CS589 ASSIGNMENT 2

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In [21]:
```
import pangolin as pg
```

Question 1

In [22]:
```
from scipy.stats import norm
```

In [23]:
```
x = [1, 2, 3, 4, 5, 6]
y = [0, 1.5, 1.0, 0.5, 1.2, 2.5]
slopes_values = [0, 0.25, 0.5, 0.75, 1]

def Probability_Y_Given_S(slope_value, x, y):
    y_equation = slope_value * x
    prob_y = norm.pdf(y, loc=y_equation, scale=1)
    return prob_y

probs_of_all_s = [1 for _ in range(len(slopes_values))]
for i, s in enumerate(slopes_values):
    for j in range(len(x)):
        cur_x, cur_y = x[j], y[j]
        prob_y_given_s = Probability_Y_Given_S(s, cur_x, cur_y)
        probs_of_all_s[i] *= prob_y_given_s

posterior = [.2 * p for p in probs_of_all_s]
sm = sum(posterior)
normal_posterior = [p / sm for p in posterior]
normal_posterior
```

Out[23]:
```
[0.009456905156440607,
 0.7751024227873098,
 0.21523816927002018,
 0.00020250214073843964,
 6.454908376547967e-10]
```

Question 2

In [26]:
```
inputs = [1, 2, 3, 4, 5, 6]
outputs = [0, 1.5, 1.0, 0.5, 1.2, 2.5]

w = pg.categorical([.2,.2,.2,.2,.2])
s_values = pg.makerv([0, 0.25, 0.5, 0.75, 1])
s_floats = [0, 0.25, 0.5, 0.75, 1]
noise = pg.normal(0, 1)



y = [pg.normal(s_values[w] * x, 1) for x in inputs]
```

```
w_samples, n_samples = pg.sample((w, noise), y, outputs)
w_samples = [.25 * w for w in w_samples]

probs = [0 for i in range(len(s_values))]
for j, s in enumerate(w_samples):
    for i, sval in enumerate(s_floats):
        if s == sval:
            probs[i] += 1

probs = [p / len(w_samples) for p in probs]

posterior = [p * .2 for p in probs]

s = sum(posterior)
normal_posterior = [p / s for p in posterior]
normal_posterior
```

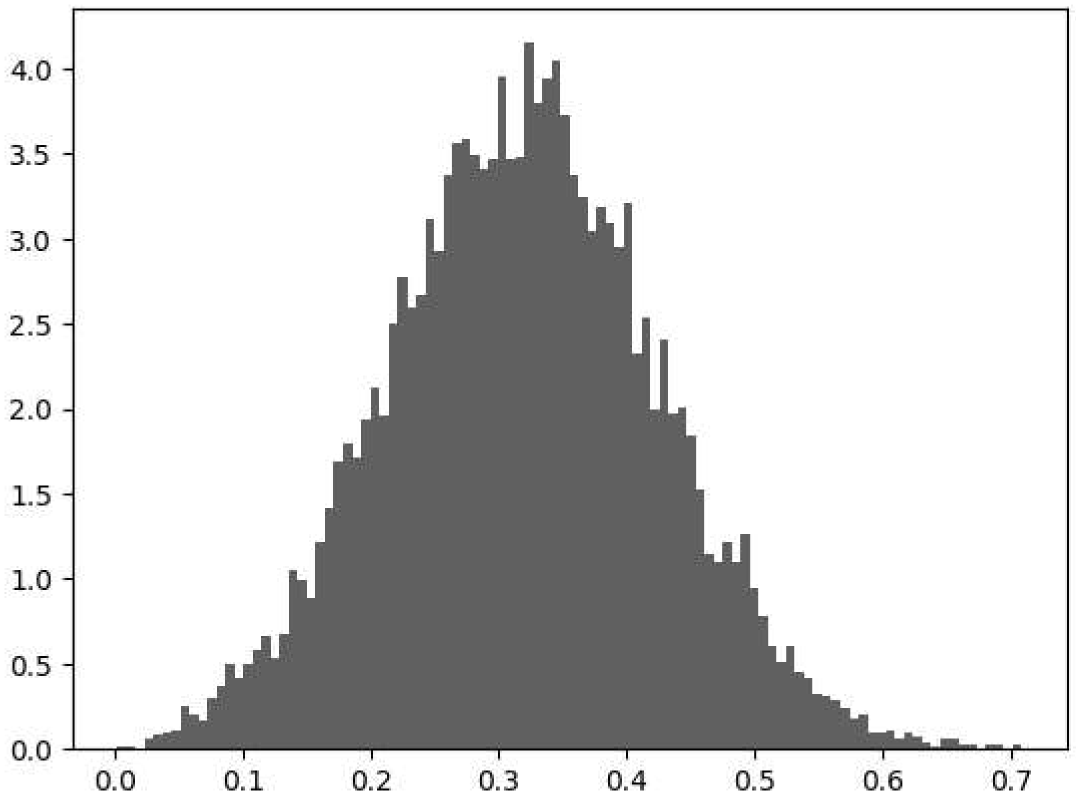
Out[26]:
```
[0.011299999999999998, 0.7761, 0.2122, 0.00039999999999999996, 0.0]
```

