1. The joint probability density function of two discrete random variables X and Y is given by the following table:

		Y		
		1	3	9
X	2	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$
	4	$\frac{1}{4}$	$\frac{1}{4}$	0
	6	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$

Calculating the marginal probabilities table, we get:

		Y			
		1	3	9	
X	2	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{1}{4}$
	4	$\frac{1}{4}$	$\frac{1}{4}$	0	$\frac{1}{2}$
	6	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$	$\frac{1}{4}$
		$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{6}$	

$P(XY) = \sum_X \sum_Y = 1$

$\sum_X = \frac{1}{4} + \frac{1}{2} + \frac{1}{4} = 1$

$\sum_Y = \frac{1}{2} + \frac{1}{3} + \frac{1}{6} = 1$

$\sum_X \sum_Y = (1)(1) = 1$ ✓

(a) Find the marginal probability density function of Y.

$f(y) = \sum_y f(x,y)$; for y = 1, 3, 9

Y	1	3	9
f(y)	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{6}$

(b) Find the conditional probability density function of Y given that X = 2.

Y	1	3	9
$f(y\|x=2)$	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$

$f(y|x=2) = \dfrac{f(x,y)}{f(x=2)}$; for y = 1, 3, 9

$$\frac{f(2,1)}{f(x=2)} = \frac{\frac{1}{8}}{\frac{1}{4}} = \frac{1}{2}$$

$$\frac{f(2,3)}{f(x=2)} = \frac{\frac{1}{24}}{\frac{1}{4}} = \frac{1}{6} \qquad \frac{f(2,9)}{f(x=2)} = \frac{\frac{1}{12}}{\frac{1}{4}} = \frac{1}{3}$$

(c) Find the covariance of X and Y.

$cov(X+Y) = E(XY) - E(X) * E(Y)$

X	2	4	6
P(X)	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{1}{4}$

For the expected value of X and the expected value of Y:

$$\begin{aligned} E(X) &= \sum x f(x) \\ &= 2 * \frac{1}{4} + 4 * \frac{1}{2} + 6 * \frac{1}{4} \\ &= \frac{1}{2} + 2 + \frac{3}{2} \\ &= 4 \end{aligned}$$

$$\begin{aligned} &= E(Y) = \sum y f(y) \\ &= 1 * \frac{1}{2} + 3 * \frac{1}{3} + 9 * \frac{1}{6} \\ &= \frac{1}{2} + 1 + \frac{3}{2} \\ &= 3 \end{aligned}$$

For the expected value of XY:

$$\begin{aligned} E(XY) =& \sum_i \sum_j x_i y_j f(x_i, y_j) \\ =&(2)(1)(\frac{1}{8}) + (2)(3)(\frac{1}{24}) + (2)(9)(\frac{1}{12}) + \\ &(4)(1)(\frac{1}{4}) + (4)(3)(\frac{1}{4}) + (4)(9)(0) + \\ &(6)(1)(\frac{1}{8}) + 6(3)(\frac{1}{24}) + (6)(9)(\frac{1}{12}) \\ =&\frac{1}{4} + \frac{1}{4} + \frac{3}{2} + 1 + 3 + 0 + \frac{3}{4} + \frac{3}{4} + \frac{9}{2} \\ =&12 \end{aligned}$$

Therefore,

$$\begin{aligned} cov(X+Y) &= E(XY) - E(X) * E(Y) \\ &= 12 - 4 * 3 \\ &= 0 \end{aligned}$$

(d) Are X and Y independent?

Y	1	3	9
$f(y)$	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{6}$
$f(y\|x=2)$	$\frac{1}{8}$	$\frac{1}{24}$	$\frac{1}{12}$

For X and Y to be independent, $P(Y)$ must be equal to all other values given X. However, as we can see for $f(y|x=2)$, for values Y = 1, 3, 9; $\frac{1}{2} \neq \frac{1}{8}$, $\frac{1}{3} \neq \frac{1}{24}$, and $\frac{1}{6} \neq \frac{1}{12}$, respectively.

Although from (c), we found the covariance value of X and Y to be 0, X and Y are not independent, because X = 2 changes the probability distribution of Y—from answers (a) and (b). There could be a nonlinear relationship between X and Y that would result in a covariance value of 0.

