Session 10: Data Assembly (with Solutions)

1. Concatenating DataFrames

Setting up

```
[1]: import pandas as pd
     df1=pd.DataFrame([[1,3],[2,4]],columns=['A','B'])
     df1
```

```
   A  B
0  1  3
1  2  4
```

```
[2]: df2=pd.DataFrame([[3,5],[4,6]],columns=['A','B'])
     df2
```

```
   A  B
0  3  5
1  4  6
```

```
[3]: df3=pd.DataFrame([[1,1],[1,1]],columns=['B','C'])
     df3
```

```
   B  C
0  1  1
1  1  1
```

Vertical concatenation

```
[4]: df=pd.concat([df1,df2])
     df
```

```
   A  B
0  1  3
1  2  4
0  3  5
1  4  6
```

```
[5]: df.loc[0,:]
```

```
   A  B
0  1  3
0  3  5
```

```
[6]: pd.concat([df1,df2],ignore_index=True)
```

```
   A  B
0  1  3
1  2  4
2  3  5
3  4  6
```

Column names do not match

```
[7]: pd.concat([df1,df3],sort=False)
```

```
     A  B    C
0  1.0  3  NaN
1  2.0  4  NaN
0  NaN  1  1.0
1  NaN  1  1.0
```

```
[8]: pd.concat([df1,df3],join='inner')
```

```
   B
0  3
1  4
0  1
1  1
```

Horizontal Concatenation

```
[9]: df=pd.concat([df1,df2],axis=1)
     df
```

```
   A  B  A  B
0  1  3  3  5
1  2  4  4  6
```

```
[10]: df.T
```

```
   0  1
A  1  2
B  3  4
A  3  4
B  5  6
```

Q1-a: Vertically concatenate 3 copies of `df1` together and avoid repeated row labels.

```
[11]: pd.concat([df1,df1,df1],ignore_index=True)
```

```
   A  B
0  1  3
1  2  4
2  1  3
3  2  4
4  1  3
5  2  4
```

Q1-b: Horizontally concatenate `df1` with the last column of `df3`.

```
[12]: pd.concat([df1,df3.iloc[:,-1]],axis=1)
```

```
   A  B  C
0  1  3  1
1  2  4  1
```

Case 8: Analyzing Cancelled Courses by Department

Download the "Marshall Course Scheduling Data" from Blackboard->Datasets and extract all of the files into the current directory. Then run the following two code cells to load in the Marshall courses from the 2015-2016 and 2016-2017 academic years, as well as all the cancelled courses fromt the same years. Note that the column names of the two files are identical, which makes them suitable for concatenation.

```
[13]: courses=pd.read_excel('Marshall_Course_Enrollment_1516_1617.xlsx')
      courses['Cancelled']=False
      courses.columns
```

```
Index(['Course', 'Course Prefix', 'Course Suffix', 'Department',
       'First Begin Time', 'First Days', 'First End Time', 'First Instructor',
       'First Instructor UID', 'First Room', 'Link', 'Max Units', 'Min Units',
       'Mode', 'Reg Count', 'Seats', 'Second Begin Time', 'Second Days',
       'Second End Time', 'Second Instructor', 'Second Instructor UID',
       'Second Room', 'Section', 'Session', 'Term', 'Title', 'Cancelled'],
      dtype='object')
```

```
[14]: cancelled=pd.read_excel('Cancelled_Courses_1516_1617.xlsx')
      cancelled['Cancelled']=True
      cancelled.columns
```

```
Index(['Course', 'Course Prefix', 'Course Suffix', 'Department',
       'First Begin Time', 'First Days', 'First End Time', 'First Instructor',
       'First Instructor UID', 'First Room', 'Link', 'Max Units', 'Min Units',
       'Mode', 'Reg Count', 'Seats', 'Second Begin Time', 'Second Days',
       'Second End Time', 'Second Instructor', 'Second Instructor UID',
       'Second Room', 'Section', 'Session', 'Term', 'Title', 'Cancelled'],
      dtype='object')
```

Concatenate the DataFrame "cancelled" at the bottom of the DataFrame "courses" and call the resulting DataFrame "combined", making sure that there are no two rows with the same row label.

```
[15]: combined=pd.concat([courses,cancelled],ignore_index=True)
      combined.head()
```

	Course	Course Prefix	Course Suffix	Department	First Begin Time	\
0	ACCT-370	ACCT	370	ACCT	10:00:00	
1	ACCT-370	ACCT	370	ACCT	08:00:00	
2	ACCT-370	ACCT	370	ACCT	10:00:00	
3	ACCT-370	ACCT	370	ACCT	12:00:00	
4	ACCT-371	ACCT	371	ACCT	10:00:00	

	First Days	First End Time	First Instructor	First Instructor UID	\
0	F	11:50:00	Hopkins, Merle, W	3.783354e+09	
1	MW	09:50:00	Hopkins, Merle, W	3.783354e+09	
2	MW	11:50:00	Hopkins, Merle, W	3.783354e+09	
3	MW	13:50:00	Hopkins, Merle, W	3.783354e+09	
4	F	11:50:00	NaN	NaN	

```
  First Room    ...    Second Days  Second End Time  Second Instructor  \
0     SLH200    ...            NaN              NaN                NaN
1     ACC303    ...            NaN              NaN                NaN
2     ACC303    ...            NaN              NaN                NaN
3     ACC303    ...            NaN              NaN                NaN
4     SLH200    ...            NaN              NaN                NaN

  Second Instructor UID  Second Room  Section Session   Term  \
0                   NaN          NaN    14029       1  20153
1                   NaN          NaN    14025       1  20153
2                   NaN          NaN    14026       1  20153
3                   NaN          NaN    14027       1  20153
4                   NaN          NaN    14044       1  20153

                              Title Cancelled
0  External Financial Reporting Issues     False
1  External Financial Reporting Issues     False
2  External Financial Reporting Issues     False
3  External Financial Reporting Issues     False
4   Introduction to Accounting Systems     False

[5 rows x 27 columns]
```

Once you have done the above, you can run the following command to compare departments by percentage of proposed courses that were cancelled.

```
[1]: combined.groupby('Course Prefix')['Cancelled'].mean()\
         .sort_values(ascending=False)\
         .plot(kind='bar',title='Percentage of cancelled course sections')


        ---------------------------------------------------------------------------

        NameError                                 Traceback (most recent call last)

        <ipython-input-1-379cca7c6ae0> in <module>
    ----> 1 combined.groupby('Course Prefix')['Cancelled'].mean()\
          2     .sort_values(ascending=False)\
          3     .plot(kind='bar',title='Percentage of cancelled course sections')


        NameError: name 'combined' is not defined
```

2. Merging DataFrames

Setting up

```
[17]: courses_small=courses[['First Room','Seats','Reg Count']].head(3)
      courses_small

  First Room  Seats  Reg Count
0     SLH200    135        106
```

```
1     ACC303     42         24
2     ACC303     42         40
```

```
[18]: rooms=pd.DataFrame([['ACC303', 46],['JKP102',52]],columns=['Room','Size'])
      rooms
```

```
     Room  Size
0  ACC303    46
1  JKP102    52
```

Four kinds of merges

```
[19]: courses_small.merge(rooms,left_on='First Room',right_on='Room')
```

```
  First Room  Seats  Reg Count    Room  Size
0     ACC303     42         24  ACC303    46
1     ACC303     42         40  ACC303    46
```

```
[20]: courses_small.merge(rooms,left_on='First Room',right_on='Room',how='left')
```

```
  First Room  Seats  Reg Count    Room  Size
0     SLH200    135        106     NaN   NaN
1     ACC303     42         24  ACC303  46.0
2     ACC303     42         40  ACC303  46.0
```

```
[21]: courses_small.merge(rooms,left_on='First Room',right_on='Room',how='right')
```

```
  First Room  Seats  Reg Count    Room  Size
0     ACC303   42.0       24.0  ACC303    46
1     ACC303   42.0       40.0  ACC303    46
2        NaN    NaN        NaN  JKP102    52
```

```
[22]: courses_small.merge(rooms,left_on='First Room',right_on='Room',how='outer')
```

```
  First Room  Seats  Reg Count    Room  Size
0     SLH200  135.0      106.0     NaN   NaN
1     ACC303   42.0       24.0  ACC303  46.0
2     ACC303   42.0       40.0  ACC303  46.0
3        NaN    NaN        NaN  JKP102  52.0
```

Q2: In your own words, explain to your neighbor the difference between the following settings of "how" in the merge function: inner (default), left, right, and outer.

Answer:

- inner: only keep rows in which there is a successful match between the two DataFrames.
- left: keep every row in the left DataFrame, but only keep rows in the right DataFrame that match to the left.
- right: keep every row in the right DataFrame, but only keep rows in the left DataFrame that match to the right.
- outer: keep every row in both DataFrames.

Merging by Index

```
[23]: # Merging on row labels instead of column values
      courses_small.merge(rooms,left_index=True,right_index=True)
```

```
  First Room  Seats  Reg Count    Room  Size
0     SLH200    135        106  ACC303    46
1     ACC303     42         24  JKP102    52
```

Merging by Multiple Columns

```
[24]: courses_small['Building']=courses_small['First Room'].str.slice(0,3)
      courses_small['Room']=courses_small['First Room'].str.slice(3).astype(int)
      courses_small
```

```
  First Room  Seats  Reg Count Building  Room
0     SLH200    135        106      SLH   200
1     ACC303     42         24      ACC   303
2     ACC303     42         40      ACC   303
```

```
[25]: rooms2=pd.DataFrame([['ACC',303, 46],['JKP',102,52]]\
                          ,columns=['Building','Room','Size'])
      rooms2
```

```
  Building  Room  Size
0      ACC   303    46
1      JKP   102    52
```

```
[26]: courses_small.merge(rooms2,left_on=['Building','Room']\
                        ,right_on=['Building','Room'])
```

```
  First Room  Seats  Reg Count Building  Room  Size
0     ACC303     42         24      ACC   303    46
1     ACC303     42         40      ACC   303    46
```

```
[27]: # Identical to the above if column names are the same in both DataFrames
      courses_small.merge(rooms2,on=['Building','Room'])
```

```
  First Room  Seats  Reg Count Building  Room  Size
0     ACC303     42         24      ACC   303    46
1     ACC303     42         40      ACC   303    46
```

Case 9: Efficiency of Room Use in Marshall Course Scheduling

Run the following two cells to load in a smaller version of the scheduling data as well as the rooms data.

```
[28]: data=pd.read_excel('Marshall_Course_Enrollment_1516_1617.xlsx')\
         [['Term','Course','Section','Title','First Room','Department','Reg Count','Seats']]
      data.head()
```

```
    Term    Course  Section                                Title First Room  \
0  20153  ACCT-370    14029  External Financial Reporting Issues     SLH200
1  20153  ACCT-370    14025  External Financial Reporting Issues     ACC303
```

```
2  20153  ACCT-370    14026  External Financial Reporting Issues     ACC303
3  20153  ACCT-370    14027  External Financial Reporting Issues     ACC303
4  20153  ACCT-371    14044   Introduction to Accounting Systems     SLH200

  Department  Reg Count  Seats
0       ACCT        106    135
1       ACCT         24     42
2       ACCT         40     42
3       ACCT         42     42
4       ACCT        110    150
```

```
[29]: rooms=pd.read_excel('Marshall_Room_Capacity_Chart.xlsx',usecols=range(2))
      rooms.head()
```

```
       Room  Size
0  ACC 306B    16
1    ACC201    48
2    ACC205    36
3    ACC236    39
4    ACC303    46
```

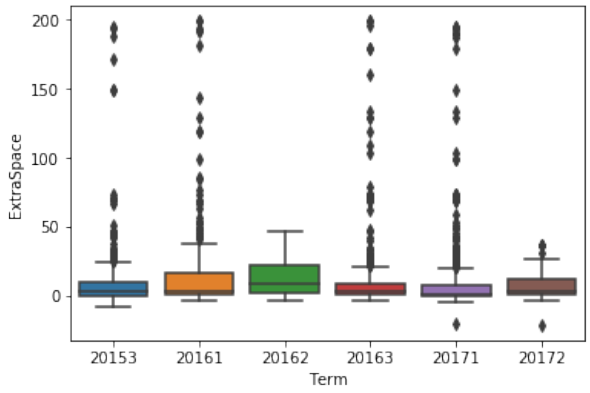
Create a DataFrame called "data2" from an inner merge of the "data" DataFrame and the "rooms" DataFrame. Add a new column in "data2" called "ExtraSpace" which is the "Size" minus the "Seats" columns.

```
[30]: data2=data.merge(rooms,left_on='First Room',right_on='Room')
      data2['ExtraSpace']=data2['Size']-data2['Seats']
      data2.head()
```

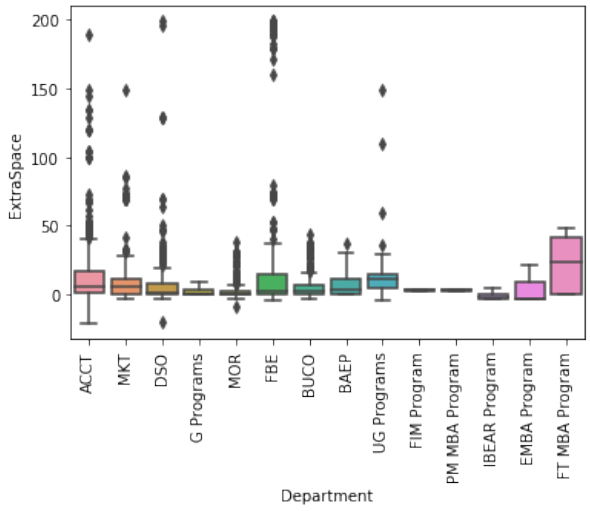
```
    Term    Course  Section                                Title First Room  \
0  20153  ACCT-370    14025  External Financial Reporting Issues     ACC303
1  20153  ACCT-370    14026  External Financial Reporting Issues     ACC303
2  20153  ACCT-370    14027  External Financial Reporting Issues     ACC303
3  20153  ACCT-371    14040   Introduction to Accounting Systems     ACC303
4  20153  ACCT-371    14042   Introduction to Accounting Systems     ACC303

  Department  Reg Count  Seats    Room  Size  ExtraSpace
0       ACCT         24     42  ACC303    46           4
1       ACCT         40     42  ACC303    46           4
2       ACCT         42     42  ACC303    46           4
3       ACCT         29     42  ACC303    46           4
4       ACCT         40     42  ACC303    46           4
```

Once you finish the above, you can compare the wastage in room assignment by term and by department.

```
[31]: import seaborn as sns
      sns.boxplot(x='Term',y='ExtraSpace',data=data2)
```



[41]:
```
import matplotlib.pyplot as plt
sns.boxplot(x='Department',y='ExtraSpace',data=data2)
plt.xticks(rotation=90)
plt.show()
```



[33]:
```
data2.query('Department=="FT MBA Program"')\
    .sort_values(by='ExtraSpace',ascending=False).head()
```

	Term	Course	Section	Title	First Room	\
997	20161	GSBA-580C	15998	The Global Context of Business	JKP212	
1029	20171	GSBA-580C	15999	The Global Context of Business	JKP212	
998	20161	GSBA-580C	15999	The Global Context of Business	JKP212	
999	20161	GSBA-580C	16002	The Global Context of Business	JKP212	
1032	20171	GSBA-580C	16003	The Global Context of Business	JKP212	

	Department	Reg Count	Seats	Room	Size	ExtraSpace
997	FT MBA Program	30	30	JKP212	78	48
1029	FT MBA Program	33	34	JKP212	78	44
998	FT MBA Program	35	35	JKP212	78	43
999	FT MBA Program	35	35	JKP212	78	43
1032	FT MBA Program	36	36	JKP212	78	42

Case 10: Analyzing Popularity of Courses

Execute the below two code cells to load in the student course selection data and compute the number of students in each term who chose each course and section as their first choice.

```
[34]: students=pd.read_excel('Student_Course_Selection_1516.xlsx')
      students.rename(columns={'Randomized Unique Identifier':'ID'},inplace=True)
      students.head()
```

```
     ID    Major Class      Owner Objective   Term     Course  \
0  1001      USC     0        USC      NONE  20163  ACCT-551T
1  1001      USC     0        USC      NONE  20163  ACCT-561T
2  1001      USC     0        USC      NONE  20163  ACCT-568T
3  1002  ECON,IR    U4  LASS,LASS     BA,BA  20163   ACCT-410
4  1002  ECON,IR    U4  LASS,LASS     BA,BA  20163    DSO-401

                                          Title  Section  \
0              Taxation of Partnerships and S-Corps    14222
1  Income Tax of Corporations and Their Shareholders    14236
2                           International Taxation    14248
3                        Foundations of Accounting    14092
4  Business Information Systems -- Spreadsheet Ap...    16214

                Instructor  # Students  Units Enroll Withdraw
0          Mills, Patricia           8    3.0      L      NaN
1              Keller, Joe           5    3.0      L      NaN
2  Werner, Maryanne, Sabido          5    3.0      L      NaN
3        Karayan, John, E           12    4.0      L      NaN
4         Pereira, Francis           8    2.0     PN      NaN
```

```
[35]: students['Rank']=students.groupby(['ID','Term']).cumcount()
      topchoice=students.query('Rank==0')\
          .groupby(['Term','Course','Section'])['ID'].count().reset_index()
      topchoice.rename(columns={'ID':'FirstChoice'},inplace=True)
      topchoice.head()
```

```
    Term    Course  Section  FirstChoice
0  20153  ACCT-370    14025           24
1  20153  ACCT-370    14026           40
2  20153  ACCT-370    14027           42
3  20153  ACCT-371    14040            7
4  20153  ACCT-371    14041            1
```

Merge the "topchoice" DataFrame above with the "data" DataFrame from Case 9, and call the result "data3". You should merge on Term, Course, and Section.

```
[36]: data3=data.merge(topchoice,on=['Term','Course','Section'])
      data3.head()
```

```
    Term    Course  Section                                Title First Room  \
0  20153  ACCT-370    14025  External Financial Reporting Issues     ACC303
1  20153  ACCT-370    14026  External Financial Reporting Issues     ACC303
2  20153  ACCT-370    14027  External Financial Reporting Issues     ACC303
```

```
3  20153  ACCT-371    14040   Introduction to Accounting Systems     ACC303
4  20153  ACCT-371    14042   Introduction to Accounting Systems     ACC303
```

	Department	Reg Count	Seats	FirstChoice
0	ACCT	24	42	24
1	ACCT	40	42	40
2	ACCT	42	42	42
3	ACCT	29	42	7
4	ACCT	40	42	7

After you are done, you can run the following code to create a column "VeryDesirable" to identify course sections for which 80 percent of the registered students chose it as their first choice, and at least 20 students chose it as first choice. The second line produces a graph that compares department in the number of very desirable course sections.

```
[37]: data3['VeryDesirable']=(data3['FirstChoice']>=data3['Reg Count']*0.8) \
          & (data3['FirstChoice']>20)
      data3.groupby('Department')['VeryDesirable'].sum()\
          .sort_values(ascending=False)\
          .plot(kind='bar',title='Count of very desirable course sections')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fbd33663240>
```