Question 3

In [27]:
```
import matplotlib.pyplot as plt
```

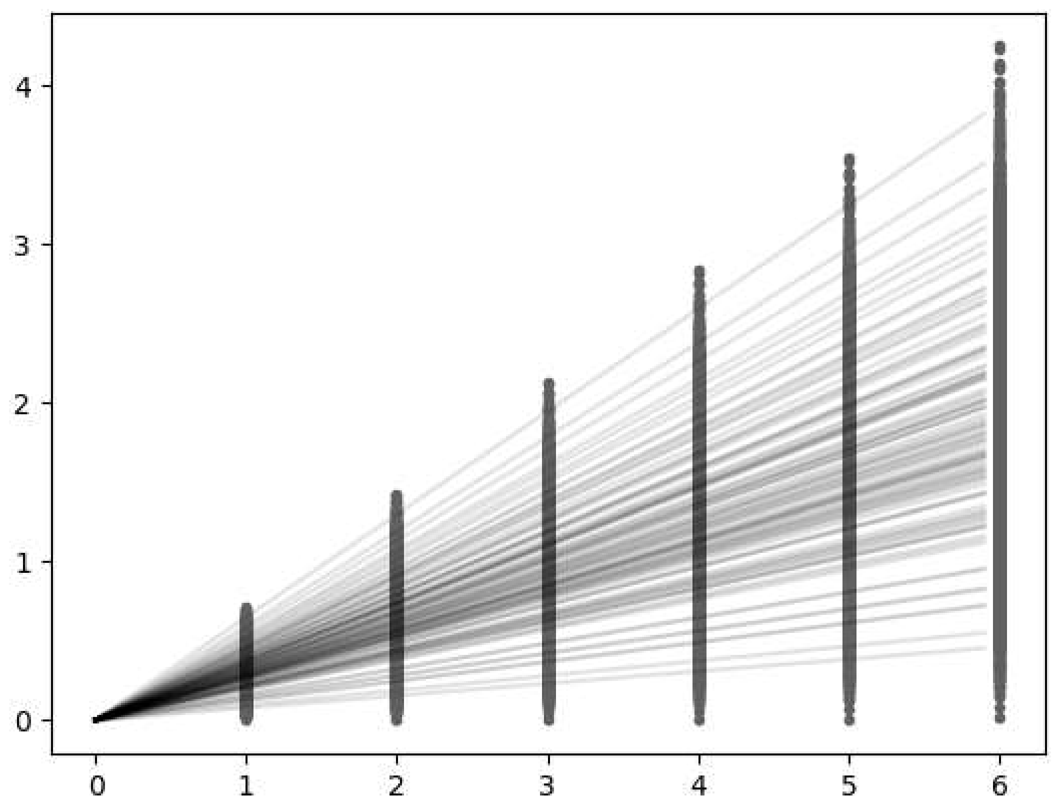
In [28]:
```
inputs = [1, 2, 3, 4, 5, 6]
outputs = [0, 1.5, 1.0, 0.5, 1.2, 2.5]


s = pg.uniform(0, 1)
s_floats = [i * .1 for i in range(0, 10)]
noise = pg.normal(0, 1)


y = [pg.normal(s * x, 1) for x in inputs]



s_samples, n_samples = pg.sample((s, noise), y, outputs)
plt.hist(s_samples, density=True, bins=100)
```

```
Out[28]: (array([0.01415681, 0.01415681, 0.        , 0.05662723, 0.08494085,
         0.09909766, 0.11325447, 0.25482255, 0.19819532, 0.1698817 ,
         0.29729298, 0.36807702, 0.4954883 , 0.41054745, 0.4954883 ,
         0.58042915, 0.66537   , 0.53795872, 0.67952752, 1.04760272,
         0.99097764, 0.89187799, 1.21748681, 1.41567935, 1.68466198,
         1.79791278, 1.71297563, 1.93948071, 2.12352351, 1.95363751,
         2.50575774, 2.77473153, 2.59069868, 2.66147718, 3.11450114,
         2.93046244, 3.36931686, 3.56751197, 3.58166876, 3.49674275,
         3.41178724, 3.46841441, 3.94974539, 3.46842905, 3.48257121,
         4.1479405 , 3.79402066, 3.9356052 , 4.04884295, 3.7232367 ,
         3.36931686, 3.24191939, 3.04371061, 3.18527854, 3.08619401,
         2.94461305, 3.21359213, 2.32171414, 2.53407673, 1.99610789,
         2.4066549 , 1.9677943 , 2.01027316, 1.84038316, 1.5289337 ,
         1.14670028, 1.10423455, 1.21748424, 1.10422989, 1.25995462,
         0.94850517, 0.77862364, 0.60874726, 0.50964457, 0.60874212,
         0.45301739, 0.41054701, 0.32560625, 0.31144946, 0.28313587,
         0.24066752, 0.18403832, 0.19819511, 0.09909755, 0.09909755,
