28]:
```
numbers = list(map(lambda x: roll("10d6") , range(1000)))
plt.plot( numbers,'bo' )
```



In [ ]:

Shuffle and Choice

- `shuffle` randomizes the order
- `choice` picks a random element.

What if you wanted to pick 5 random elements and be sure that nothing got picked twice?

Write a function `pick(x,n)` that picks n elements from x "without repetition".

In [34]:
```
cards = ['a','b','c']
rand.shuffle(cards)
cards
```

Out[34]:
```
['b', 'c', 'a']
```

In [35]:
```
rand.choice(cards)
```

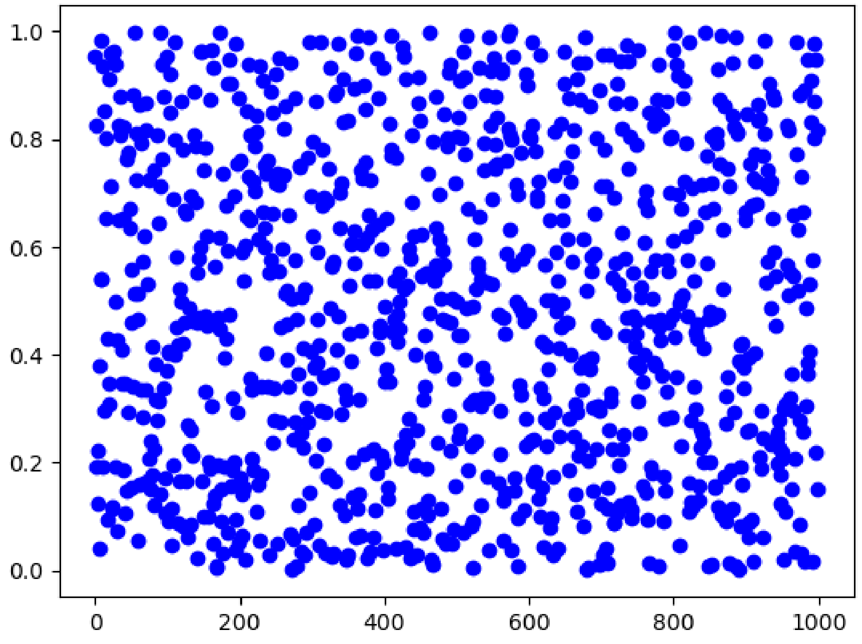
Out[35]:
```
'c'
```

Distributions

If every number is equally likely, you get a *uniform* distribution.

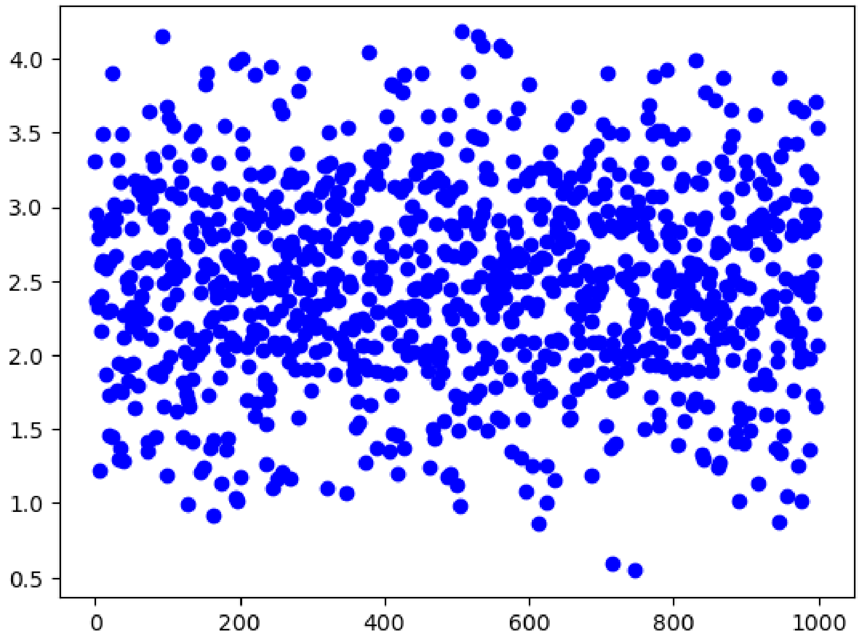
```
In [37]: numbers = rand.uniform( size=1000 )
         plt.plot( numbers,'bo' )
         rand.uniform( )

Out[37]: 0.5450808014552269
```



```
In [38]: n1 = rand.uniform(size=1000)
         n2 = rand.uniform(size=1000)
         n3 = rand.uniform(size=1000)
         n4 = rand.uniform(size=1000)
         n5 = rand.uniform(size=1000)
         plt.plot(n1 + n2 + n3 + n4 + n5, 'bo')

Out[38]: [<matplotlib.lines.Line2D at 0x7fb522b075e0>]
```



