# Cheat Sheet: The pandas DataFrame Object

## Preliminaries

**Always start by importing these Python modules**

```
import numpy as np
import matplotlib.pyplot as plt
import pandas as pd
from pandas import DataFrame, Series
```

**Note**: these are the recommended import aliases

## Cheat sheet conventions

**Code examples**

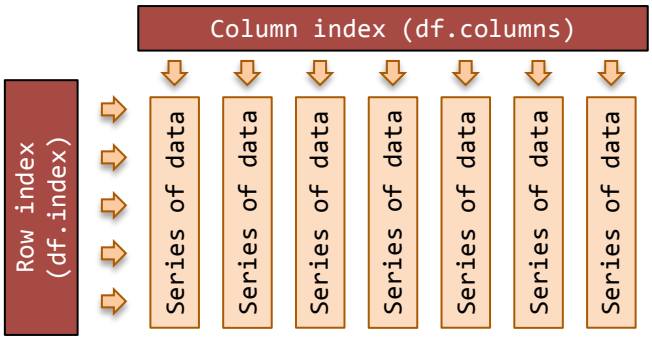
```
# Code examples are found in yellow boxes
# These are designed to be cut and paste
```

**In the code examples, typically I use:**

- `s` to represent a pandas Series object;
- `df` to represent a pandas DataFrame object;
- `idx` to represent a pandas Index object.
- Also: `t` – tuple, `l` – list, `b` – Boolean, `i` – integer, `a` – numpy array, st – string, d – dictionary, etc.

## The conceptual model

**DataFrame object**: The pandas DataFrame is a two-dimensional table of data with column and row indexes (something like a spread sheet). The columns are made up of pandas Series objects (more below).




**A DataFrame has two Indexes:**

- Typically, the column index (df.columns) is a list of strings (observed variable names) or (less commonly) integers
- Typically, the row index (df.index) might be:
  - Integers - for case or row numbers;
  - Strings – for case names; or
  - DatetimeIndex or PeriodIndex – for time series

**Series object**: an ordered, one-dimensional array of data with an index. All the data in a Series is of the same data type. Series arithmetic is vectorised after first aligning the Series index for each of the operands.

```
s1 = Series(range(0,4))  # -> 0, 1, 2, 3
s2 = Series(range(1,5))  # -> 1, 2, 3, 4
s3 = s1 + s2             # -> 1, 3, 5, 7
```

## Get your data into a DataFrame

**Instantiate an empty DataFrame**

```
df = DataFrame()
```

**Load a DataFrame from a CSV file**

```
df = pd.read_csv('file.csv')# often works
df = pd.read_csv('file.csv', header=0,
      index_col=0, quotechar='"',sep=':',
      na_values = ['na', '-', '.', ''])
```

**Note**: refer to pandas docs for all arguments

**Get data from inline CSV text to a DataFrame**

```
from io import StringIO
data = """, Animal, Cuteness, Desirable
row-1,      dog,    8.7,      True
row-2,      cat,    9.5,      True
row-3,      bat,    2.6,      False"""
df = pd.read_csv(StringIO(data),
      header=0, index_col=0,
      skipinitialspace=True)
```

**Note**: *`skipinitialspace=True`* allows a pretty layout

**Load DataFrames from a Microsoft Excel file**

```
# Each Excel sheet in a Python dictionary
workbook = pd.ExcelFile('file.xlsx')
d = {} # start with an empty dictionary
for sheet_name in workbook.sheet_names:
    df = workbook.parse(sheet_name)
    d[sheet_name] = df
```

**Note**: the parse() method takes many arguments like read_csv() above. Refer to the pandas documentation.

**Load a DataFrame from a MySQL database**

```
import pymysql
from sqlalchemy import create_engine
engine = create_engine('mysql+pymysql://'
    +'USER:PASSWORD@HOST/DATABASE')
df = pd.read_sql_table('table', engine)
```

**Data in Series then combine into a DataFrame**

```
# Example 1 ...
s1 = Series(range(6))
s2 = s1 * s1
s2.index = s2.index + 2# misalign indexes
df = pd.concat([s1, s2], axis=1)

# Example 2 ...
s3 = Series({'Tom':1, 'Dick':4, 'Har':9})
s4 = Series({'Tom':3, 'Dick':2, 'Mar':5})
df = pd.concat({'A':s3, 'B':s4 }, axis=1)
```

**Note**: 1st method has in integer column labels
**Note**: 2nd method does not guarantee col order
**Note**: index alignment on DataFrame creation

**Get a DataFrame from a Python dictionary**

```
# default --- assume data is in columns
df = DataFrame({
        'col0' : [1.0, 2.0, 3.0, 4.0],
        'col1' : [100, 200, 300, 400]
    })
```

### Get a DataFrame from data in a Python dictionary

```
# --- use helper method for data in rows
df = DataFrame.from_dict({ # data by row
        # rows as python dictionaries
        'row0' : {'col0':0, 'col1':'A'},
        'row1' : {'col0':1, 'col1':'B'}
    }, orient='index')

df = DataFrame.from_dict({ # data by row
        # rows as python lists
        'row0' : [1, 1+1j, 'A'],
        'row1' : [2, 2+2j, 'B']
    }, orient='index')
```