         0.11325435, 0.05662717, 0.09909755, 0.07078456, 0.04247038,
         0.01415679, 0.05662717, 0.05662717, 0.02831359, 0.02831359,
         0.        , 0.02831383, 0.02831359, 0.        , 0.02831359]),
  array([0.00215142, 0.00921515, 0.01627889, 0.02334263, 0.03040637,
         0.03747011, 0.04453385, 0.05159759, 0.05866133, 0.06572507,
         0.0727888 , 0.07985254, 0.08691628, 0.09398002, 0.10104376,
         0.1081075 , 0.11517124, 0.12223498, 0.12929872, 0.13636245,
         0.14342619, 0.15048993, 0.15755367, 0.1646174 , 0.17168115,
         0.17874488, 0.18580863, 0.19287236, 0.19993611, 0.20699984,
         0.21406358, 0.22112732, 0.22819106, 0.23525479, 0.24231854,
         0.24938227, 0.256446  , 0.26350975, 0.2705735 , 0.27763724,
         0.28470096, 0.29176471, 0.29882845, 0.3058922 , 0.31295592,
         0.32001966, 0.32708341, 0.33414716, 0.34121087, 0.34827462,
         0.35533836, 0.36240211, 0.36946583, 0.37652957, 0.38359332,
         0.39065704, 0.39772078, 0.40478453, 0.41184828, 0.41891199,
         0.42597574, 0.43303949, 0.44010323, 0.44716695, 0.4542307 ,
         0.46129444, 0.46835819, 0.47542191, 0.48248565, 0.4895494 ,
         0.49661314, 0.50367689, 0.51074064, 0.51780432, 0.52486807,
         0.53193182, 0.53899556, 0.54605931, 0.55312306, 0.5601868 ,
         0.56725055, 0.57431424, 0.58137798, 0.58844173, 0.59550548,
         0.60256922, 0.60963297, 0.61669672, 0.62376046, 0.63082415,
         0.6378879 , 0.64495164, 0.65201539, 0.65907913, 0.66614288,
         0.67320663, 0.68027037, 0.68733406, 0.69439781, 0.70146155,
         0.7085253 ]),
  <BarContainer object of 100 artists>)
```



Question 4

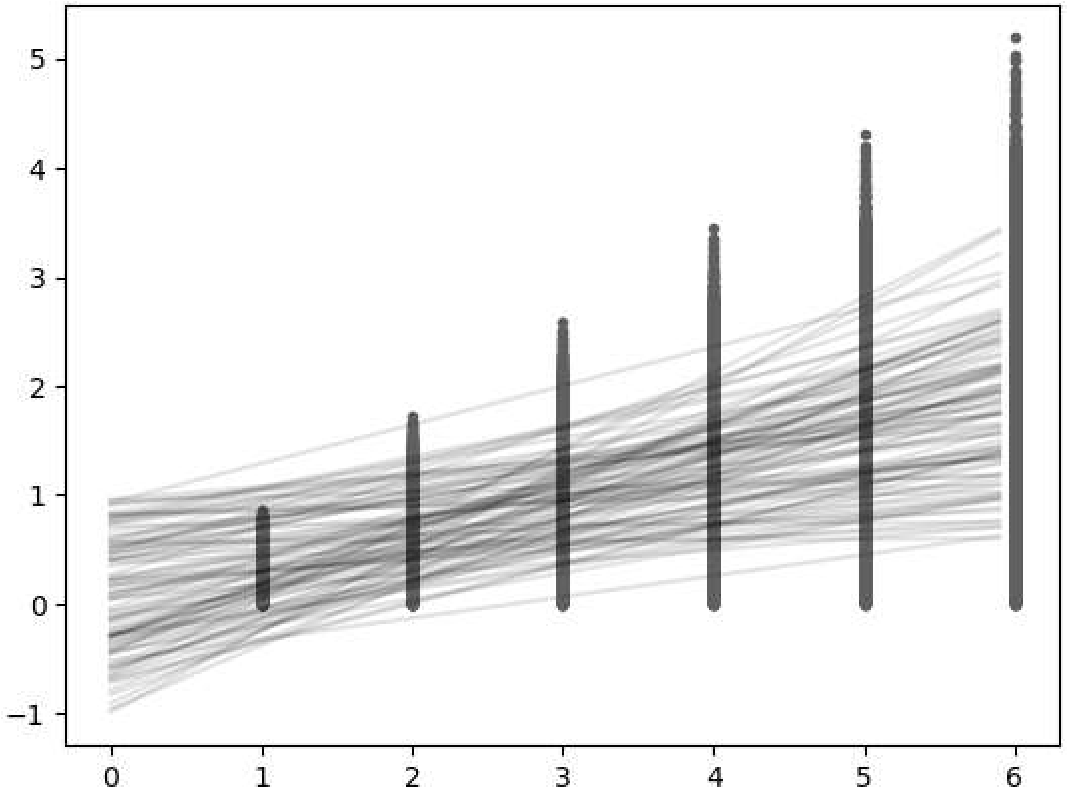
```
In [29]: import numpy as np

x,y = [x for s in s_samples for x in inputs], [s * x for s in s_samples for x in in

plt.plot(x,y,'.')
for s in s_samples[::100]:
    xs = np.arange(0,6,.1)
    plt.plot(xs, s*xs,'k-',alpha=0.1)
```



Question 5

In [30]:
```
inputs = [1, 2, 3, 4, 5, 6]
outputs = [0, 1.5, 1.0, 0.5, 1.2, 2.5]



s = pg.uniform(0, 1)
s_floats = [0, 0.25, 0.5, 0.75, 1]
noise = pg.normal(0, 1)
bias = pg.uniform(-1,1)

y = [pg.normal(bias + s * x, 1) for x in inputs]




s_samples, n_samples, bias_samples = pg.sample((s, noise, bias), y, outputs)

probs = [0 for i in range(len(s_floats))]
for j, s in enumerate(s_samples):
    for i, sval in enumerate(s_floats):
        if s <= sval + .25 and s >= sval:
            probs[i] += 1

probs = [p / len(s_samples) for p in probs]

posterior = [p * .2 for p in probs]

s = sum(posterior)
normal_posterior = [p / s for p in posterior]
normal_posterior
```

```
x,y = [x for s in s_samples for x in inputs], [s * x for s in s_samples for x in in
plt.plot(x,y,'.')
for (b, s) in zip(bias_samples[::100], s_samples[::100]):
    xs = np.arange(0,6,.1)
    plt.plot(xs, b + s*xs,'k-',alpha=0.1)
```



Question 6

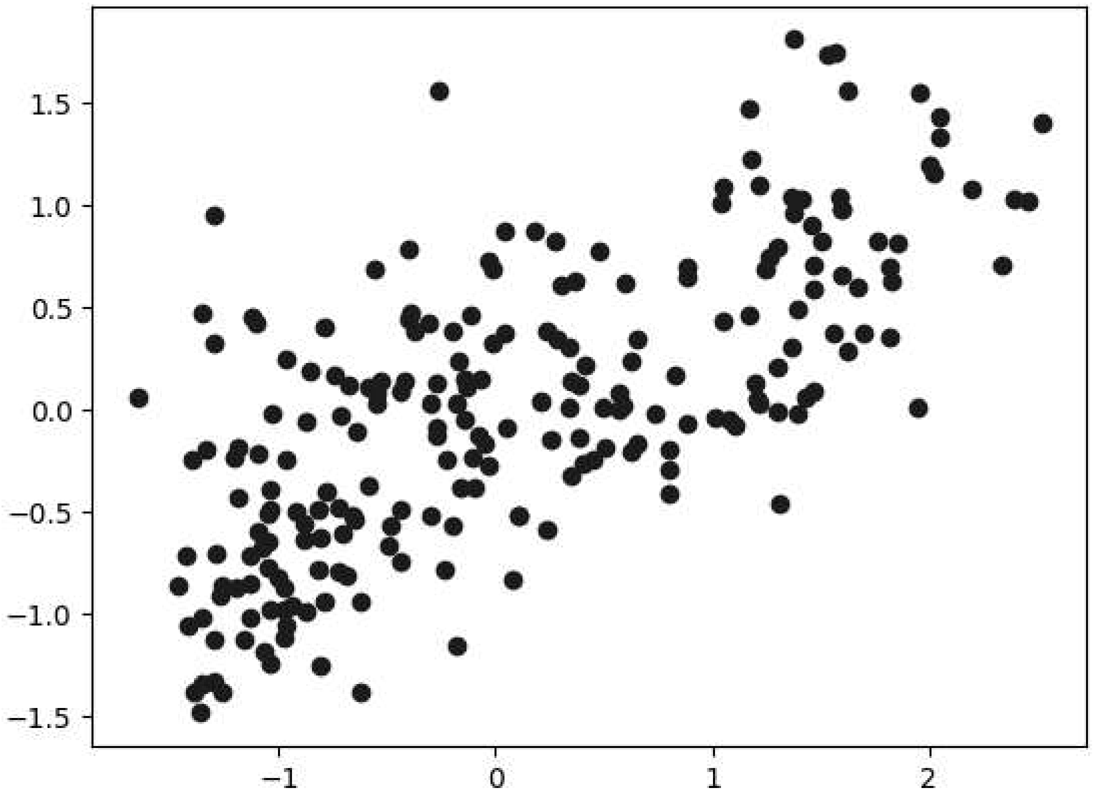
```
In [31]: import numpy as np
         from sklearn.datasets import load_diabetes
         X,y = load_diabetes(return_X_y=True)
         y = y - np.mean(y)
         y = y / np.std(y)

         X_train = X[1::2]
         X_test = X[::2]
         y_train = y[1::2]
         y_test = y[::2]


         num_train, num_features = X_train.shape
         num_test = X_test.shape[0]

         X_train = pg.makerv(X_train)


         dist_y_train = pg.slot()
         w = pg.slot()
         with pg.Loop(num_features) as i:
             w[i] = pg.normal(0, 10)
```

```
with pg.Loop(len(X_train)) as j:
    x = X_train[j]
    dist_y_train[j] = pg.normal(w @ x, 1)

dist_y_test = [pg.normal(w @ X_test[i], 1) for i in range(len(X_test))]



e = pg.E(dist_y_test, dist_y_train, y_train)
print("mean: ", np.mean(e))
w_samples = pg.sample((dist_y_test), dist_y_train, [y for y in y_train], niter=100)
```

```
mean:  0.016898083
```

In [32]:
```
import matplotlib.pyplot as plt
X_test = np.array(X_test)
w_samples = np.array([np.median(row) for row in w_samples])
y_test = np.array(y_test)
plt.scatter(y_test, w_samples, color='blue')
```

Out[32]:
```
<matplotlib.collections.PathCollection at 0x2063a03af10>
```



In [33]:
```
# calculate mean squared difference
sq_diff = (w_samples - y_test) ** 2
mean_sq_diff = np.mean(sq_diff)
mean_sq_diff
```

Out[33]:
```
0.5697750148423903
```

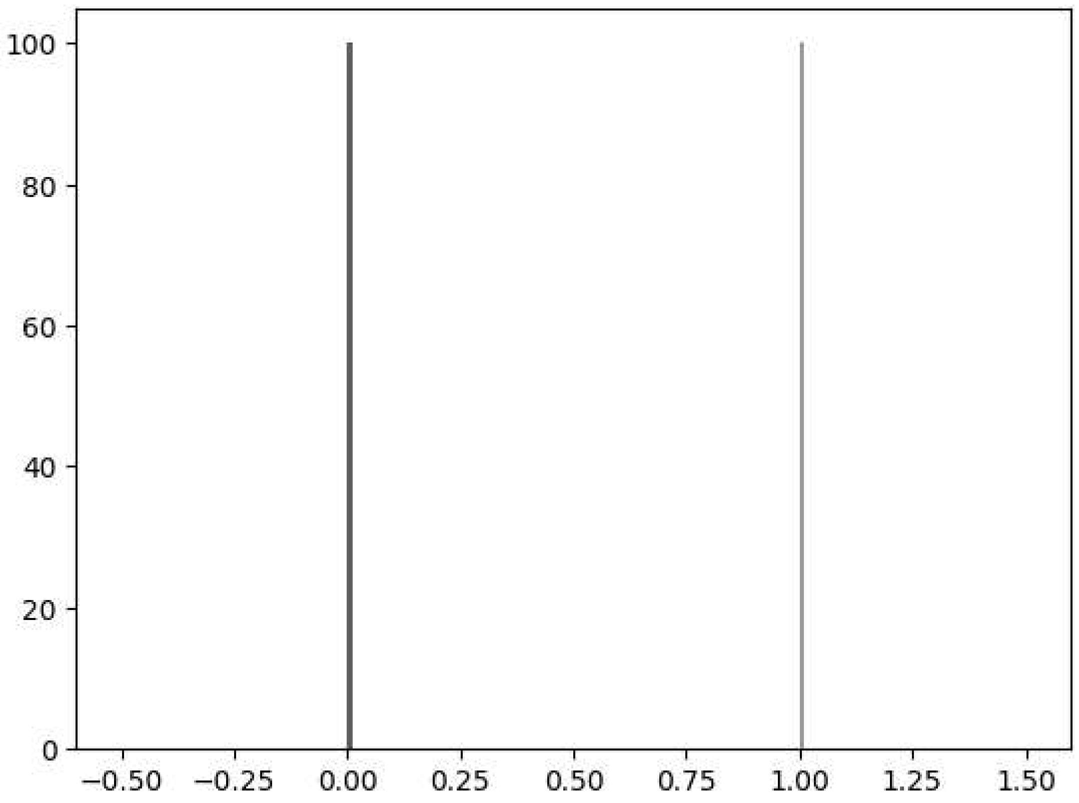
Question 7

```
In [34]: from sklearn.datasets import load_breast_cancer
         X,y = load_breast_cancer(return_X_y=True)

         X_train = X[1::2]
         X_test = X[::2]
         y_train = y[1::2]
         y_test = y[::2]

         num_train, num_features = X_train.shape
         num_test = X_test.shape[0]

         X_train = pg.makerv(X_train)



         w = pg.slot()
         with pg.Loop(num_features) as i:
             w[i] = pg.normal(0, 10)

         dist_y_train = pg.slot()
         with pg.Loop(len(X_train)) as j:
             x = X_train[j]
             dist_y_train[j] = pg.bernoulli(pg.sigmoid(w @ x))



         sigmoids = [pg.sigmoid(w @ X_test[i]) for i in range(len(X_test))]
         bernoullis = [pg.bernoulli(sigmoids[i]) for i in range(len(sigmoids))]



         e= pg.E(bernoullis, dist_y_train, y_train)
         print("mean: ", np.mean(e))
         zeroes = [expected_val for expected_val in e if expected_val == 0]
         ones = [expected_val for expected_val in e if expected_val == 1]
```

```
mean:  0.6219765
```

```
In [36]: plt.hist(zeroes, density=True, bins=100)
         plt.hist(ones, density=True, bins=100)
```

```
Out[36]: (array([  0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        , 100.00009537,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ,
           0.        ,   0.        ,   0.        ,   0.        ]),
  array([0.5       , 0.50999999, 0.51999998, 0.52999997, 0.54000002,
         0.55000001, 0.56      , 0.56999999, 0.57999998, 0.58999997,
         0.60000002, 0.61000001, 0.62      , 0.63      , 0.63999999,
         0.64999998, 0.66000003, 0.67000002, 0.68000001, 0.69      ,
         0.69999999, 0.70999998, 0.72000003, 0.73000002, 0.74000001,
         0.75      , 0.75999999, 0.76999998, 0.77999997, 0.79000002,
         0.80000001, 0.81      , 0.81999999, 0.82999998, 0.83999997,
         0.85000002, 0.86000001, 0.87      , 0.88      , 0.88999999,
         0.89999998, 0.91000003, 0.92000002, 0.93000001, 0.94      ,
         0.94999999, 0.95999998, 0.97000003, 0.98000002, 0.99000001,
         1.        , 1.00999999, 1.01999998, 1.02999997, 1.03999996,
         1.04999995, 1.05999994, 1.07000005, 1.08000004, 1.09000003,
         1.10000002, 1.11000001, 1.12      , 1.13      , 1.13999999,
         1.14999998, 1.15999997, 1.16999996, 1.17999995, 1.19000006,
         1.20000005, 1.21000004, 1.22000003, 1.23000002, 1.24000001,
         1.25      , 1.25999999, 1.26999998, 1.27999997, 1.28999996,
         1.29999995, 1.30999994, 1.32000005, 1.33000004, 1.34000003,
         1.35000002, 1.36000001, 1.37      , 1.38      , 1.38999999,
         1.39999998, 1.40999997, 1.41999996, 1.42999995, 1.44000006,
         1.45000005, 1.46000004, 1.47000003, 1.48000002, 1.49000001,
         1.5       ]),
  <BarContainer object of 100 artists>)
```



100
80
60
40
20
0
−0.50
−0.25
0.00
0.25
0.50
0.75
1.00
1.25
1.50