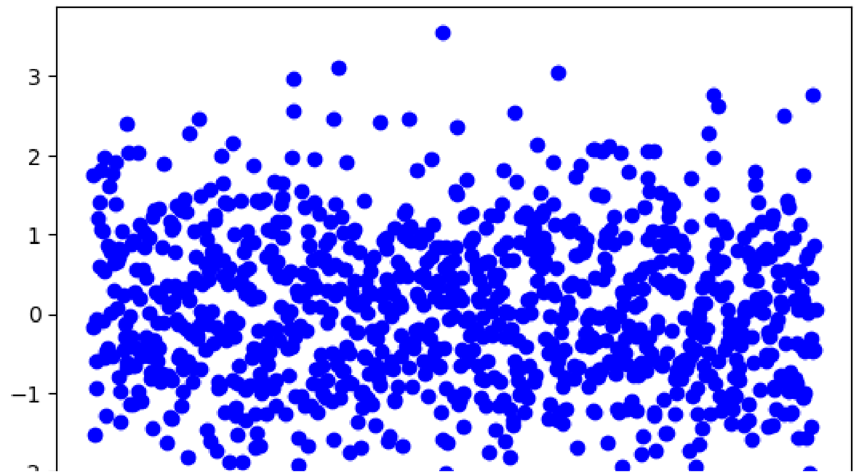
```
In [ ]:
```

When probabilities are summed...

... you get a "normal" distribution. *Statitistics disclaimer: this is simplified a bit...*

```
In [39]: numbers = rand.normal( size=1000 )
         plt.plot( numbers,'bo' )
```

```
Out[39]: [<matplotlib.lines.Line2D at 0x7fb522971540>]
```



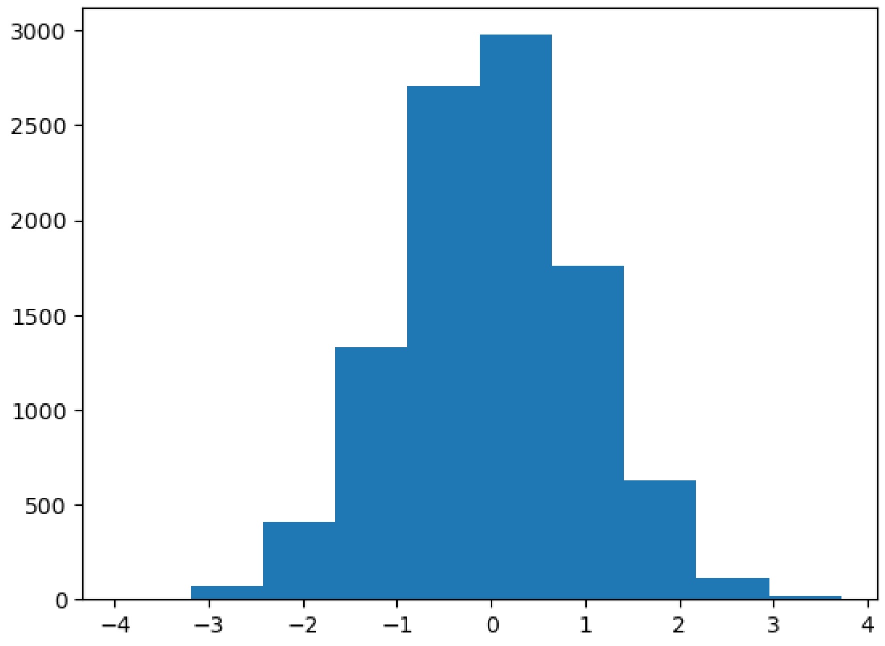
```
In [ ]:
```

Histograms

- Examples:
  - Show uniform histogram
  - Take histogram of 3d6 - why doesn't it work?

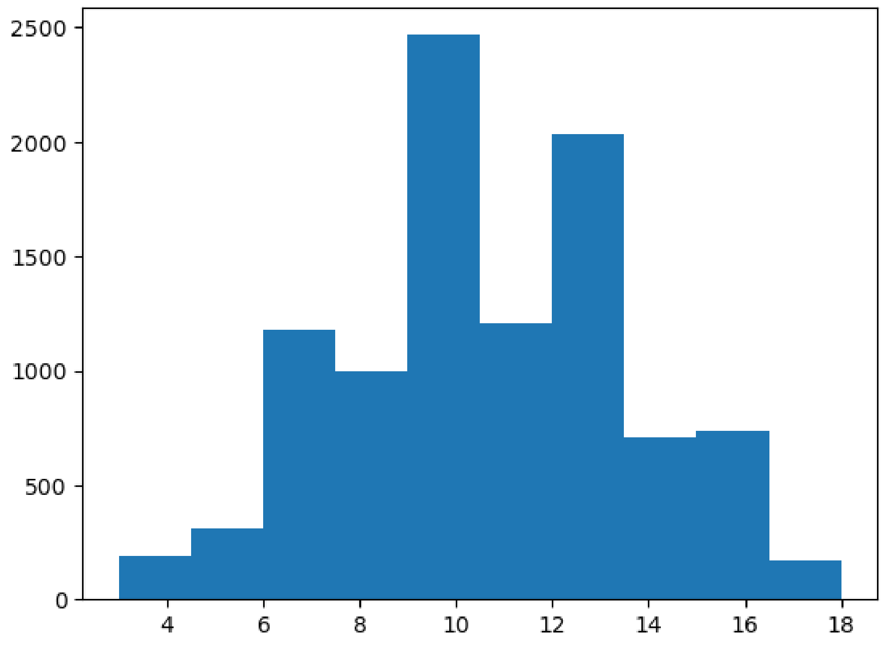
```
In [40]: plt.hist(rand.normal(size=10000))
```

```
Out[40]: (array([2.000e+00, 6.700e+01, 4.050e+02, 1.327e+03, 2.705e+03, 2.974e+03,
                 1.760e+03, 6.300e+02, 1.110e+02, 1.900e+01]),
          array([-3.95863513, -3.19040929, -2.42218345, -1.65395761, -0.88573177,
                 -0.11750593,  0.65071991,  1.41894575,  2.18717159,  2.95539743,
                  3.72362327]),
          <BarContainer object of 10 artists>)
```



```
In [41]: plt.hist(rand.randint(1,7,10000) + rand.randint(1,7,10000) + rand.randint(1,7,10000))
```

```
Out[41]: (array([ 193.,  307., 1182.,  994., 2466., 1207., 2035.,  708.,  736.,
                  172.]),
          array([ 3. ,  4.5,  6. ,  7.5,  9. , 10.5, 12. , 13.5, 15. , 16.5, 18. ]),
          <BarContainer object of 10 artists>)
```



In [ ]:

In [ ]:

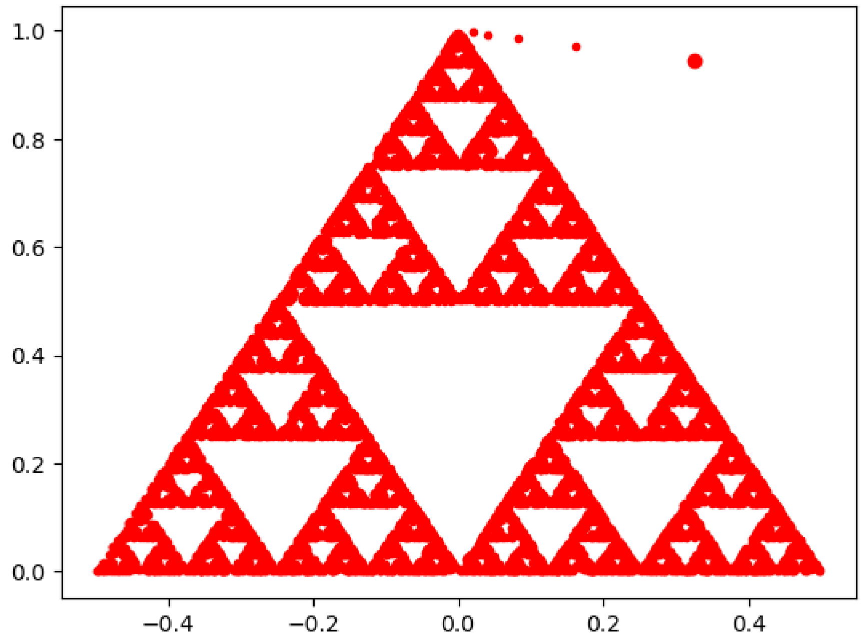
Fern Fractals

Let's do a random fractal!

In [42]:
```
px = [ -0.5, 0, 0.5]
py = [ 0, 1, 0 ]

rx = rand.uniform( )
ry = rand.uniform( )
plt.plot(rx,ry,"ro")

for i in range(10000):
    z = rand.randint(0,3)
    rx = (rx + px[z])/2
    ry = (ry + py[z])/2
    plt.plot(rx,ry,"r.")
```



In [48]:
```
def estPi(times):
    inCount = 0
    for i in range(times):
        x = rand.uniform( )
        y = rand.uniform( )
        if (np.sqrt(x*x + y * y) <= 1.0):
            inCount = inCount + 1
    return inCount * 4 / times
```

In [61]:
```
estPi(1000000)
```

Out[61]:
```
3.141792
```

In [ ]: