

Question 1

Q1 1.

S&P-500

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Date      Year      Month      Day Weekday Week_Number Year_Week  Open   High   Low
Close     Volume  Adj Close  Return Short_MA  Long_MA True Label
0  2016-01-04  2016      1   4  Monday  1    2016-01 200.49  201.03  198.59  201.02
222353500  178.05  0.000000  178.050000 178.0500  +
1  2016-01-05  2016      1   5  Tuesday 1    2016-01 201.40  201.90  200.05  201.36
110845800  178.35  0.001692  178.200000 178.2000  +
2  2016-01-06  2016      1   6  Wednesday 1    2016-01 198.34  200.06  197.60
198.82  152112600  176.10 -0.012614  177.500000 177.5000  -
3  2016-01-07  2016      1   7  Thursday  1    2016-01 195.33  197.44  193.59
194.05  213436100  171.88 -0.023992  176.095000 176.0950  -
4  2016-01-08  2016      1   8  Friday  1    2016-01 195.19  195.85  191.58  191.92
209817200  169.99 -0.010977  174.874000 174.8740  -
... ..
1253  2020-12-23  2020      12  23  Wednesday  51  2020-51 368.28  369.62  367.22
367.57  46201400  358.58  0.000899  358.296429 345.3106  +
1254  2020-12-24  2020      12  24  Thursday  51  2020-51 368.08  369.03  367.45
369.00  26457900  359.98  0.003890  358.346429 345.7506  +
1255  2020-12-28  2020      12  28  Monday  52  2020-52 371.74  372.59  371.07
372.17  39000400  363.07  0.008591  358.670000 346.2608  +
1256  2020-12-29  2020      12  29  Tuesday 52  2020-52 373.81  374.00  370.83
371.46  53680500  362.38 -0.001908  358.869286 346.7612  -
1257  2020-12-30  2020      12  30  Wednesday 52  2020-52 372.34  373.10  371.57
371.99  49455300  362.89  0.001427  359.335714 347.3744  +
1258 rows x 17 columns

```

KO stock

```

Date      Year      Month      Day Weekday Week_Number Year_Week  Open   High   Low
Close     Volume  Adj Close  Return Short_MA  Long_MA True Label
0  2016-01-04  2016      1   4  Monday  1    2016-01 42.34  42.50  41.97  42.40
16084100  34.13  0.000000  34.130000 34.130000  +
1  2016-01-05  2016      1   5  Tuesday 1    2016-01 42.31  42.63  42.17  42.55
15781900  34.25  0.003538  34.190000 34.190000  +
2  2016-01-06  2016      1   6  Wednesday 1    2016-01 42.20  42.51  42.04
42.32  16245100  34.06 -0.005405  34.146667 34.146667  -
3  2016-01-07  2016      1   7  Thursday  1    2016-01 41.65  42.11  41.45
41.62  20563600  33.50 -0.016541  33.985000 33.985000  -
4  2016-01-08  2016      1   8  Friday  1    2016-01 41.65  42.12  41.41  41.51
14645900  33.41 -0.002643  33.870000 33.870000  -
... ..
1253  2020-12-23  2020      12  23  Wednesday  51  2020-51 52.95  53.39  52.94
53.08  7040300  50.33  0.006065  50.499286 48.862000  +
1254  2020-12-24  2020      12  24  Thursday  51  2020-51 53.02  53.55  53.02

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53.44  3265500 50.67  0.006782  50.471429  48.932200  +
1255   2020-12-28 2020    12 28 Monday 52 2020-52 53.85  54.44  53.73
54.16  9020500 51.36  0.013473  50.550714  49.018800  +
1256   2020-12-29 2020    12 29 Tuesday 52 2020-52 54.45  54.49  54.02
54.13  8320600 51.33  -0.000554  50.615000  49.104000  -
1257   2020-12-30 2020    12 30 Wednesday 52 2020-52 54.05  54.63  54.03
54.44  8142700 51.62  0.005727  50.690000  49.202600  +
1258 rows x 17 columns

```

Q1 2.

S&P-500 $p^* = 0.5543766578249337$

KO $p^* = 0.5411140583554377$

Q1 3.

S&P-500 $k=1$:

-- : 0.32432432432432434

+- : 0.6756756756756757

S&P-500 $k=2$:

--- : 0.3076923076923077

---+ : 0.6923076923076923

S&P-500 $k=3$:

---- : 0.2857142857142857

----+ : 0.7142857142857143

KO $k=1$:

-- : 0.3708609271523179

+- : 0.6291390728476821

KO $k=2$:

--- : 0.31343283582089554

---+ : 0.6865671641791045

KO $k=3$:

---- : 0.3103448275862069

----+ : 0.6896551724137931

Q1 4.

S&P-500 $k=1$:

++ : 0.41690962099125367

+- : 0.5830903790087464

S&P-500 $k=2$:

+++ : 0.38285714285714284

++- : 0.6171428571428571

S&P-500 $k=3$:

++++ : 0.30952380952380953

+++ - : 0.6904761904761905

KO k=1:

++ : 0.43283582089552236

+ - : 0.5671641791044776

KO k=2:

+++ : 0.3614457831325301

++- : 0.6385542168674698

KO k=3:

++++ : 0.38095238095238093

+++ - : 0.6190476190476191

Question 2

Q2 1.

S&P-500

Date	Year	Month	Day	Weekday	Week_Number	Year_Week	Open	High	Low	Close	Volume	Adj Close	Return	Short_MA	Long_MA	True Label	Predict Label
2	Predict Label 2	Predict Label 3	Predict Label 4														
754	2019-01-02	2019	1	2	Wednesday	0	2019-00	245.98	251.21	245.95	250.18	126925200	235.14	0.001040	235.427857	248.2308	+ + + -
755	2019-01-03	2019	1	3	Thursday	0	2019-00	248.23	248.57	243.67	244.21	144140700	229.53	-0.023863	234.105000	247.6588	- + + +
756	2019-01-04	2019	1	4	Friday	0	2019-00	247.59	253.11	247.17	252.39	142628800	237.21	0.033496	233.337143	247.2636	+ + + +
757	2019-01-07	2019	1	7	Monday	1	2019-01	252.69	255.95	251.69	254.38	103139100	239.08	0.007885	233.029286	246.9320	+ + + -
758	2019-01-08	2019	1	8	Tuesday	1	2019-01	256.82	257.31	254.00	256.77	102512600	241.33	0.009395	233.223571	246.8002	+ + + +
...
...
1253	2020-12-23	2020	12	23	Wednesday	51	2020-51	368.28	369.62	367.22	367.57	46201400	358.58	0.000899	358.296429	345.3106	+ + + +
1254	2020-12-24	2020	12	24	Thursday	51	2020-51	368.08	369.03	367.45	369.00	26457900	359.98	0.003890	358.346429	345.7506	+ + + +
1255	2020-12-28	2020	12	28	Monday	52	2020-52	371.74	372.59	371.07	372.17	39000400	363.07	0.008591	358.670000	346.2608	+ + + +
1256	2020-12-29	2020	12	29	Tuesday	52	2020-52	373.81	374.00	370.83	371.46	53680500	362.38	-0.001908	358.869286	346.7612	- + - -
1257	2020-12-30	2020	12	30	Wednesday	52	2020-52	372.34	373.10	371.57	371.99	49455300	362.89	0.001427	359.335714	347.3744	+ + + +

504 rows x 20 columns

KO

Date	Year	Month	Day	Weekday	Week_Number	Year_Week	Open	High	Low	Close	Volume	Adj Close	Return	Short_MA	Long_MA	True Label	Predict Label
2	Predict Label 2	Predict Label 3	Predict Label 4														
754	2019-01-02	2019	1	2	Wednesday	0	2019-00	46.94	47.22	46.56							

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46.93 11603700 41.71 -0.008870 42.507143 42.8642 - + + +
755 2019-01-03 2019 1 3 Thursday 0 2019-00 46.82 47.37 46.53
46.64 14714400 41.45 -0.006179 42.343571 42.8762 - + + +
756 2019-01-04 2019 1 4 Friday 0 2019-00 46.75 47.57 46.64 47.57
13013700 42.28 0.019940 42.222857 42.9112 + + + +
757 2019-01-07 2019 1 7 Monday 1 2019-01 47.57 47.75 46.90 46.95
13135500 41.73 -0.013034 42.071429 42.9282 - + + +
758 2019-01-08 2019 1 8 Tuesday 1 2019-01 47.25 47.57 47.04 47.48
15420700 42.20 0.011289 42.017857 42.9482 + + + -
... ..
...
1253 2020-12-23 2020 12 23 Wednesday 51 2020-51 52.95 53.39 52.94
53.08 7040300 50.33 0.006065 50.499286 48.8620 + + + +
1254 2020-12-24 2020 12 24 Thursday 51 2020-51 53.02 53.55 53.02
53.44 3265500 50.67 0.006782 50.471429 48.9322 + + + +
1255 2020-12-28 2020 12 28 Monday 52 2020-52 53.85 54.44 53.73
54.16 9020500 51.36 0.013473 50.550714 49.0188 + + - -
1256 2020-12-29 2020 12 29 Tuesday 52 2020-52 54.45 54.49 54.02
54.13 8320600 51.33 -0.000554 50.615000 49.1040 - + + +
1257 2020-12-30 2020 12 30 Wednesday 52 2020-52 54.05 54.63 54.03
54.44 8142700 51.62 0.005727 50.690000 49.2026 + + + +
504 rows x 20 columns

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Q2 2.

S&P-500

W = 2 accuracy of '+' : 1.0

W = 2 accuracy of '-' : 0.0

W = 2 total accuracy : 0.5853174603174603

W = 3 accuracy of '+' : 0.8372881355932204

W = 3 accuracy of '-' : 0.22966507177033493

W = 3 total accuracy : 0.5853174603174603

W = 4 accuracy of '+' : 0.8

W = 4 accuracy of '-' : 0.2583732057416268

W = 4 total accuracy : 0.5753968253968254

KO

W = 2 accuracy of '+' : 1.0

W = 2 accuracy of '-' : 0.0

W = 2 accuracy - 0.5337301587301587

W = 3 accuracy of '+' : 0.8661710037174721

W = 3 accuracy of '-' : 0.12340425531914893

W = 3 accuracy - 0.5198412698412699

W = 4 accuracy of '+' : 0.6468401486988847

W = 4 accuracy of '-' : 0.28936170212765955

W = 4 accuracy - 0.4801587301587302

Q2 3.

W=2 accuracy is the highest for the KO stock

W=2 and W=3 accuracies are the highest for the S&P-500 stock

Question 3

Q3 1.

S&P-500

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Date      Year      Month      Day Weekday Week_Number Year_Week  Open   High   Low
... Volume Adj Close Return Short_MA Long_MA True Label Predict Label 2
Predict Label 3 Predict Label 4 Ensemble Predict
754 2019-01-02 2019      1   2   Wednesday      0   2019-00 245.98 251.21 245.95
... 126925200 235.14 0.001040 235.427857 248.2308 + + + - +
755 2019-01-03 2019      1   3   Thursday      0   2019-00 248.23 248.57 243.67
... 144140700 229.53 -0.023863 234.105000 247.6588 - + + + +
756 2019-01-04 2019      1   4   Friday      0   2019-00 247.59 253.11 247.17 ...
142628800 237.21 0.033496 233.337143 247.2636 + + + + +
757 2019-01-07 2019      1   7   Monday      1   2019-01 252.69 255.95 251.69 ...
103139100 239.08 0.007885 233.029286 246.9320 + + + - +
758 2019-01-08 2019      1   8   Tuesday      1   2019-01 256.82 257.31 254.00 ...
102512600 241.33 0.009395 233.223571 246.8002 + + + + +
... ..
... ..
1253 2020-12-23 2020     12  23   Wednesday     51  2020-51 368.28 369.62 367.22
... 46201400 358.58 0.000899 358.296429 345.3106 + + + + +
1254 2020-12-24 2020     12  24   Thursday      51  2020-51 368.08 369.03 367.45
... 26457900 359.98 0.003890 358.346429 345.7506 + + + + +
1255 2020-12-28 2020     12  28   Monday      52  2020-52 371.74 372.59 371.07
... 39000400 363.07 0.008591 358.670000 346.2608 + + + + +
1256 2020-12-29 2020     12  29   Tuesday      52  2020-52 373.81 374.00 370.83
... 53680500 362.38 -0.001908 358.869286 346.7612 - + - - -
1257 2020-12-30 2020     12  30   Wednesday     52  2020-52 372.34 373.10 371.57
... 49455300 362.89 0.001427 359.335714 347.3744 + + + + +
504 rows x 21 columns

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KO

```

Date      Year      Month      Day Weekday Week_Number Year_Week  Open   High   Low
... Volume Adj Close Return Short_MA Long_MA True Label Predict Label 2
Predict Label 3 Predict Label 4 Ensemble Predict
754 2019-01-02 2019      1   2   Wednesday      0   2019-00 46.94 47.22 46.56
... 11603700 41.71 -0.008870 42.507143 42.8642 - + + + +
755 2019-01-03 2019      1   3   Thursday      0   2019-00 46.82 47.37 46.53
... 14714400 41.45 -0.006179 42.343571 42.8762 - + + + +
756 2019-01-04 2019      1   4   Friday      0   2019-00 46.75 47.57 46.64 ...
13013700 42.28 0.019940 42.222857 42.9112 + + + + +
757 2019-01-07 2019      1   7   Monday      1   2019-01 47.57 47.75 46.90 ...

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13135500    41.73    -0.013034    42.071429    42.9282 -    +    +    +    +
758 2019-01-08 2019      1    8    Tuesday 1    2019-01 47.25    47.57    47.04    ...
15420700    42.20    0.011289    42.017857    42.9482 +    +    +    -    +
... ..
... ..
1253    2020-12-23    2020      12    23    Wednesday    51    2020-51 52.95    53.39    52.94
... 7040300 50.33    0.006065    50.499286    48.8620 +    +    +    +    +
1254    2020-12-24    2020      12    24    Thursday    51    2020-51 53.02    53.55    53.02
... 3265500 50.67    0.006782    50.471429    48.9322 +    +    +    +    +
1255    2020-12-28    2020      12    28    Monday    52    2020-52 53.85    54.44    53.73
... 9020500 51.36    0.013473    50.550714    49.0188 +    +    -    -    -
1256    2020-12-29    2020      12    29    Tuesday    52    2020-52 54.45    54.49    54.02
... 8320600 51.33    -0.000554    50.615000    49.1040 -    +    +    +    +
1257    2020-12-30    2020      12    30    Wednesday    52    2020-52 54.05    54.63    54.03
... 8142700 51.62    0.005727    50.690000    49.2026 +    +    +    +    +
504 rows x 21 columns

```

Q3 2.

S&P-500

Ensemble accuracy of '+' : 0.9220338983050848

Ensemble accuracy of '-' : 0.11961722488038277

Ensemble total accuracy : 0.5892857142857143

KO

Ensemble accuracy of '+' : 0.9368029739776952

Ensemble accuracy of '-' : 0.05106382978723404

Ensemble total accuracy : 0.5238095238095238

Q3 3.

For S&P-500 the accuracy of predicting '-' in ensemble is better than only W=2

For KO the accuracy of predicting '-' in ensemble is better than only W=2

Q3 4.

For S&P-500 the accuracy of predicting '+' in ensemble is better than W=3 and W=4

For KO the accuracy of predicting '+' in ensemble is better than W=3 and W=4

Question 4

Q4 1., 2., 3., 4., 5., 6.

S&P-500

W=2

TP - 295 , FP - 209 , TN - 0 , FN - 0

TPR - 1.0

TNR - 0.0

W=3

TP - 247 , FP - 161 , TN - 48 , FN - 48

TPR - 0.8372881355932204

TNR - 0.22966507177033493

W=4

TP - 236 , FP - 155 , TN - 54 , FN - 59

TPR - 0.8

TNR - 0.2583732057416268

Ensemble

TP - 272 , FP - 184 , TN - 25 , FN - 23

TPR - 0.9220338983050848

TNR - 0.11961722488038277

KO

W=2

TP - 269 , FP - 235 , TN - 0 , FN - 0

TPR - 1.0

TNR - 0.0

W=3

TP - 233 , FP - 206 , TN - 29 , FN - 36

TPR - 0.8661710037174721

TNR - 0.12340425531914893

W=4

TP - 174 , FP - 167 , TN - 68 , FN - 95

TPR - 0.6468401486988847

TNR - 0.28936170212765955

Ensemble

TP - 252 , FP - 223 , TN - 12 , FN - 17

TPR - 0.9368029739776952

TNR - 0.05106382978723404

Q4 7.

ind	W	ticker	TP	FP	TN	FN	accuracy	TPR	TNR
0	2	S&P-500	295.0	209.0	0.0	0.0	0.585317	1.000000	0.000000
1	3	S&P-500	247.0	161.0	48.0	48.0	0.585317	0.837288	0.229665
2	4	S&P-500	236.0	155.0	54.0	59.0	0.575397	0.800000	0.258373
3	Ensemble	S&P-500	272.0	184.0	25.0	23.0	0.589286	0.922034	0.119617
4	2	KO	269.0	235.0	0.0	0.0	0.533730	1.000000	0.000000
5	3	KO	233.0	206.0	29.0	36.0	0.519841	0.866171	0.123404

ind	W	ticker	TP	FP	TN	FN	accuracy	TPR	TNR
6	4	KO	174.0	167.0	68.0	95.0	0.480159	0.646840	0.289362
7	Ensemble	KO	252.0	223.0	12.0	17.0	0.523810	0.936803	0.051064

Q4 8.

w2 has highest TP and FP while it has the least TN and FN for both SPY and Ko ticker.

Question 5

Q5 1.

 KO Graph

Q5 2.

There is a huge dip in returns of the stock during the beginning of 2020 and then there was considerable rise of the returns.

W=2 graph is the most similar to the Buy and Hold graph