Assignment 3

December 8, 2018

```
In [0]: import pandas as pd
        import numpy as np
        import matplotlib.pyplot as plt
        import seaborn as sns
        sns.set()
```

```
In [40]: Income = 200
         Pas = [10.5, 12.5, 15.5, 20]
         Pb = 40
         Qa = np.arange(0,21,0.5)
         Qb = [((Income)/(Pb)) - ((Pa*Qa)/(Pb)) for Pa in Pas]
         df = pd.DataFrame(list(zip(Qa,Qb[0],Qb[1],Qb[2],Qb[3])),
                           columns=['Quantity of Product A'] +
                                   ['Quantity of Product B at Price A = {}'.format(Pa) for Pa
         print(df)
```

```
    Quantity of Product A  Quantity of Product B at Price A = 10.5  \
0                     0.0                                  5.00000
1                     0.5                                  4.86875
2                     1.0                                  4.73750
3                     1.5                                  4.60625
4                     2.0                                  4.47500
5                     2.5                                  4.34375
6                     3.0                                  4.21250
7                     3.5                                  4.08125
8                     4.0                                  3.95000
9                     4.5                                  3.81875
10                    5.0                                  3.68750
11                    5.5                                  3.55625
12                    6.0                                  3.42500
13                    6.5                                  3.29375
14                    7.0                                  3.16250
15                    7.5                                  3.03125
16                    8.0                                  2.90000
17                    8.5                                  2.76875
18                    9.0                                  2.63750
19                    9.5                                  2.50625
```

20	10.0	2.37500
21	10.5	2.24375
22	11.0	2.11250
23	11.5	1.98125
24	12.0	1.85000
25	12.5	1.71875
26	13.0	1.58750
27	13.5	1.45625
28	14.0	1.32500
29	14.5	1.19375
30	15.0	1.06250
31	15.5	0.93125
32	16.0	0.80000
33	16.5	0.66875
34	17.0	0.53750
35	17.5	0.40625
36	18.0	0.27500
37	18.5	0.14375
38	19.0	0.01250
39	19.5	-0.11875
40	20.0	-0.25000
41	20.5	-0.38125

	Quantity of Product B at Price A = 12.5 \
0	5.00000
1	4.84375
2	4.68750
3	4.53125
4	4.37500
5	4.21875
6	4.06250
7	3.90625
8	3.75000
9	3.59375
10	3.43750
11	3.28125
12	3.12500
13	2.96875
14	2.81250
15	2.65625
16	2.50000
17	2.34375
18	2.18750
19	2.03125
20	1.87500
21	1.71875
22	1.56250
23	1.40625

24	1.25000
25	1.09375
26	0.93750
27	0.78125
28	0.62500
29	0.46875
30	0.31250
31	0.15625
32	0.00000
33	-0.15625
34	-0.31250
35	-0.46875
36	-0.62500
37	-0.78125
38	-0.93750
39	-1.09375
40	-1.25000
41	-1.40625