2. In the study of finance, an important model is the capital asset pricing model (CAPM), which is concerned with the risk of a security's return. Financial economists define a security's systematic risk (risk that is related to the market's risk) as

$$\beta = \frac{cov(r_s, r_m)}{var(r_m)},$$

where r_s is the rate of return on a security minus the risk-free rate (r_f), and r_m is the rate of return on the market portfolio minus the risk-free rate. Use the Yahoo Finance website (www.finance.yahoo.com) to download two securities of your choice, the S&P 500 index (ˆGSPC), and the 13 Week Treasury Bill (ˆIRX)

(a) Compute the rate of return on the securities you choose and the excess return

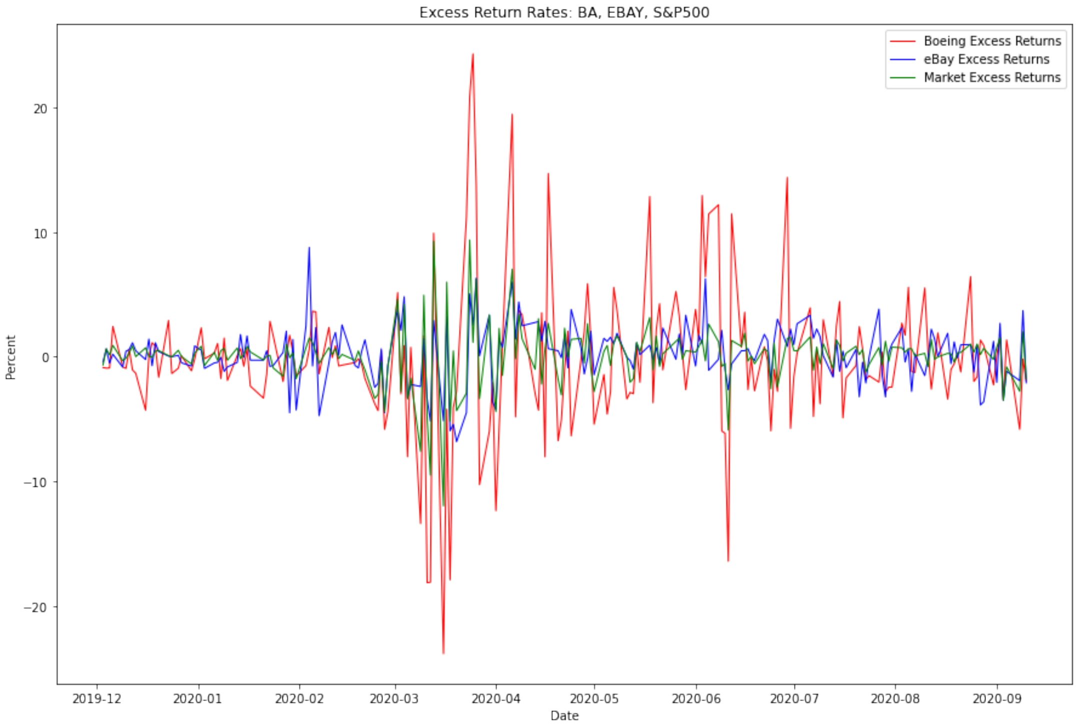
```
Boeing returns is

Date
2019-12-02         NaN
2019-12-03   -0.872797
2019-12-04   -0.920251
2019-12-05   -0.905855
2019-12-06    2.432886
...
2020-09-03   -3.438605
2020-09-04    1.350950
2020-09-08   -5.828706
2020-09-09   -0.186245
2020-09-10   -1.946763
Name: BA_return, Length: 196, dtype: float64

and the excess return is

Date
2019-12-02         NaN
2019-12-03   -2.410797
2019-12-04   -2.418251
2019-12-05   -2.398856
2019-12-06    0.952886
...
2020-09-03   -3.538605
2020-09-04    1.247950
2020-09-08   -5.936706
2020-09-09   -0.291245
2020-09-10   -2.049763
Name: r_BA, Length: 196, dtype: float64

EBAY returns is

Date
2019-12-02         NaN
2019-12-03   -0.429805
2019-12-04    0.633093
2019-12-05   -0.514732
2019-12-06    0.201212
...
2020-09-03   -3.503359
2020-09-04   -1.166288
2020-09-08   -1.922349
2020-09-09    3.706578
2020-09-10   -2.095806
Name: EBAY_return, Length: 196, dtype: float64

and the excess return is
```

```
Date
2019-12-02         NaN
2019-12-03   -1.967805
2019-12-04   -0.864907
2019-12-05   -2.007732
2019-12-06   -1.278788
...
2020-09-03   -3.603359
2020-09-04   -1.269288
2020-09-08   -2.030349
2020-09-09    3.601578
2020-09-10   -2.198806
Name: r_EBAY, Length: 196, dtype: float64
```

(b) Compute the rate of return on the market and the market excess return m.

```
S&P500 returns is

Date
2019-12-02         NaN
2019-12-03   -0.663810
2019-12-04    0.632357
2019-12-05    0.150025
2019-12-06    0.913572
...
2020-09-03   -3.512584
2020-09-04   -0.813303
2020-09-08   -2.775634
2020-09-09    2.014499
2020-09-10   -1.762595
Name: SP500_return, Length: 196, dtype: float64

and the excess return is

Date
2019-12-02         NaN
2019-12-03   -2.201809
2019-12-04   -0.865643
2019-12-05   -1.342975
2019-12-06   -0.566428
...
2020-09-03   -3.612584
2020-09-04   -0.916303
2020-09-08   -2.883634
2020-09-09    1.909499
2020-09-10   -1.865595
Name: r_m, Length: 196, dtype: float64
```

(c) Plot the excess returns of the two securities against the market excess return m.



(d) Calculate the sample mean and variance of r_1, r_2, and m.

```
Boeing sample mean is -0.7838264323398203 and variance is 36.02759600576681
EBAY sample mean is -0.3109152346379197 and variance is 5.902394166106553
S&P500 sample mean is -0.48744107911117 and variance is 6.261304797264734
```

(e) Calculate the sample correlation coefficient for each pair of variables.

```
The correlation coefficient for each pair of variables are:
rho(BA,EBAY) = 0.39677940569603837
rho(BA,m) = 0.6896656617717738
rho(EBAY,m) = 0.6586225914471965
```

(f) Use the previous results to calculate the β value of each security. What do you conclude?

```
For Boeing Beta is 1.654336388248806
For Ebay Beta is 0.639467246650082
```

For Boeing (BA), $\beta = 1.654$ and for eBay (EBAY), $\beta = 0.6394$. Since the $\beta_{Boeing} > 1$, this indicates the price of Boeing's security tends to be more volatile than the rest of the market of the S&P500 while because the $\beta_{eBay} < 1$, this indicates the price of eBay's security tends to be less volatile than the market of the S&P500.

3. Table 2.5 contains data on 32 light water reactor power plants constructed in the United States

(a) Classify each variable as continuous or discrete. Justify your choice.

Discrete variables:

- C - the cost is in terms of $dollars * 10^{-6}$ (millions of dollars). The smallest unit of cost would be cents for which there would be no value between one cent and the next consecutive cent (e.g. no cost value between \$0.01 and \$0.02)

• PR - a binary variable where 1 indicates the prior existence of a LWR at the same site, so it is discrete (either 0 or 1).
• NE - a binary variable where 1 indicates the plant was constructed in the north-east region of the United States, so it is discrete (either 0 or 1).
• CT - a binary variable where 1 indicates the use of a cooling tower in the plant, so it is discrete (either 0 or 1).
• BW - a binary variable where 1 indicates that the nuclear steam supply system was manufactured by Babcock-Wilcox, so it is discrete (either 0 or 1).
• N - the cumulative number of power plants constructed by each architect-engineer. Since it counts whole plants, the number value must be a positive whole number with no other possible values between them, so it is discrete.
• PT - a binary variable where 1 indicates those plants with partial turnkey guarantees, so it is discrete (either 0 or 1).

Discrete variables but could be made continuous:

- D - the date the construction permit was issued, since the number is rounded to the nearest month, the value is discrete (smallest unit is month). However, time could be divided further into microseconds, nanoseconds, picoseconds, and etc., into ever smaller units.
- T1 - the time between application for and issue of construction permit, since this value, like the date, would be rounded to the nearest month, it would also be discrete (smallest unit is month). However, time could be divided further into microseconds, nanoseconds, picoseconds, and etc., into ever smaller units.
- T2 - the time between issue of operating license and construction permit,since this value, like the date, would be rounded to the nearest month, it would also be discrete (smallest unit is month). However, time could be divided further into microseconds, nanoseconds, picoseconds, and etc., into ever smaller units.
- S - Power plant capacity, which is rounded to the nearest megawatt electric. The unit could be divided further into smaller units of energy, such as watts, microwatts, nanowatts, picowatts, and etc., into ever smaller units.

(b) Find the mean and variance of cost (C) and power plant capacity (S) and the correlation between them. Does the sign of the correlation seem reasonable. Explain.

The mean and variance for cost (C):

$$\begin{aligned}\bar{C} &= \frac{\sum_{t=1}^{T} C_t}{T} \\ &= \frac{460.05 + 452.99 + 443.22 + ... + 270.71}{32} \\ &= 461.5603125 \\ &= \$461.56\end{aligned}$$

$$\begin{aligned}s_C^2 &= \frac{\sum_{t=1}^{T} (C_t - \bar{C})^2}{T-1} \\ &= \frac{(460.05 - 461.56)^2 + ... + (270.71 - 461.56)^2}{32-1} \\ &= 28941.04222 \\ &= \$28,941.04\end{aligned}$$

The mean and variance for power plant capacity (S):

$$\begin{aligned}\bar{S} &= \frac{\sum_{t=1}^{T} S_t}{T} \\ &= \frac{687 + 1065 + 1065 + ... + 886}{32} \\ &= 825.375\end{aligned}$$

$$\begin{aligned}s_S^2 &= \frac{\sum_{t=1}^{T} (S_t - \bar{S})^2}{T-1} \\ &= \frac{(687 - 825.375)^2 + ... + (886 - 825.375)^2}{32-1} \\ &= 35,856.8871\end{aligned}$$

The covariance between cost (C) and power plant capacity (S):

$$\begin{aligned} cov(C,S) &= \frac{\sum(C_i - \bar{C})(S_j - \bar{S})}{T-1} \\ &= \frac{(460.05-461.56)(687-825.375)+...+(270.71-461.56)(886-825.375)}{32-1} \\ &= 14,722.34738 \end{aligned}$$

The covariance value of +15197.26181 indicates a strong positive relationship between the cost and the power plant capacity (i.e. as power plant capacity goes up, costs goes up as well). This makes reasonable sense since building more power plant capacity requires additional valuable materials and labor, and will therefore drive up the costs.

(c) Provide a frequency table for the cumulative number of power plants constructed by each architect-engineer (N).

Architect (N)	Frequency
1	4
2	3
3	4
5	2
6	1
7	2
8	3
11	3
12	2
14	1
15	1
16	1
17	1
18	1
19	1
20	1
21	1

4. Suppose a real-estate investor is considering investing in two pieces of property, one in Lubbock, X and one in Midland, Y. The possible returns on investment for property X are -$5,000, $0, and $10,000 with corresponding probabilities of 0.2, 0.5, and 0.3, respectively. For Y, we have -$10,000, $0, and $100,000 with probabilities 0.3, 0.5, and 0.2, respectively.

(a) Find the mean and variance of X and Y.

Returns (X)	-$5,000	$0	$10,000
P(X)	0.2	0.5	0.3
E(X)	-$1,000	$0	$3,000

Returns (Y)	-$10,000	$0	$100,000
P(Y)	0.3	0.5	0.2
E(Y)	-$3,000	$0	$20,000

Since the probability of X and Y are not uniform, we must find the weighted mean of X and Y:

$$\begin{aligned} E(X) &= \sum xf(x) \\ &= -\$5,000(0.2) + 0(0.5) + \$10,000(0.3) \\ &= -\$1,000 + \$0 + \$3,000 \\ &= \$2,000 \end{aligned}$$

$$\begin{aligned} E(Y) &= \sum yf(x) \\ &= -\$10,000(0.3) + 0(0.5) + \$100,000(0.2) \\ &= -\$3,000 + \$0 + \$20,000 \\ &= \$17,000 \end{aligned}$$

$$\begin{aligned} E(X+Y) &= E(X)+E(Y) \\ &= (\$2,000)+(\$17,000) \\ &= \$19,000 \end{aligned}$$

For the variance of X and Y:

$$\begin{aligned} var(x) = \sigma_x^2 &= E(x^2)-(E(x))^2 \\ &= (-5000)^2(0.2)+(0)^2(0.5)+(10000)^2(0.3))-(2000)^2 \\ &= 5000000+0+30000000-4000000 \\ &= \$31,000,000 \end{aligned}$$

$$\begin{aligned} var(y) = \sigma_y^2 &= E(y^2)-(E(y))^2 \\ &= (-10000)^2(0.3)+(0)^2(0.5)+(100000)^2(0.2))-(17000)^2 \\ &= 30000000+0+2000000000-289000000 \\ &= \$1,741,000,000 \end{aligned}$$

Now we have everything we need to plug the numbers back to to find var(X+Y):

$$\begin{aligned} var(X+Y) &= var(X)+var(Y)+2(E(XY)-E(X)*E(Y)) \\ &= \$31,000,000+\$1,741,000,000+2(\$34,000-\$2,000*\$17,000) \\ &= \$1,772,000,000 \end{aligned}$$

(b) The total return on the two investment is given by V = X+Y. Find the expected total return and the variance of total return.

If $V = X+Y$, then the expected total return is:

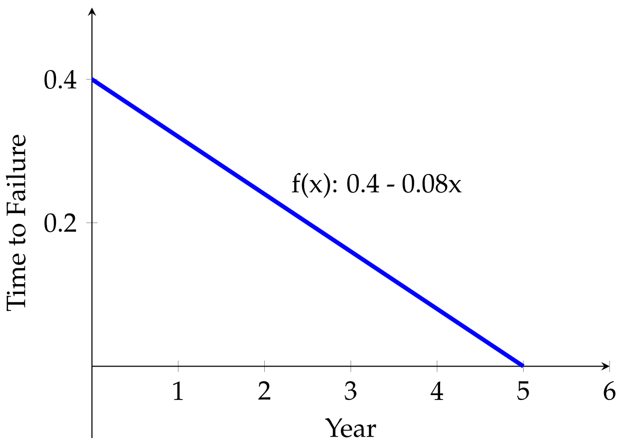
$$\begin{aligned} V &= X+Y \\ E(V) &= E(X+Y) \\ &= E(X)+E(Y) \\ &= (-\$1,000+\$0+\$3,000)+(-\$3,000+\$0+\$20,000) \\ &= \$2,000+\$17,000 \\ &= \$19,000 \end{aligned}$$

$$\begin{aligned} var(X+Y) &= var(X)+var(Y)+2(E(XY)-E(X)*E(Y)) \\ &= \$31,000,000+\$1,741,000,000+2(\$34,000-\$2,000*\$17,000) \\ &= \$1,772,000,000 \end{aligned}$$

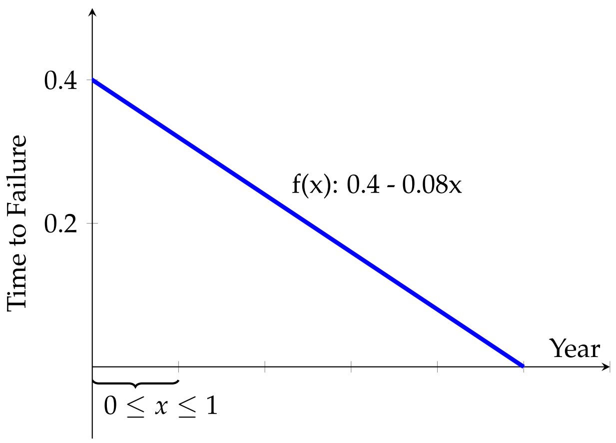
5. (Bonus Question) The life or time to failure of a particular type of equipment is a random variable with a probability density function given by

$$f(x) = \begin{cases} 0.4-0.08x & 0 \le X \le 5 \\ 0\text{ , elsewhere} \end{cases}$$

(a) Determine the probability that a piece of this equipment will fail in the first year.



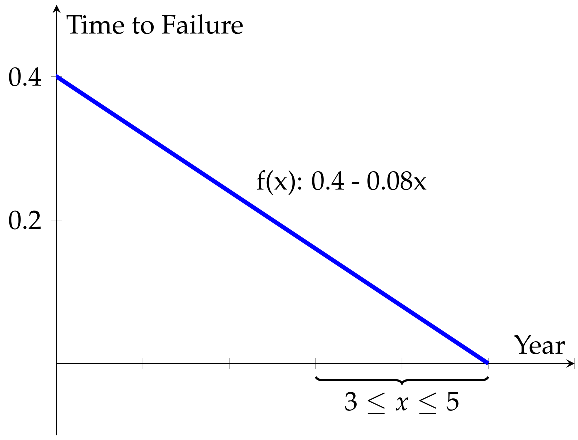
To determine the probability that this piece of equipment will fail in the first year, we will need to find the area of the probability density function from year 0 to year 1:



$$
\begin{aligned}
&= \int_0^1 0.4 - 0.08x dx \\
&= [_0^1 \frac{2x}{5} - \frac{x^2}{25} \\
&= (\frac{2}{5} - \frac{1}{25}) - 0 \\
&= \frac{9}{25} = 0.36
\end{aligned}
$$

There is a 0.36 probability that this piece of equipment will fail in the first year.

(b) Determine the probability that a piece of this equipment will last at least 3 years.



To calculate, we can either find the area of the probability density function from year 0 to 1 and subtract it from 1 or find the area of the probability density function from year 3 to year 5. We'll do the former option:

$$f(x \geq 3) = 1 - f(x \leq 3)$$
$$f(x \geq 3) = 1 - \int_0^3 0.4 - 0.08xdx$$
$$= 1 - [_0^3 \frac{2x}{5} - \frac{x^2}{25}$$
$$= 1 - (\frac{6}{5} - \frac{9}{25} - 0)$$
$$= 1 - \frac{21}{25}$$
$$= \frac{4}{25} = 0.16$$

To double check, we can try to latter option:

$$f(x \geq 3) = \int_3^5 0.4 - 0.08xdx$$
$$= [_3^5 \frac{2x}{5} - \frac{x^2}{25}$$
$$= (\frac{10}{5} - \frac{25}{25}) - (\frac{6}{5} - \frac{9}{25})$$
$$= 1 - \frac{21}{25}$$
$$= \frac{4}{25} = 0.16$$

As we can see:

$f(x \geq 3) = 1 - \int_0^3 0.4 - 0.08xdx = \int_3^5 0.4 - 0.08xdx = 0.16$

There is a 0.16 probability that the piece of equipment will last at least 3 years.

(c) Determine the expected (average) life and the standard deviation of the life of the equipment.

$$\begin{aligned}
\mu = E(x) &= \int_a^b xf(x)dx \\
&= \int_0^5 x(0.4 - 0.08x)dx \\
&= \int_0^5 x(\frac{2}{5} - \frac{2x}{25})dx \\
&= \int_0^5 (\frac{2x}{5} - \frac{2x^2}{25})dx \\
&= [_0^5 \frac{x^2}{5} - \frac{2x^3}{75} \\
&= (\frac{25}{5} - \frac{250}{75}) - (0 - 0) \\
&= 5 - \frac{10}{3} \\
&= \frac{5}{3}
\end{aligned}$$

The expected average life of that piece of equipment is $\frac{5}{3}$ years.

$$\begin{aligned}
\sigma = \sqrt{V(x)} &= \sqrt{\int_a^b (x-\mu)^2 f(x)dx} && (1) \\
&= \sqrt{\int_0^5 (x - \frac{5}{3})^2(0.4 - 0.08x)dx} && (2) \\
&= \sqrt{\int_0^5 (x^2 - \frac{10x}{3} + \frac{25}{9})(\frac{2}{5} - \frac{2x}{25})dx} && (3) \\
&= \sqrt{\int_0^5 \frac{2x^2}{5} - \frac{2x^3}{25} - \frac{4x}{3} + \frac{4x^2}{15} + \frac{10}{9} - \frac{2x}{9}dx} && (4) \\
&= \sqrt{[_0^5 \frac{2x^3}{15} - \frac{x^4}{50} - \frac{2x^2}{3} + \frac{4x^3}{45} + \frac{10x}{9} - \frac{x^2}{9}} && (5) \\
&= \frac{250}{15} - \frac{625}{50} - \frac{50}{3} + \frac{500}{45} + \frac{50}{9} - \frac{25}{9} && (6) \\
&= \sqrt{\frac{25}{18}} && (7) \\
&= 1.17855 && (8)
\end{aligned}$$

(d) Suppose two pieces of this equipment are purchased. Determine the mean and standard deviation of the sum of their lives.

Suppose X_1 is the first piece and X_2 is the second piece of equipment:

If the two pieces are running concurrently, then the mean would be the same: $\mu = \frac{5}{3}$ years

If the two pieces are running consecutively, then the mean would be: $\mu(X_1 + X_2) = \mu_1 + \mu_2$. Since $X_1 = X_2$ and the mean would be the same, $\mu(X_1 + X_2) = \mu_1 + \mu_1 = \frac{5}{3} + \frac{5}{3} = \frac{10}{3}$ years

For the standard deviation of the two pieces of equipment, we cannot sum up the standard deviation. Instead, we need to sum up the two variances and then square root the result to get the standard deviation of the two pieces of equipment:

$\sigma(X_1 + X_2) = \sqrt{var(X_1, X_2)} = \sqrt{var_{X1} + var_{X2} - 2cov(X_1 + X_2)}$

Since the two equipment are independent:

$$\begin{aligned}\sigma(X_1 + X_2) = \sqrt{var(X_1, X_2)} &= \sqrt{var_{X1} + var_{X2}} \\ &= \sqrt{\frac{25}{18} + \frac{25}{18}} \\ &= \sqrt{\frac{50}{18}} \\ &= \frac{5}{3} years\end{aligned}$$

Python code for AAEC 5307: Homework 1

September 11, 2020

[3]:
```
# -*- coding: utf-8 -*-
"""
Created on Mon Sep  7 14:10:51 2020

@author: Don Lim
"""

#%%
import pandas as pd
import numpy as np
from pandas_datareader import data as web
from scipy.stats import norm
from matplotlib import pyplot as plt
from statsmodels.distributions.empirical_distribution import ECDF
from pandas.plotting import register_matplotlib_converters
register_matplotlib_converters()

#%%
tickers = ['BA', 'EBAY','^GSPC','^IRX']
stocks = web.DataReader(tickers, data_source = 'yahoo', start =␣
↪'2019-12-1')['Adj Close']

#%% Problem 2 (a)

stocks['BA_return'] = 100*stocks['BA'].pct_change()
stocks['EBAY_return'] = 100*stocks['EBAY'].pct_change()

stocks['r_BA'] = stocks['BA_return'] - stocks['^IRX']
stocks['r_EBAY'] = stocks['EBAY_return'] - stocks['^IRX']

boeing_returns = stocks.BA_return
ebay_returns = stocks.EBAY_return

boeing_excess = stocks.r_BA
ebay_excess = stocks.r_EBAY
```

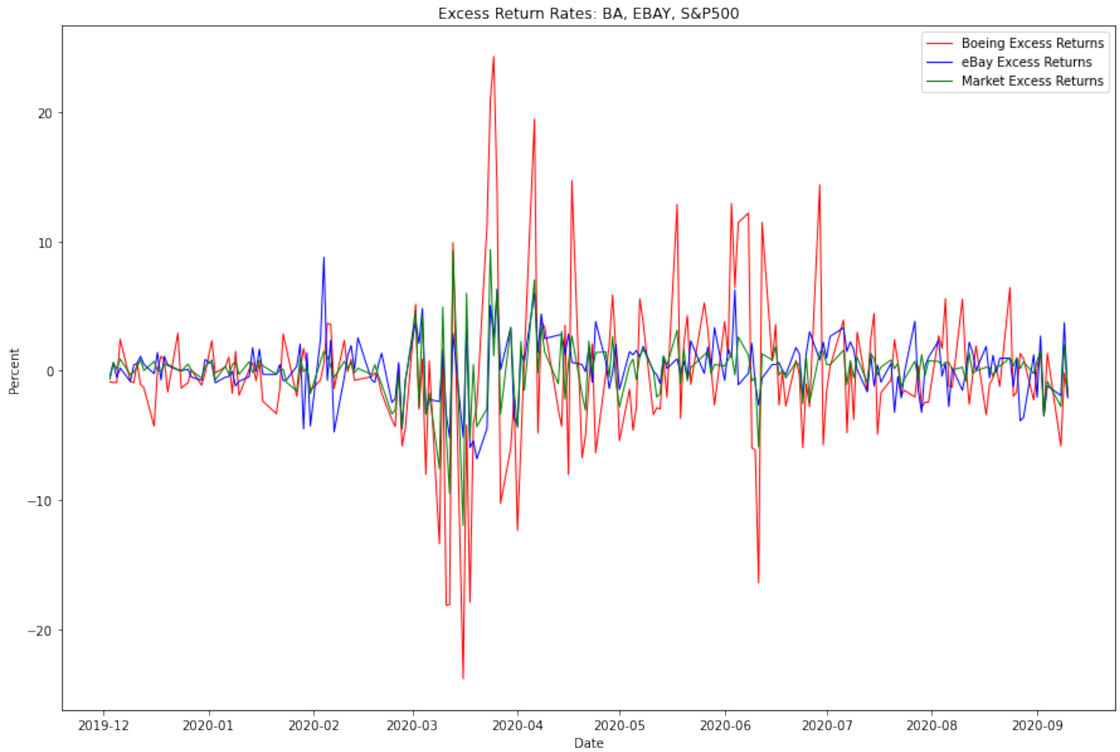
```
print("Boeing returns is\n", boeing_returns, "\n and the excess return is\n",␣
↪boeing_excess)
print ("EBAY returns is\n", ebay_returns, "\n and the excess return is\n",␣
↪ebay_excess)

#%% Problem 2(b)
stocks['SP500_return'] = 100*stocks['^GSPC'].pct_change()
stocks['r_m'] = stocks['SP500_return'] - stocks['^IRX']
market_returns = stocks.SP500_return
market_excess = stocks.r_m

print ("S&P500 returns is", market_returns, "and the excess return is",␣
↪market_excess)

#%% Problem 2(c)

plt.figure(figsize = (15,10))
plt.plot(stocks['BA_return'], linewidth = 1, label = 'Boeing Excess Returns',␣
↪color = 'red')
plt.plot(stocks['EBAY_return'], linewidth = 1,label = 'eBay Excess Returns',␣
↪color = 'blue')
plt.plot(stocks['SP500_return'], linewidth = 1, label = 'Market Excess Returns',␣
↪color = 'green')
plt.ylabel('Percent')
plt.xlabel('Date')
plt.title('Excess Return Rates: BA, EBAY, S&P500')
plt.legend(loc = "upper right")

#%% Problem 2(d)

mean_BA = stocks.r_BA.mean()
mean_EBAY = stocks.r_EBAY.mean()
mean_market = stocks.r_m.mean()

var_BA = stocks.r_BA.var()
var_EBAY = stocks.r_EBAY.var()
var_market = stocks.r_m.var()

market_variance = stocks.r_m.var()

print("Boeing mean is", mean_BA, "and variance is", var_BA)
print ("EBAY mean is", mean_EBAY, "and variance is", var_EBAY)
print ("S&P500 mean is", mean_market, "and variance is", var_market)

#%% Problem 2(e)
cor_BA = stocks.r_BA.corr(stocks.r_EBAY, method = 'pearson')
```

```python
cor_EBAY = stocks.r_BA.corr(stocks.r_m, method = 'pearson')
cor_EBAY_r_m = stocks.r_EBAY.corr(stocks.r_m, method = 'pearson')
print('The correlation coefficient for each pair of variables are:')
print('rho(BA,EBAY) =', cor_BA)
print('rho(BA,m) =', cor_EBAY)
print('rho(EBAY,m) =', cor_EBAY_r_m)

#%% Problem 2(f)

beta_BA = stocks.r_BA.cov(stocks.r_m)/stocks.r_m.var()
beta_EBAY = stocks.r_EBAY.cov(stocks.r_m)/stocks.r_m.var()

print("For Boeing Beta is", beta_BA)
print("For Ebay Beta is", beta_EBAY)
```

```
Boeing returns is
 Date
2019-12-02          NaN
2019-12-03    -0.872797
2019-12-04    -0.920251
2019-12-05    -0.905855
2019-12-06     2.432886
                 ...
2020-09-03    -3.438605
2020-09-04     1.350950
2020-09-08    -5.828706
2020-09-09    -0.186245
2020-09-10    -1.946763
Name: BA_return, Length: 196, dtype: float64
 and the excess return is
 Date
2019-12-02          NaN
2019-12-03    -2.410797
2019-12-04    -2.418251
2019-12-05    -2.398856
2019-12-06     0.952886
                 ...
2020-09-03    -3.538605
2020-09-04     1.247950
2020-09-08    -5.936706
2020-09-09    -0.291245
2020-09-10    -2.049763
Name: r_BA, Length: 196, dtype: float64
EBAY returns is
 Date
2019-12-02          NaN
2019-12-03    -0.429805
```

```
2019-12-04    0.633093
2019-12-05   -0.514732
2019-12-06    0.201212
                ...
2020-09-03   -3.503359
2020-09-04   -1.166288
2020-09-08   -1.922349
2020-09-09    3.706578
2020-09-10   -2.095806
Name: EBAY_return, Length: 196, dtype: float64
 and the excess return is
 Date
2019-12-02         NaN
2019-12-03   -1.967805
2019-12-04   -0.864907
2019-12-05   -2.007732
2019-12-06   -1.278788
                ...
2020-09-03   -3.603359
2020-09-04   -1.269288
2020-09-08   -2.030349
2020-09-09    3.601578
2020-09-10   -2.198806
Name: r_EBAY, Length: 196, dtype: float64
S&P500 returns is Date
2019-12-02         NaN
2019-12-03   -0.663810
2019-12-04    0.632357
2019-12-05    0.150025
2019-12-06    0.913572
                ...
2020-09-03   -3.512584
2020-09-04   -0.813303
2020-09-08   -2.775634
2020-09-09    2.014499
2020-09-10   -1.762595
Name: SP500_return, Length: 196, dtype: float64 and the excess return is Date
2019-12-02         NaN
2019-12-03   -2.201809
2019-12-04   -0.865643
2019-12-05   -1.342975
2019-12-06   -0.566428
                ...
2020-09-03   -3.612584
2020-09-04   -0.916303
2020-09-08   -2.883634
2020-09-09    1.909499
2020-09-10   -1.865595
```

```
Name: r_m, Length: 196, dtype: float64
Boeing mean is -0.7838264323398203 and variance is 36.02759600576681
EBAY mean is -0.3109152346379197 and variance is 5.902394166106553
S&P500 mean is -0.48744107911117 and variance is 6.261304797264734
The correlation coefficient for each pair of variables are:
rho(BA,EBAY) = 0.39677940569603837
rho(BA,m) = 0.6896656617717738
rho(EBAY,m) = 0.6586225914471965
For Boeing Beta is 1.654336388248806
For Ebay Beta is 0.639467246650082
```



[ ]: