1) $\mu = 100 \quad \sigma = 50$

a) 0.962

b) 0.705

c) 0.655

d) 0.125

Work found in Jupyter Notebook

2) $q = 1 - P$

Discrete mean formula: $\mu = \sum x P(x)$

Discrete Variance formula: $\sigma^2 = \sum (x-\mu)^2 P(x)$

$$\mu = (1)(P) + (0)(q) = P$$

$$\sigma^2 = (1-P)^2(P) + (0-P)^2(1-P)$$

$$= (q)^2(P) + (P)^2(q) = Pq(q+P) = Pq(1-P+P)$$

$$\sigma^2 = Pq$$

$$\sigma = \sqrt{Pq}$$

3) $u = 1.005 \qquad P = .7$

$d = 0.994 \qquad q = .3$

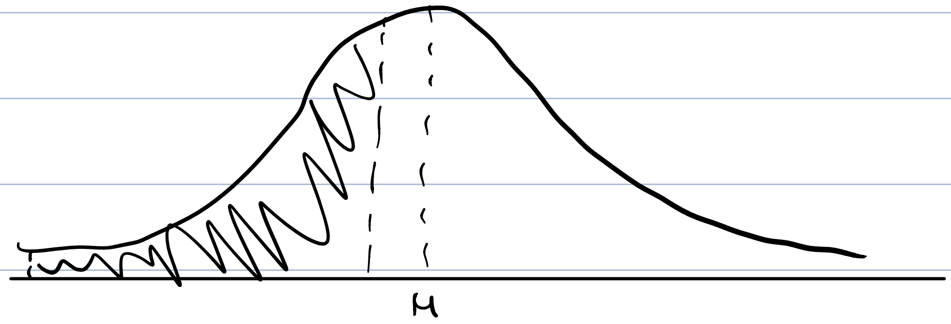
$\mu = 0.7$

$\sigma = \sqrt{Pq} = \sqrt{0.7 \cdot 0.3} = 0.458 \qquad n = 252$

$1.005^r(0.994)^{252-r} = 1.5 \qquad 1.005^r(0.994)^{252-r} = \frac{2}{3}$

$r = \frac{\ln\left(\frac{1.5}{(0.994)^{252}}\right)}{\ln\left(\frac{1.005}{0.994}\right)} = 174.64 \qquad r = \frac{\ln\left(\frac{\frac{2}{3}}{(0.994)^{252}}\right)}{\ln\left(\frac{1.005}{0.994}\right)} = 100.96$

$P\left(z \geq \frac{\frac{174}{252} - \mu}{\sigma/\sqrt{n}}\right) = P(z \geq -0.330) \qquad P\left(z \geq \frac{\frac{101}{252} - \mu}{\sigma/\sqrt{n}}\right) = P(z \geq -10.36)$



Approximation: 0.371

Exact: 0.394

Rest of work found in Jupyter Notebook

4) a) Daily = 0.00360

Annual = 0.90665

b) Daily = 0.041

Annual = 0.651

d) Both graphs look approximately like a nearly identical normal distribution, given the same number of samples.

e) 4c and 4e look like they are both normally distributed with the same mean but different variance. We can assume that daily returns are distributed normally over a given period of time.

g) Bootstrapping gave almost the same value as 4f. 4f gave about 0.17, while 4g gave about 0.16.

Graphs and work found in Jupyter Notebook

```
from scipy.stats import norm
import numpy as np
import pandas as pd
from datetime import datetime
import pandas_datareader.data as web
import matplotlib.pyplot as plt
import math
import random

#Number 1
mean = 100
std = 50
#Part a
print("Part 1a:", norm.cdf(1.78))
#Part b
print("Part 1b:", 1 - norm.cdf(-0.54))
#Part c
z = (80-100)/50
print("Part 1c:", 1 - norm.cdf(z))
#Part d
z1 = (65-100)/50
z2 = (83-100)/50
print("Part 1d:", norm.cdf(z2) - norm.cdf(z1))
```

```
    Part 1a: 0.9624620196514833
    Part 1b: 0.705401483784302
    Part 1c: 0.6554217416103242
    Part 1d: 0.1249646117408989
```

```
#Number 3
#Approximation
p = 0.7
q = 0.3
u = 1.005
d = 0.994
mean = 0.7
std = np.sqrt(p*q)
n = 252
r1 = 174
r2 = 101

z1 = ((r1/n) - mean)/(std/np.sqrt(n))
z2 = ((r2/n) - mean)/(std/np.sqrt(n))

a1 = norm.cdf(z1)
a2 = norm.cdf(z2)
print("Question 3:")
print("Approximate value:", a1 - a2)

#Exact
summation1 = 0
temp = 0
for i in range(r1+1, n+1):
    combination = (math.factorial(n)) / (math.factorial(i)*math.factorial(n-i))
    temp = combination*(p**i)*(q**(n-i))
    summation1 += temp

summation2 = 0
temp = 0
for i in range(r2, n+1):
    combination = (math.factorial(n)) / (math.factorial(i)*math.factorial(n-i))
    temp = combination*(p**i)*(q**(n-i))
    summation2 += temp

print("Exact value:", summation2 - summation1)
```