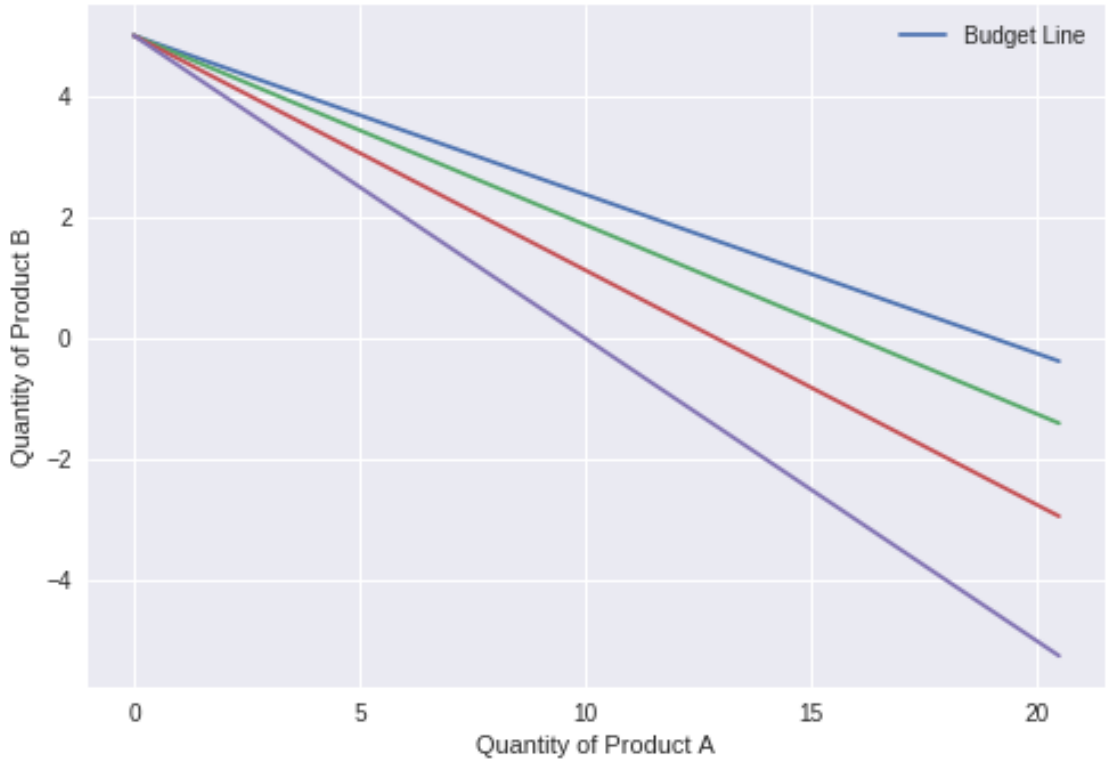
	Quantity of Product B at Price A = 15.5 \
0	5.00000
1	4.80625
2	4.61250
3	4.41875
4	4.22500
5	4.03125
6	3.83750
7	3.64375
8	3.45000
9	3.25625
10	3.06250
11	2.86875
12	2.67500
13	2.48125
14	2.28750
15	2.09375
16	1.90000
17	1.70625
18	1.51250
19	1.31875
20	1.12500
21	0.93125
22	0.73750
23	0.54375
24	0.35000
25	0.15625
26	-0.03750
27	-0.23125

28	-0.42500
29	-0.61875
30	-0.81250
31	-1.00625
32	-1.20000
33	-1.39375
34	-1.58750
35	-1.78125
36	-1.97500
37	-2.16875
38	-2.36250
39	-2.55625
40	-2.75000
41	-2.94375

	Quantity of Product B at Price A = 20
0	5.00
1	4.75
2	4.50
3	4.25
4	4.00
5	3.75
6	3.50
7	3.25
8	3.00
9	2.75
10	2.50
11	2.25
12	2.00
13	1.75
14	1.50
15	1.25
16	1.00
17	0.75
18	0.50
19	0.25
20	0.00
21	-0.25
22	-0.50
23	-0.75
24	-1.00
25	-1.25
26	-1.50
27	-1.75
28	-2.00
29	-2.25
30	-2.50
31	-2.75

```
32                                  -3.00
33                                  -3.25
34                                  -3.50
35                                  -3.75
36                                  -4.00
37                                  -4.25
38                                  -4.50
39                                  -4.75
40                                  -5.00
41                                  -5.25
```

In [41]:
```
[plt.plot(df['Quantity of Product A'], df['Quantity of Product B at Price A = {}'.forr
plt.xlabel('Quantity of Product A')
plt.ylabel('Quantity of Product B')
plt.legend(['Budget Line'])
plt.show()
```



In [42]:
```
x = np.arange(1, 20.1, 0.1)
indifference_curve = lambda x: 25/(2*x)
for Pa in Pas:
    df['Indifference Curve at Pa = {}'.format(Pa)] = indifference_curve(df['Quantity
print(df)
```

	Quantity of Product A	Quantity of Product B at Price A = 10.5	\
0	0.0	5.00000	
1	0.5	4.86875	
2	1.0	4.73750	
3	1.5	4.60625	
4	2.0	4.47500	
5	2.5	4.34375	
6	3.0	4.21250	
7	3.5	4.08125	
8	4.0	3.95000	
9	4.5	3.81875	
10	5.0	3.68750	
11	5.5	3.55625	
12	6.0	3.42500	
13	6.5	3.29375	
14	7.0	3.16250	
15	7.5	3.03125	
16	8.0	2.90000	
17	8.5	2.76875	
18	9.0	2.63750	
19	9.5	2.50625	
20	10.0	2.37500	
21	10.5	2.24375	
22	11.0	2.11250	
23	11.5	1.98125	
24	12.0	1.85000	
25	12.5	1.71875	
26	13.0	1.58750	
27	13.5	1.45625	
28	14.0	1.32500	
29	14.5	1.19375	
30	15.0	1.06250	
31	15.5	0.93125	
32	16.0	0.80000	
33	16.5	0.66875	
34	17.0	0.53750	
35	17.5	0.40625	
36	18.0	0.27500	
37	18.5	0.14375	
38	19.0	0.01250	
39	19.5	-0.11875	
40	20.0	-0.25000	
41	20.5	-0.38125	

	Quantity of Product B at Price A = 12.5	\
0	5.00000	
1	4.84375	
2	4.68750	

3	4.53125
4	4.37500
5	4.21875
6	4.06250
7	3.90625
8	3.75000
9	3.59375
10	3.43750
11	3.28125
12	3.12500
13	2.96875
14	2.81250
15	2.65625
16	2.50000
17	2.34375
18	2.18750
19	2.03125
20	1.87500
21	1.71875
22	1.56250
23	1.40625
24	1.25000
25	1.09375
26	0.93750
27	0.78125
28	0.62500
29	0.46875
30	0.31250
31	0.15625
32	0.00000
33	-0.15625
34	-0.31250
35	-0.46875
36	-0.62500
37	-0.78125
38	-0.93750
39	-1.09375
40	-1.25000
41	-1.40625

	Quantity of Product B at Price A = 15.5 \
0	5.00000
1	4.80625
2	4.61250
3	4.41875
4	4.22500
5	4.03125
6	3.83750

7	3.64375
8	3.45000
9	3.25625
10	3.06250
11	2.86875
12	2.67500
13	2.48125
14	2.28750
15	2.09375
16	1.90000
17	1.70625
18	1.51250
19	1.31875
20	1.12500
21	0.93125
22	0.73750
23	0.54375
24	0.35000
25	0.15625
26	-0.03750
27	-0.23125
28	-0.42500
29	-0.61875
30	-0.81250
31	-1.00625
32	-1.20000
33	-1.39375
34	-1.58750
35	-1.78125
36	-1.97500
37	-2.16875
38	-2.36250
39	-2.55625
40	-2.75000
41	-2.94375

	Quantity of Product B at Price A = 20	Indifference Curve at Pa = 10.5 \
0	5.00	2.500000
1	4.75	2.567394
2	4.50	2.638522
3	4.25	2.713704
4	4.00	2.793296
5	3.75	2.877698
6	3.50	2.967359
7	3.25	3.062787
8	3.00	3.164557
9	2.75	3.273322
10	2.50	3.389831

11	2.25	3.514938
12	2.00	3.649635
13	1.75	3.795066
14	1.50	3.952569
15	1.25	4.123711
16	1.00	4.310345
17	0.75	4.514673
18	0.50	4.739336
19	0.25	4.987531
20	0.00	5.263158
21	-0.25	5.571031
22	-0.50	5.917160
23	-0.75	6.309148
24	-1.00	6.756757
25	-1.25	7.272727
26	-1.50	7.874016
27	-1.75	8.583691
28	-2.00	9.433962
29	-2.25	10.471204
30	-2.50	11.764706
31	-2.75	13.422819
32	-3.00	15.625000
33	-3.25	18.691589
34	-3.50	23.255814
35	-3.75	30.769231
36	-4.00	45.454545
37	-4.25	86.956522
38	-4.50	1000.000000
39	-4.75	-105.263158
40	-5.00	-50.000000
41	-5.25	-32.786885

	Indifference Curve at Pa = 12.5	Indifference Curve at Pa = 15.5 \
0	2.500000	2.500000
1	2.580645	2.600780
2	2.666667	2.710027
3	2.758621	2.828854
4	2.857143	2.958580
5	2.962963	3.100775
6	3.076923	3.257329
7	3.200000	3.430532
8	3.333333	3.623188
9	3.478261	3.838772
10	3.636364	4.081633
11	3.809524	4.357298
12	4.000000	4.672897
13	4.210526	5.037783
14	4.444444	5.464481

15	4.705882	5.970149
16	5.000000	6.578947
17	5.333333	7.326007
18	5.714286	8.264463
19	6.153846	9.478673
20	6.666667	11.111111
21	7.272727	13.422819
22	8.000000	16.949153
23	8.888889	22.988506
24	10.000000	35.714286
25	11.428571	80.000000
26	13.333333	-333.333333
27	16.000000	-54.054054
28	20.000000	-29.411765
29	26.666667	-20.202020
30	40.000000	-15.384615
31	80.000000	-12.422360
32	inf	-10.416667
33	-80.000000	-8.968610
34	-40.000000	-7.874016
35	-26.666667	-7.017544
36	-20.000000	-6.329114
37	-16.000000	-5.763689
38	-13.333333	-5.291005
39	-11.428571	-4.889976
40	-10.000000	-4.545455
41	-8.888889	-4.246285

	Indifference Curve at Pa = 20
0	2.500000
1	2.631579
2	2.777778
3	2.941176
4	3.125000
5	3.333333
6	3.571429
7	3.846154
8	4.166667
9	4.545455
10	5.000000
11	5.555556
12	6.250000
13	7.142857
14	8.333333
15	10.000000
16	12.500000
17	16.666667
18	25.000000

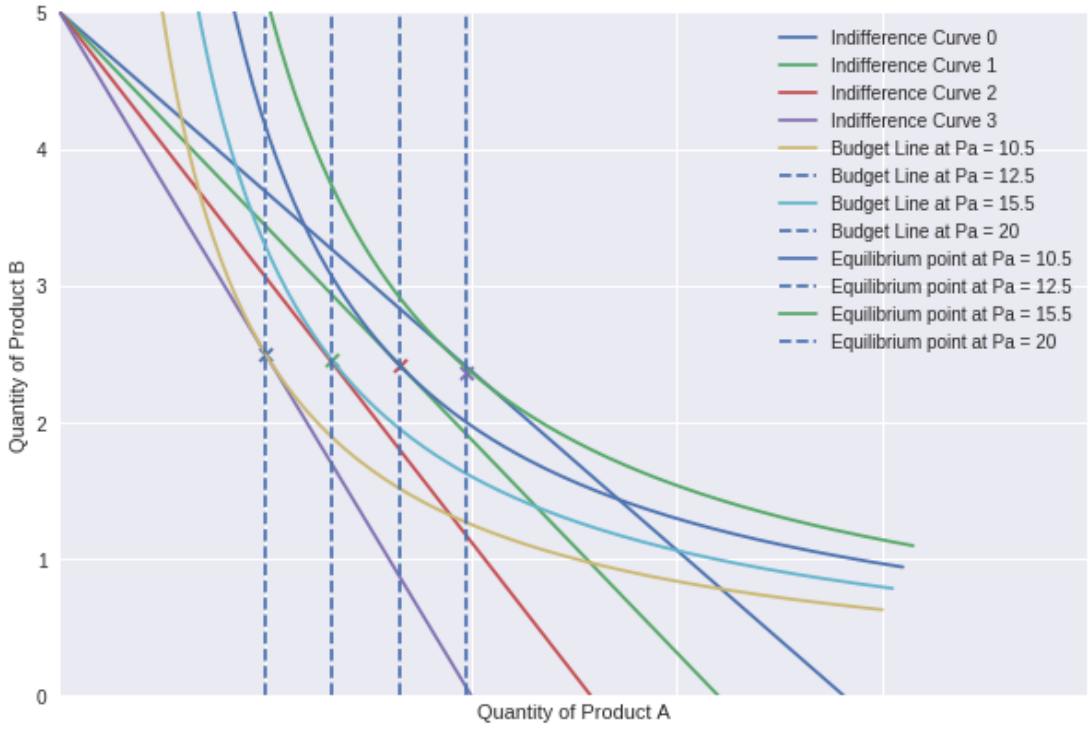
```
19                    50.000000
20                          inf
21                   -50.000000
22                   -25.000000
23                   -16.666667
24                   -12.500000
25                   -10.000000
26                    -8.333333
27                    -7.142857
28                    -6.250000
29                    -5.555556
30                    -5.000000
31                    -4.545455
32                    -4.166667
33                    -3.846154
34                    -3.571429
35                    -3.333333
36                    -3.125000
37                    -2.941176
38                    -2.777778
39                    -2.631579
40                    -2.500000
41                    -2.380952
```

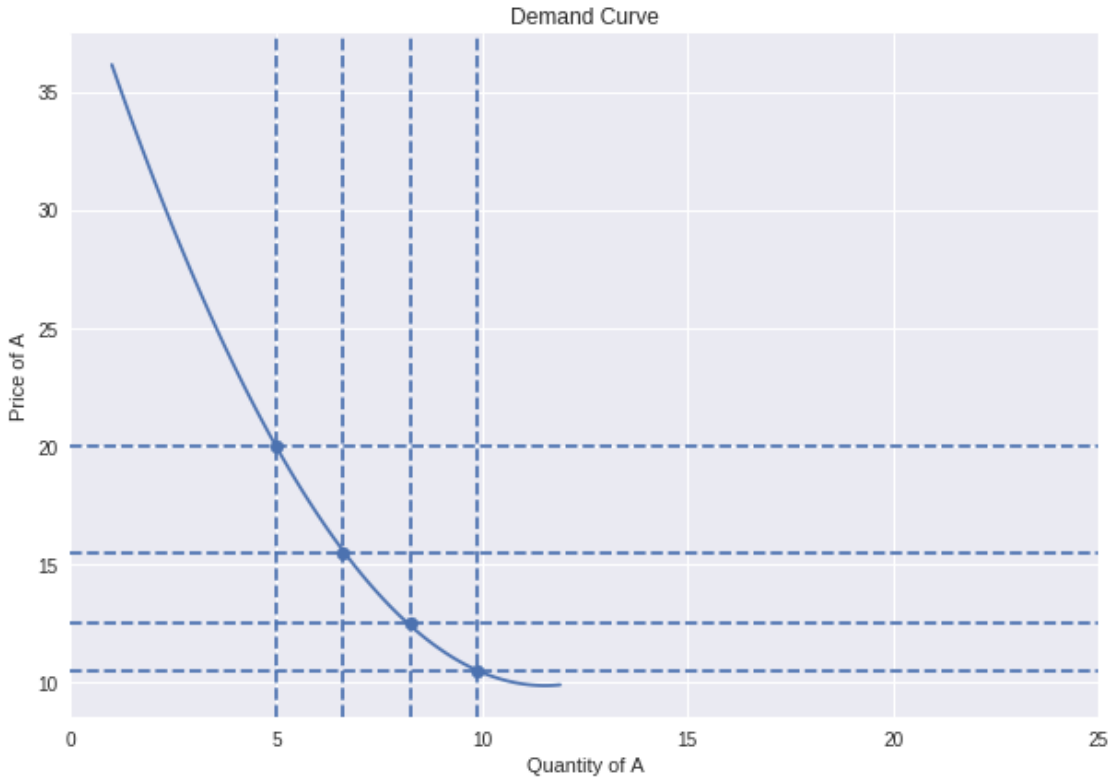
In [83]:
```
fig, ax = plt.subplots(ncols=1, nrows=2, sharex=True, figsize=(10,15))
for Pa in Pas:
    ax[0].plot(df['Quantity of Product A'], df['Quantity of Product B at Price A = {}
for i in np.arange(1,2,0.25):
    ax[0].plot(x+i-1, i*indifference_curve(x))
    ax[0].scatter([5+6.5*(i-1)],indifference_curve(5)-(i-1)/5.5, marker='x')
    ax[0].axvline([5+6.5*(i-1)],0,indifference_curve(5)-(i-1)/5.5, linestyle='dashed'
    ax[1].axvline([5+6.5*(i-1)],0,indifference_curve(5)-(i-1)/5.5, linestyle='dashed'
ax[0].set_xlabel('Quantity of Product A')
ax[0].set_ylabel('Quantity of Product B')
ax[0].set_ylim(0, 5)
ax[0].set_xlim(0, 20)
ax[0].legend(['Indifference Curve {}'.format(i) for i in range(4)] +
             ['Budget Line at Pa = {}'.format(Pa) for Pa in Pas] +
             ['Equilibrium point at Pa = {}'.format(Pa) for Pa in Pas])

ax[1].scatter([5+6.5*(i-1) for i in np.arange(1,2,0.25)],Pas[::-1])
for Pa in Pas:
  ax[1].axhline(Pa, linestyle='dashed')
values = np.polyfit([5+6.5*(i-1) for i in np.arange(1,2,0.25)],Pas[::-1], deg=2)
ax[1].plot(x[:110], values[2] + x[:110]*values[1] + (x[:110]**2)*values[0])
ax[1].set_xlim(0,11)
ax[1].set_xlim(0,25)
```

```
ax[1].set_title('Demand Curve')
ax[1].set_xlabel('Quantity of A')
ax[1].set_ylabel('Price of A')

plt.show()
```


Indifference Curve 0
Indifference Curve 1
Indifference Curve 2
Indifference Curve 3
Budget Line at Pa = 10.5
Budget Line at Pa = 12.5
Budget Line at Pa = 15.5
Budget Line at Pa = 20
Equilibrium point at Pa = 10.5
Equilibrium point at Pa = 12.5
Equilibrium point at Pa = 15.5
Equilibrium point at Pa = 20
Quantity of Product B
Quantity of Product A
0
1
2
3
4
5


Demand Curve
Price of A
Quantity of A
10
15
20
25
30
35
0
5
10
15
20
25