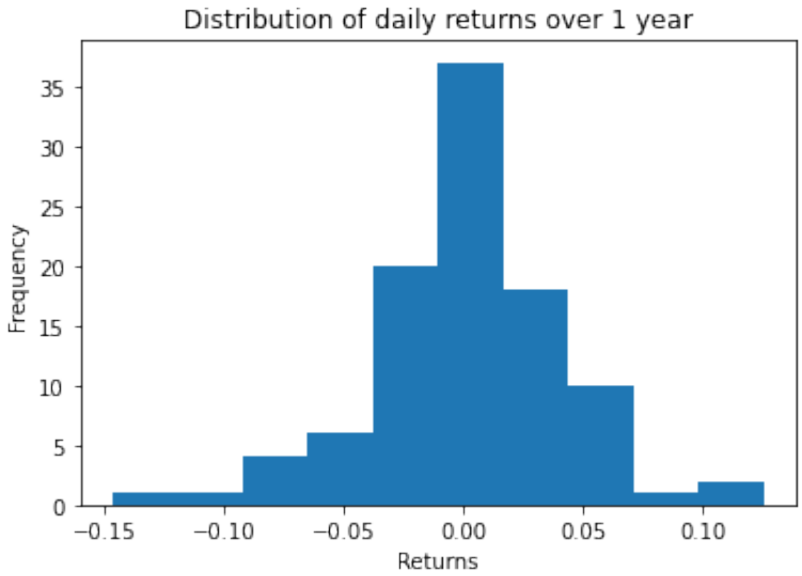
```
    Question 3:
    Approximate value: 0.3707323063164889
    Exact value: 0.3937178191670707
```

```
#Number 4
amd = web.DataReader("AMD", "yahoo", datetime(2016,1,1), datetime(2021,1,1))
stockPrice = amd["Adj Close"]
```

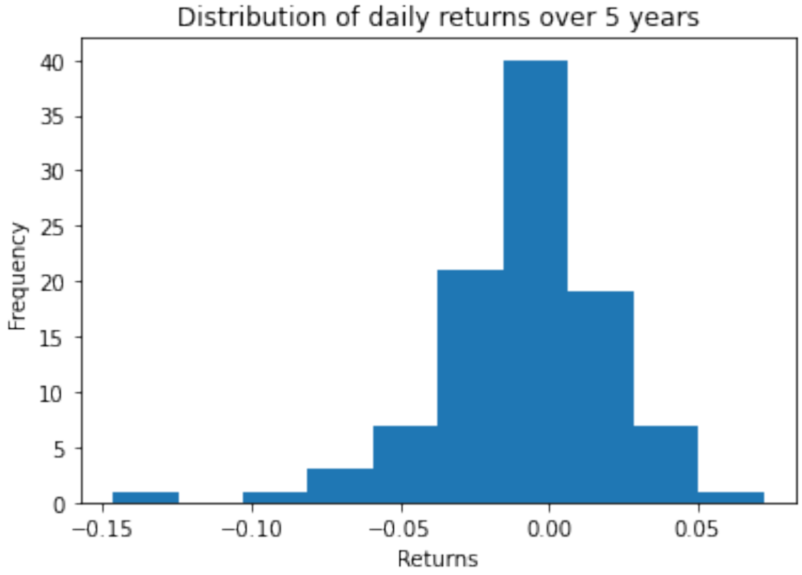
```
#For daily returns
dailyReturnsMean = stockPrice.pct_change()[1:].mean()
dailyReturnsSTD = stockPrice.pct_change()[1:].std()

#For annual returns
annualReturnsMean = stockPrice.pct_change()[1:].mean()*252.0
annualReturnsSTD = stockPrice.pct_change()[1:].std()*np.sqrt(252.0)

#Part a
print("Question 4a:")
print("Daily mean return:", dailyReturnsMean)
print("Annual mean return:", annualReturnsMean)

#Part b
print("Question 4b:")
print("Daily standard deviation of returns:", dailyReturnsSTD)
print("Annual standard deviation of returns:", annualReturnsSTD)

#Part c
#Looks like a normal distribution
print("Question 4c:")
amd1 = web.DataReader("AMD", "yahoo", datetime(2020,1,1), datetime(2021,1,1))
stockPrice1 = amd1["Adj Close"]
dailyReturns1 = stockPrice1.pct_change()[1:]

randomDraws1 = []
seen1 = []
count = 0
while count < 100:
  temp = random.randrange(0, len(dailyReturns1) - 1)
  if temp not in seen1:
    randomDraws1.append(dailyReturns1[temp])
    seen1.append(temp)
    count += 1

plt.xlabel("Returns")
plt.ylabel("Frequency")
plt.title("Distribution of daily returns over 1 year")
plt.hist(randomDraws1)
plt.show()

#Part d
print("Question 4d:")
amd2 = web.DataReader("AMD", "yahoo", datetime(2016,1,1), datetime(2021,1,1))
```

```
stockPrice2 = amd2["Adj Close"]
dailyReturns2 = stockPrice2.pct_change()[1:]

randomDraws2 = []
seen2 = []
count = 0
while count < 100:
  temp = random.randrange(0, len(dailyReturns2) - 1)
  if temp not in seen2:
    randomDraws2.append(dailyReturns2[temp])
    seen2.append(temp)
    count += 1

plt.xlabel("Returns")
plt.ylabel("Frequency")
plt.title("Distribution of daily returns over 5 years")
plt.hist(randomDraws2)
plt.show()
```

```
Question 4a:
Daily mean return: 0.003597817438545137
Annual mean return: 0.9066499945133745
Question 4b:
Daily standard deviation of returns: 0.04103006624222502
Annual standard deviation of returns: 0.6513321093206031
Question 4c:
```



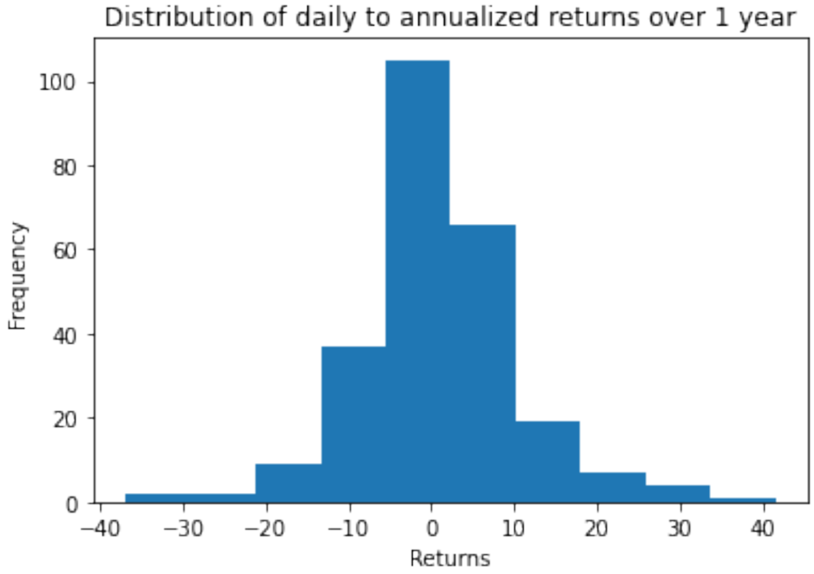
```
Question 4d:
```



```
#Part e
daily_to_annualReturns = []
for i in dailyReturns1:
  temp = (i)*252.00
  daily_to_annualReturns.append(temp)
```

```
print("Question 4e:")
plt.xlabel("Returns")
plt.ylabel("Frequency")
plt.title("Distribution of daily to annualized returns over 1 year")
plt.hist(daily_to_annualReturns)
plt.show()

#Part f
z = ((-0.1/20) - dailyReturnsMean)/(dailyReturnsSTD/np.sqrt(20))
prob = norm.cdf(z)
print("Question 4f:", prob)

#Part g
amd = web.DataReader("AMD", "yahoo", datetime(2016,1,1), datetime(2021,1,1))
stockPrice = amd["Adj Close"]
dailyReturns = stockPrice.pct_change()[1:]

count = 0
for i in range(100000):
  rep = 0
  randomSelection = []
  seen = []
  while rep < 20:
    temp = random.randrange(0, len(dailyReturns) - 1)
    if temp not in seen:
      randomSelection.append(dailyReturns[temp])
      seen.append(temp)
      rep += 1
  if np.sum(randomSelection) <= -0.1:
    count += 1

print("Question 4g:", count/100000)
```

```
Question 4e:
```



```
Question 4f: 0.17434520313751345
Question 4g: 0.16182
```