### Create play/fake data (useful for testing)

```
# --- simple - default integer indexes
df = DataFrame(np.random.rand(50,5))

# --- with a time-stamp row index:
df = DataFrame(np.random.rand(500,5))
df.index = pd.date_range('1/1/2005',
       periods=len(df), freq='M')

# --- with alphabetic row and col indexes
#          and a "groupable" variable
import string
import random
r = 52 # note: min r is 1; max r is 52
c = 5
df = DataFrame(np.random.randn(r, c),
   columns = ['col'+str(i) for i in
         range(c)],
   index = list((string. ascii_uppercase+
         string.ascii_lowercase)[0:r]))
df['group'] = list(
   ''.join(random.choice('abcde')
         for _ in range(r)) )
```

## Saving a DataFrame

### Saving a DataFrame to a CSV file

```
df.to_csv('name.csv', encoding='utf-8')
```

### Saving DataFrames to an Excel Workbook

```
from pandas import ExcelWriter
writer = ExcelWriter('filename.xlsx')
df1.to_excel(writer,'Sheet1')
df2.to_excel(writer,'Sheet2')
writer.save()
```

### Saving a DataFrame to MySQL

```
import pymysql
from sqlalchemy import create_engine
e = create_engine('mysql+pymysql://' +
    'USER:PASSWORD@HOST/DATABASE')
df.to_sql('TABLE',e, if_exists='replace')
```

**Note**: if_exists → 'fail', 'replace', 'append'

### Saving to Python objects

```
d = df.to_dict()          # to dictionary
str = df.to_string()      # to string
m = df.as_matrix()        # to numpy matrix
```

## Working with the whole DataFrame

### Peek at the DataFrame contents/structure

```
df.info()           # index & data types
dfh = df.head(i)    # get first i rows
dft = df.tail(i)    # get last i rows
dfs = df.describe() # summary stats cols
top_left_corner_df = df.iloc[:4, :4]
```

### DataFrame non-indexing attributes

```
dfT = df.T    # transpose rows and cols
l = df.axes   # list row and col indexes
(r, c) = df.axes    # from above
s = df.dtypes # Series column data types
b = df.empty  # True for empty DataFrame
i = df.ndim   # number of axes (it is 2)
t = df.shape  # (row-count, column-count)
i = df.size   # row-count * column-count
a = df.values # get a numpy array for df
```

### DataFrame utility methods

```
df = df.copy() # copy a DataFrame
df = df.rank() # rank each col (default)
df = df.sort_values(by=col)
df = df.sort_values(by=[col1, col2])
df = df.sort_index()
df = df.astype(dtype) # type conversion
```

### DataFrame iteration methods

```
df.iteritems()# (col-index, Series) pairs
df.iterrows() # (row-index, Series) pairs

# example ... iterating over columns
for (name, series) in df.iteritems():
    print('Col name: ' + str(name))
    print('First value: ' +
        str(series.iat[0]) + '\n')
```

### Maths on the whole DataFrame (not a complete list)

```
df = df.abs()  # absolute values
df = df.add(o) # add df, Series or value
s = df.count() # non NA/null values
df = df.cummax()  # (cols default axis)
df = df.cummin()  # (cols default axis)
df = df.cumsum()  # (cols default axis)
df = df.diff() # 1st diff (col def axis)
df = df.div(o) # div by df, Series, value
df = df.dot(o) # matrix dot product
s = df.max()   # max of axis (col def)
s = df.mean()  # mean (col default axis)
s = df.median()# median (col default)
s = df.min()   # min of axis (col def)
df = df.mul(o) # mul by df Series val
s = df.sum()   # sum axis (cols default)
df = df.where(df > 0.5, other=np.nan)
```

**Note**: The methods that return a series default to working on columns.

### DataFrame select/filter rows/cols on label values

```
df = df.filter(items=['a', 'b']) # by col
df = df.filter(items=[5], axis=0) #by row
df = df.filter(like='x') # keep x in col
df = df.filter(regex='x') # regex in col
df = df.select(lambda x: not x%5)#5th rows
```

**Note**: select takes a Boolean function, for cols: axis=1
**Note**: filter defaults to cols; select defaults to rows

## Working with Columns

**Each DataFrame column is a pandas Series object**

### Get column index and labels

```
idx = df.columns        # get col index
label = df.columns[0]   # first col label
l = df.columns.tolist() # list col labels
```

### Change column labels

```
df.rename(columns={'old1':'new1',
    'old2':'new2'}, inplace=True)
```

**Note**: can rename multiple columns at once.

### Selecting columns

```
s = df['colName'] # select col to Series
df = df[['colName']] # select col to df
df = df[['a','b']]    # select 2 or more
df = df[['c','a','b']]# change col order
s = df[df.columns[0]] # select by number
df = df[df.columns[[0, 3, 4]] # by number
s = df.pop('c') # get col & drop from df
```

### Selecting columns with Python attributes

```
s = df.a            # same as s = df['a']
# cannot create new columns by attribute
df.existing_column = df.a / df.b
df['new_column'] = df.a / df.b
```

**Trap**: column names must be valid identifiers.

### Adding new columns to a DataFrame

```
df['new_col'] = range(len(df))
df['new_col'] = np.repeat(np.nan,len(df))
df['random'] = np.random.rand(len(df))
df['index_as_col'] = df.index
df1[['b','c']] = df2[['e','f']]
df3 = df1.append(other=df2)
```

**Trap**: When adding an indexed pandas object as a new column, only items from the new series that have a corresponding index in the DataFrame will be added. The receiving DataFrame is **not** extended to accommodate the new series. To merge, see below.
**Trap**: when adding a python list or numpy array, the column will be added by integer position.

### Swap column contents – change column order

```
df[['B', 'A']] = df[['A', 'B']]
```

### Dropping (deleting) columns (mostly by label)

```
df = df.drop('col1', axis=1)
df.drop('col1', axis=1, inplace=True)
df = df.drop(['col1','col2'], axis=1)
s = df.pop('col') # drops from frame
del df['col'] # even classic python works
df.drop(df.columns[0], inplace=True)
```

### Vectorised arithmetic on columns

```
df['proportion']=df['count']/df['total']
df['percent'] = df['proportion'] * 100.0
```

### Apply numpy mathematical functions to columns

```
df['log_data'] = np.log(df['col1'])
```

**Note**: Many more numpy mathematical functions.
**Hint**: Prefer pandas math over numpy where you can.

### Set column values set based on criteria

```
df['b']=df['a'].where(df['a']>0,other=0)
df['d']=df['a'].where(df.b!=0,other=df.c)
```

**Note**: where other can be a Series or a scalar

### Data type conversions

```
st =  df['col'].astype(str)# Series dtype
a = df['col'].values       # numpy array
pl = df['col'].tolist()    # python list
```

**Note**: useful dtypes for Series conversion: int, float, str
**Trap**: index lost in conversion from Series to array or list

### Common column-wide methods/attributes

```
value = df['col'].dtype  # type of data
value = df['col'].size   # col dimensions
value = df['col'].count()# non-NA count
value = df['col'].sum()
value = df['col'].prod()
value = df['col'].min()
value = df['col'].max()
value = df['col'].mean() # also median()
value = df['col'].cov(df['col2'])
s =     df['col'].describe()
s =     df['col'].value_counts()
```

### Find index label for min/max values in column

```
label =  df['col1'].idxmin()
label =  df['col1'].idxmax()
```

### Common column element-wise methods

```
s = df['col'].isnull()
s = df['col'].notnull() # not isnull()
s = df['col'].astype(float)
s = df['col'].abs()
s = df['col'].round(decimals=0)
s = df['col'].diff(periods=1)
s = df['col'].shift(periods=1)
s = df['col'].to_datetime()
s = df['col'].fillna(0) # replace NaN w 0
s = df['col'].cumsum()
s = df['col'].cumprod()
s = df['col'].pct_change(periods=4)
s = df['col'].rolling_sum(periods=4,
                          window=4)
```

**Note**: also rolling_min(), rolling_max(), and many more.

### Append a column of row sums to a DataFrame

```
df['Total'] = df.sum(axis=1)
```

**Note**: also means, mins, maxs, etc.

### Multiply every column in DataFrame by Series

```
df = df.mul(s, axis=0) # on matched rows
```

**Note**: also add, sub, div, etc.

### Selecting columns with .loc, .iloc and .ix

```
df = df.loc[:, 'col1':'col2'] # inclusive
df = df.iloc[:, 0:2]          # exclusive
```

### Get the integer position of a column index label

```
j = df.columns.get_loc('col_name')
```

### Test if column index values are unique/monotonic

```
if df.columns.is_unique: pass # ...
b = df.columns.is_monotonic_increasing
b = df.columns.is_monotonic_decreasing
```

## Working with rows

**Get the row index and labels**

```
idx = df.index              # get row index
label = df.index[0]         # 1st row label
lst = df.index.tolist()     # get as a list
```

**Change the (row) index**

```
df.index = idx        # new ad hoc index
df = df.set_index('A')# col A new index
df = df.set_index(['A', 'B'])# MultiIndex
df = df.reset_index() # replace old w new
# note: old index stored as a col in df
df.index = range(len(df)) # set with list
df = df.reindex(index=range(len(df)))
df = df.set_index(keys=['r1','r2','etc'])
df.rename(index={'old':'new'},
                          inplace=True)
```

**Adding rows**

```
df = original_df.append(more_rows_in_df)
```

**Hint**: convert to a DataFrame and then append. Both DataFrames should have same column labels.

**Dropping rows (by name)**

```
df = df.drop('row_label')
df = df.drop(['row1','row2']) # multi-row
```

**Boolean row selection by values in a column**

```
df = df[df['col2'] >= 0.0]
df = df[(df['col3']>=1.0) |
                       (df['col1']<0.0)]
df = df[df['col'].isin([1,2,5,7,11])]
df = df[~df['col'].isin([1,2,5,7,11])]
df = df[df['col'].str.contains('hello')]
```

**Trap**: bitwise "or", "and" "not; (ie. | & ~) co-opted to be Boolean operators on a Series of Boolean
**Trap**: need parentheses around comparisons.

**Selecting rows using isin over multiple columns**

```
# fake up some data
data = {1:[1,2,3], 2:[1,4,9], 3:[1,8,27]}
df = DataFrame(data)

# multi-column isin
lf = {1:[1, 3], 3:[8, 27]} # look for
f = df[df[list(lf)].isin(lf).all(axis=1)]
```

**Selecting rows using an index**

```
idx = df[df['col'] >= 2].index
print(df.ix[idx])
```

**Select a slice of rows by integer position**
[inclusive-from : exclusive-to [: step]]
default start is 0; default end is len(df)

```
df = df[:]       # copy DataFrame
df = df[0:2]     # rows 0 and 1
df = df[-1:]     # the last row
df = df[2:3]     # row 2 (the third row)
df = df[:-1]     # all but the last row
df = df[::2]     # every 2nd row (0 2 ..)
```

**Trap**: a single integer without a colon is a column label for integer numbered columns.

**Select a slice of rows by label/index**
[inclusive-from : inclusive–to [ : step]]

```
df = df['a':'c'] # rows 'a' through 'c'
```

**Trap**: doesn't work on integer labelled rows

**Append a row of column totals to a DataFrame**

```
# Option 1: use dictionary comprehension
sums = {col: df[col].sum() for col in df}
sums_df = DataFrame(sums,index=['Total'])
df = df.append(sums_df)

# Option 2: All done with pandas
df = df.append(DataFrame(df.sum(),
                    columns=['Total']).T)
```

**Iterating over DataFrame rows**

```
for (index, row) in df.iterrows(): # pass
```

**Trap**: row data type may be coerced.

**Sorting DataFrame rows values**

```
df = df.sort(df.columns[0],
                           ascending=False)
df.sort(['col1', 'col2'], inplace=True)
```

**Sort DataFrame by its row index**

```
df.sort_index(inplace=True) # sort by row
df = df.sort_index(ascending=False)
```

**Random selection of rows**

```
import random as r
k = 20 # pick a number
selection = r.sample(range(len(df)), k)
df_sample = df.iloc[selection, :]
```

**Note**: this sample is not sorted

**Drop duplicates in the row index**

```
df['index'] = df.index # 1 create new col
df = df.drop_duplicates(cols='index',
        take_last=True)# 2 use new col
del df['index']        # 3 del the col
df.sort_index(inplace=True)# 4 tidy up
```

**Test if two DataFrames have same row index**

```
len(a)==len(b) and all(a.index==b.index)
```

**Get the integer position of a row or col index label**

```
i = df.index.get_loc('row_label')
```

**Trap**: index.get_loc() returns an integer for a unique match. If not a unique match, may return a slice or mask.

**Get integer position of rows that meet condition**

```
a = np.where(df['col'] >= 2) #numpy array
```

**Test if the row index values are unique/monotonic**

```
if df.index.is_unique: pass # ...
b = df.index.is_monotonic_increasing
b = df.index.is_monotonic_decreasing
```

## Working with cells

**Selecting a cell by row and column labels**

```
value = df.at['row', 'col']
value = df.loc['row', 'col']
value = df['col'].at['row']      # tricky
```

**Note**: .at[] fastest label based scalar lookup

**Setting a cell by row and column labels**

```
df.at['row', 'col'] = value
df.loc['row', 'col'] = value
df['col'].at['row'] = value      # tricky
```

**Selecting and slicing on labels**

```
df = df.loc['row1':'row3', 'col1':'col3']
```

Note: the "to" on this slice is inclusive.

**Setting a cross-section by labels**

```
df.loc['A':'C', 'col1':'col3'] = np.nan
df.loc[1:2,'col1':'col2']=np.zeros((2,2))
df.loc[1:2,'A':'C']=othr.loc[1:2,'A':'C']
```

**Remember**: inclusive "to" in the slice

**Selecting a cell by integer position**

```
value = df.iat[9, 3]          # [row, col]
value = df.iloc[0, 0]         # [row, col]
value = df.iloc[len(df)-1,
                len(df.columns)-1]
```

**Selecting a range of cells by int position**

```
df = df.iloc[2:4, 2:4] # subset of the df
df = df.iloc[:5, :5]   # top left corner
s = df.iloc[5, :] # returns row as Series
df = df.iloc[5:6, :] # returns row as row
```

Note: exclusive "to" – same as python list slicing.

**Setting cell by integer position**

```
df.iloc[0, 0] = value         # [row, col]
df.iat[7, 8] = value
```

**Setting cell range by integer position**

```
df.iloc[0:3, 0:5] = value
df.iloc[1:3, 1:4] = np.ones((2, 3))
df.iloc[1:3, 1:4] = np.zeros((2, 3))
df.iloc[1:3, 1:4] = np.array([[1, 1, 1],
                              [2, 2, 2]])
```

**Remember**: exclusive-to in the slice

**.ix for mixed label and integer position indexing**

```
value = df.ix[5, 'col1']
df = df.ix[1:5, 'col1':'col3']
```

**Views and copies**

From the manual: Setting a copy can cause subtle errors. The rules about when a view on the data is returned are dependent on NumPy. Whenever an array of labels or a Boolean vector are involved in the indexing operation, the result will be a copy.

## Summary: selecting using the Index

**Using the DataFrame index to select columns**

```
s =  df['col_label']  # returns Series
df = df[['col_label']]# return DataFrame
df = df[['L1', 'L2']] # select with list
df = df[index]        # select with index
df = df[s]            #select with Series
```

**Note**: the difference in return type with the first two examples above based on argument type (scalar vs list).

**Using the DataFrame index to select rows**

```
df = df['from':'inc_to']# label slice
df = df[3:7]            # integer slice
df = df[df['col'] > 0.5]# Boolean Series
df = df.loc['label']    # single label
df = df.loc[container]  # lab list/Series
df = df.loc['from':'to']# inclusive slice
df = df.loc[bs]         # Boolean Series
df = df.iloc[0]         # single integer
df = df.iloc[container] # int list/Series
df = df.iloc[0:5]       # exclusive slice
df = df.ix[x]           # loc then iloc
```

**Using the DataFrame index to select a cross-section**

```
#     r and c can be scalar, list, slice
df.loc[r, c] # label accessor (row, col)
df.iloc[r, c]# integer accessor
df.ix[r, c]  # label access int fallback
df[c].iloc[r]# chained – also for .loc
```

**Using the DataFrame index to select a cell**

```
#     r and c must be label or integer
df.at[r, c]  # fast scalar label accessor
df.iat[r, c] # fast scalar int accessor
df[c].iat[r] # chained – also for .at
```

**DataFrame indexing methods**

```
v = df.get_value(r, c)  # get by row, col
df = df.set_value(r,c,v)# set by row, col
df = df.xs(key, axis) # get cross-section
df = df.filter(items, like, regex, axis)
df = df.select(crit, axis)
```

**Note**: the indexing attributes (.loc, .iloc, .ix, .at .iat) can be used to get and set values in the DataFrame.
**Note**: the .loc, iloc and .ix indexing attributes can accept python slice objects. But .at and .iat do not.
**Note**: .loc can also accept Boolean Series arguments
**Avoid**: chaining in the form df[col_indexer][row_indexer]
**Trap**: label slices are inclusive, integer slices exclusive.

**Some index attributes and methods**

```
# --- some Index attributes
b = idx.is_monotonic_decreasing
b = idx.is_monotonic_increasing
b = idx.has_duplicates
i = idx.nlevels     # num of index levels
# --- some Index methods
idx = idx.astype(dtype)# change data type
b = idx.equals(o)  # check for equality
idx = idx.union(o) # union of two indexes
i = idx.nunique()  # number unique labels
label = idx.min()  # minimum label
label = idx.max()  # maximum label
```

## Joining/Combining DataFrames

Three ways to join two DataFrames:

- merge (a database/SQL-like join operation)
- concat (stack side by side or one on top of the other)
- combine_first (splice the two together, choosing values from one over the other)

**Merge on indexes**

```
df_new = pd.merge(left=df1, right=df2,
          how='outer', left_index=True,
          right_index=True)
```

**How**: 'left', 'right', 'outer', 'inner'
**How**: outer=union/all; inner=intersection

**Merge on columns**

```
df_new = pd.merge(left=df1, right=df2,
          how='left', left_on='col1',
          right_on='col2')
```

**Trap:** When joining on columns, the indexes on the passed DataFrames are ignored.
**Trap**: many-to-many merges on a column can result in an explosion of associated data.

**Join on indexes (another way of merging)**

```
df_new = df1.join(other=df2, on='col1',
                  how='outer')
df_new = df1.join(other=df2,on=['a','b'],
                  how='outer')
```

**Note**: DataFrame.join() joins on indexes by default. DataFrame.merge() joins on common columns by default.

**Simple concatenation is often the best**

```
df=pd.concat([df1,df2],axis=0)#top/bottom
df = df1.append([df2, df3])   #top/bottom
df=pd.concat([df1,df2],axis=1)#left/right
```

**Trap**: can end up with duplicate rows or cols
**Note**: concat has an ignore_index parameter

**Combine_first**

```
df = df1.combine_first(other=df2)

# multi-combine with python reduce()
df = reduce(lambda x, y:
        x.combine_first(y),
            [df1, df2, df3, df4, df5])
```

Uses the non-null values from df1. The index of the combined DataFrame will be the union of the indexes from df1 and df2.

## Groupby: Split-Apply-Combine

The pandas "groupby" mechanism allows us to split the data into groups, apply a function to each group independently and then combine the results.

**Grouping**

```
gb = df.groupby('cat') # by one columns
gb = df.groupby(['c1','c2']) # by 2 cols
gb = df.groupby(level=0) # multi-index gb
gb = df.groupby(level=['a','b']) # mi gb
print(gb.groups)
```

**Note**: groupby() returns a pandas groupby object
**Note**: the groupby object attribute .groups contains a dictionary mapping of the groups.
**Trap**: NaN values in the group key are automatically dropped – there will never be a NA group.

**Iterating groups – usually not needed**

```
for name, group in gb:
    print (name)
    print (group)
```

**Selecting a group**

```
dfa = df.groupby('cat').get_group('a')
dfb = df.groupby('cat').get_group('b')
```

**Applying an aggregating function**

```
# apply to a column ...
s = df.groupby('cat')['col1'].sum()
s = df.groupby('cat')['col1'].agg(np.sum)
# apply to the every column in DataFrame
s = df.groupby('cat').agg(np.sum)
df_summary = df.groupby('cat').describe()
df_row_1s = df.groupby('cat').head(1)
```

**Note**: aggregating functions reduce the dimension by one – they include: mean, sum, size, count, std, var, sem, describe, first, last, min, max

**Applying multiple aggregating functions**

```
gb = df.groupby('cat')

# apply multiple functions to one column
dfx = gb['col2'].agg([np.sum, np.mean])
# apply to multiple fns to multiple cols
dfy = gb.agg({
    'cat': np.count_nonzero,
    'col1': [np.sum, np.mean, np.std],
    'col2': [np.min, np.max]
})
```

**Note**: gb['col2'] above is shorthand for df.groupby('cat')['col2'], without the need for regrouping.

**Transforming functions**

```
# transform to group z-scores, which have
# a group mean of 0, and a std dev of 1.
zscore = lambda x: (x-x.mean())/x.std()
dfz = df.groupby('cat').transform(zscore)

# replace missing data with group mean
mean_r = lambda x: x.fillna(x.mean())
dfm = df.groupby('cat').transform(mean_r)
```

**Note**: can apply multiple transforming functions in a manner similar to multiple aggregating functions above,

**Applying filtering functions**
Filtering functions allow you to make selections based on whether each group meets specified criteria

```
# select groups with more than 10 members
eleven = lambda x: (len(x['col1']) >= 11)
df11 = df.groupby('cat').filter(eleven)
```

**Group by a row index (non-hierarchical index)**

```
df = df.set_index(keys='cat')
s = df.groupby(level=0)['col1'].sum()
dfg = df.groupby(level=0).sum()
```

## Pivot Tables: working with long and wide data

**These features work with and often create hierarchical or multi-level Indexes; (the pandas MultiIndex is powerful and complex).**

**Pivot, unstack, stack and melt**

Pivot tables move from long format to wide format data

```
# Let's start with data in long format
from StringIO import StringIO # python2.7
#from io import StringIO      # python 3
data = """Date,Pollster,State,Party,Est
13/03/2014, Newspoll, NSW,   red,   25
13/03/2014, Newspoll, NSW,   blue,  28
13/03/2014, Newspoll, Vic,   red,   24
13/03/2014, Newspoll, Vic,   blue,  23
13/03/2014, Galaxy,   NSW,   red,   23
13/03/2014, Galaxy,   NSW,   blue,  24
13/03/2014, Galaxy,   Vic,   red,   26
13/03/2014, Galaxy,   Vic,   blue,  25
13/03/2014, Galaxy,   Qld,   red,   21
13/03/2014, Galaxy,   Qld,   blue,  27"""
df = pd.read_csv(StringIO(data),
      header=0, skipinitialspace=True)

# pivot to wide format on 'Party' column
# 1st: set up a MultiIndex for other cols
df1 = df.set_index(['Date', 'Pollster',
    'State'])
# 2nd: do the pivot
wide1 = df1.pivot(columns='Party')

# unstack to wide format on State / Party
# 1st: MultiIndex all but the Values col
df2 = df.set_index(['Date', 'Pollster',
    'State', 'Party'])
# 2nd: unstack a column to go wide on it
wide2 = df2.unstack('State')
wide3 = df2.unstack() # pop last index

# Use stack() to get back to long format
long1 = wide1.stack()
# Then use reset_index() to remove the
# MultiIndex.
long2 = long1.reset_index()

# Or melt() back to long format
# 1st: flatten the column index
wide1.columns = ['_'.join(col).strip()
    for col in wide1.columns.values]
# 2nd: remove the MultiIndex
wdf = wide1.reset_index()
# 3rd: melt away
long3 = pd.melt(wdf, value_vars=
    ['Est_blue', 'Est_red'],
    var_name='Party', id_vars=['Date',
    'Pollster', 'State'])
```

**Note**: See documentation, there are many arguments to these methods.

## Working with dates, times and their indexes

**Dates and time – points and spans**

With its focus on time-series data, pandas has a suite of tools for managing dates and time: either as a point in time (a Timestamp) or as a span of time (a Period).

```
t = pd.Timestamp('2013-01-01')
t = pd.Timestamp('2013-01-01 21:15:06')
t = pd.Timestamp('2013-01-01 21:15:06.7')
p = pd.Period('2013-01-01', freq='M')
```

**Note**: Timestamps should be in range 1678 and 2261 years. (Check Timestamp.max and Timestamp.min).

**A Series of Timestamps or Periods**

```
ts = ['2015-04-01 13:17:27',
        '2014-04-02 13:17:29']

# Series of Timestamps (good)
s = pd.to_datetime(pd.Series(ts))

# Series of Periods (often not so good)
s = pd.Series( [pd.Period(x, freq='M')
        for x in ts] )
s = pd.Series(
        pd.PeriodIndex(ts,freq='S'))
```

**Note**: While Periods make a very useful index; they may be less useful in a Series.

**From non-standard strings to Timestamps**

```
t = ['09:08:55.7654-JAN092002',
        '15:42:02.6589-FEB082016']
s = pd.Series(pd.to_datetime(t,
        format="%H:%M:%S.%f-%b%d%Y"))
```

**Also**: %B = full month name; %m = numeric month; %y = year without century; and more …

**Dates and time – stamps and spans as indexes**

An index of Timestamps is a DatetimeIndex.
An index of Periods is a PeriodIndex.

```
date_strs = ['2014-01-01', '2014-04-01',
             '2014-07-01', '2014-10-01']

dti = pd.DatetimeIndex(date_strs)

pid = pd.PeriodIndex(date_strs, freq='D')
pim = pd.PeriodIndex(date_strs, freq='M')
piq = pd.PeriodIndex(date_strs, freq='Q')

print (pid[1] - pid[0])  # 90 days
print (pim[1] - pim[0])  #  3 months
print (piq[1] - piq[0])  #  1 quarter

time_strs = ['2015-01-01 02:10:40.12345',
             '2015-01-01 02:10:50.67890']
pis = pd.PeriodIndex(time_strs, freq='U')

df.index = pd.period_range('2015-01',
        periods=len(df), freq='M')

dti = pd.to_datetime(['04-01-2012'],
  dayfirst=True) # Australian date format
pi = pd.period_range('1960-01-01',
  '2015-12-31', freq='M')
```

**Hint**: unless you are working in less than seconds, prefer PeriodIndex over DateTimeImdex.

**Period frequency constants (not a complete list)**

| Name | Description |
|---|---|
| **U** | Microsecond |
| L | Millisecond |
| S | Second |
| T | Minute |
| H | Hour |
| D | Calendar day |
| B | Business day |
| W-{MON, TUE, …} | Week ending on … |
| MS | Calendar start of month |
| M | Calendar end of month |
| QS-{JAN, FEB, …} | Quarter start with year starting (QS – December) |
| Q-{JAN, FEB, …} | Quarter end with year ending (Q – December) |
| AS-{JAN, FEB, …} | Year start (AS - December) |
| A-{JAN, FEB, …} | Year end (A - December) |

**From DatetimeIndex to Python datetime objects**

```
dti = pd.DatetimeIndex(pd.date_range(
  start='1/1/2011', periods=4, freq='M'))
s = Series([1,2,3,4], index=dti)
na = dti.to_pydatetime()     #numpy array
na = s.index.to_pydatetime() #numpy array
```

**Frome Timestamps to Python dates or times**

```
df['date'] = [x.date() for x in df['TS']]
df['time'] = [x.time() for x in df['TS']]
```

**Note**: converts to datatime.date or datetime.time. But does not convert to datetime.datetime.

**From DatetimeIndex to PeriodIndex and back**

```
df = DataFrame(np.random.randn(20,3))
df.index = pd.date_range('2015-01-01',
       periods=len(df), freq='M')
dfp = df.to_period(freq='M')
dft = dfp.to_timestamp()
```

**Note**: from period to timestamp defaults to the point in time at the start of the period.

**Working with a PeriodIndex**

```
pi = pd.period_range('1960-01','2015-12',
                     freq='M')
na = pi.values  # numpy array of integers
lp = pi.tolist() # python list of Periods
sp = Series(pi)# pandas Series of Periods
ss = Series(pi).astype(str) # S of strs
ls = Series(pi).astype(str).tolist()
```

**Get a range of Timestamps**

```
dr = pd.date_range('2013-01-01',
    '2013-12-31', freq='D')
```

**Error handling with dates**

```
# 1st example returns string not Timestamp
t = pd.to_datetime('2014-02-30')
# 2nd example returns NaT (not a time)
t = pd.to_datetime('2014-02-30',
      coerce=True)
# NaT like NaN tests True for isnull()
b = pd.isnull(t) # --> True
```

**The tail of a time-series DataFrame**

```
df = df.last("5M") # the last five months
```

**Upsampling and downsampling**

```
# upsample from quarterly to monthly
pi = pd.period_range('1960Q1',
       periods=220, freq='Q')
df = DataFrame(np.random.rand(len(pi),5),
       index=pi)
dfm = df.resample('M', convention='end')
# use ffill or bfill to fill with values

# downsample from monthly to quarterly
dfq = dfm.resample('Q', how='sum')
```

**Time zones**

```
t = ['2015-06-30 00:00:00',
     '2015-12-31 00:00:00']
dti = pd.to_datetime(t
     ).tz_localize('Australia/Canberra')
dti = dti.tz_convert('UTC')
ts = pd.Timestamp('now',
     tz='Europe/London')

# get a list of all time zones
import pyzt
for tz in pytz.all_timezones:
    print tz
```

**Note**: by default, Timestamps are created without time zone information.

**Row selection with a time-series index**

```
# start with the play data above
idx = pd.period_range('2015-01',
       periods=len(df), freq='M')
df.index = idx

february_selector = (df.index.month == 2)
february_data = df[february_selector]

q1_data = df[(df.index.month >= 1) &
   (df.index.month <= 3)]

mayornov_data = df[(df.index.month == 5)
   | (df.index.month == 11)]

totals = df.groupby(df.index.year).sum()
```

**Also**: year, month, day [of month], hour, minute, second, dayofweek [Mon=0 .. Sun=6], weekofmonth, weekofyear [numbered from 1], week starts on Monday], dayofyear [from 1], …

**The Series.dt accessor attribute**

DataFrame columns that contain datetime-like objects can be manipulated with the .dt accessor attribute

```
t = ['2012-04-14 04:06:56.307000',
     '2011-05-14 06:14:24.457000',
     '2010-06-14 08:23:07.520000']

# a Series of time stamps
s = pd.Series(pd.to_datetime(t))
print(s.dtype)      # datetime64[ns]
print(s.dt.second)  # 56, 24,  7
print(s.dt.month)   #  4,  5,  6

# a Series of time periods
s = pd.Series(pd.PeriodIndex(t,freq='Q'))
print(s.dtype)      # datetime64[ns]
print(s.dt.quarter) #  2,  2,  2
print(s.dt.year)    #  2012, 2011, 2010
```

## Working with missing and non-finite data

### Working with missing data

Pandas uses the not-a-number construct (np.nan and float('nan')) to indicate missing data. The Python None can arise in data as well. It is also treated as missing data; as is the pandas not-a-time construct (pandas.NaT).

### Missing data in a Series

```
s = Series( [8,None,float('nan'),np.nan])
           #[8,     NaN,   NaN,   NaN]
s.isnull() #[False, True,  True,  True]
s.notnull()#[True,  False, False, False]
s.fillna(0)#[8,     0,     0,     0]
```

### Missing data in a DataFrame

```
df = df.dropna() # drop all rows with NaN
df = df.dropna(axis=1) # same for cols
df=df.dropna(how='all') #drop all NaN row
df=df.dropna(thresh=2) # drop 2+ NaN in r
# only drop row if NaN in a specified col
df = df.dropna(df['col'].notnull())
```

### Recoding missing data

```
df.fillna(0, inplace=True) # np.nan → 0
s = df['col'].fillna(0)    # np.nan → 0
df = df.replace(r'\s+', np.nan,
      regex=True) # white space → np.nan
```

### Non-finite numbers

With floating point numbers, pandas provides for positive and negative infinity.

```
s = Series([float('inf'), float('-inf'),
     np.inf, -np.inf])
```

Pandas treats integer comparisons with plus or minus infinity as expected.

### Testing for finite numbers

(using the data from the previous example)

```
b = np.isfinite(s)
```

## Working with Categorical Data

### Categorical data

The pandas Series has an R factors-like data type for encoding categorical data.

```
s = Series(['a','b','a','c','b','d','a'],
                        dtype='category')
df['B'] = df['A'].astype('category')
```

**Note**: the key here is to specify the "category" data type.
**Note**: categories will be ordered on creation if they are sortable. This can be turned off. See ordering below.

### Convert back to the original data type

```
s = Series(['a','b','a','c','b','d','a'],
                        dtype='category')
s = s.astype('string')
```

### Ordering, reordering and sorting

```
s = Series(list('abc'), dtype='category')
print (s.cat.ordered)
s=s.cat.reorder_categories(['b','c','a'])
s = s.sort()
s.cat.ordered = False
```

**Trap**: category must be ordered for it to be sorted

### Renaming categories

```
s = Series(list('abc'), dtype='category')
s.cat.categories = [1, 2, 3] # in place
s = s.cat.rename_categories([4,5,6])
# using a comprehension ...
s.cat.categories = ['Group ' + str(i)
    for i in s.cat.categories]
```

**Trap**: categories must be uniquely named

### Adding new categories

```
s = s.cat.add_categories([4])
```

### Removing categories

```
s = s.cat.remove_categories([4])
s.cat.remove_unused_categories() #inplace
```

## Working with strings

### Working with strings

```
# assume that df['col'] is series of
strings
s = df['col'].str.lower()
s = df['col'].str.upper()
s = df['col'].str.len()

# the next set work like Python
df['col'] += 'suffix'       # append
df['col'] *= 2              # duplicate
s = df['col1'] + df['col2'] # concatenate
```

Most python string functions are replicated in the pandas DataFrame and Series objects.

### Regular expressions

```
s = df['col'].str.contains('regex')
s = df['col'].str.startswith('regex')
s = df['col'].str.endswith('regex')
s = df['col'].str.replace('old', 'new')
df['b'] = df.a.str.extract('(pattern)')
```

**Note**: pandas has many more regex methods.

## Basic Statistics

### Summary statistics

```
s = df['col1'].describe()
df1 = df.describe()
```

### DataFrame – key stats methods

```
df.corr()     # pairwise correlation cols
df.cov()      # pairwise covariance cols
df.kurt()     # kurtosis over cols (def)
df.mad()      # mean absolute deviation
df.sem()      # standard error of mean
df.var()      # variance over cols (def)
```

### Value counts

```
s = df['col1'].value_counts()
```

### Cross-tabulation (frequency count)

```
ct = pd.crosstab(index=df['a'],
        cols=df['b'])
```

### Quantiles and ranking

```
quants = [0.05, 0.25, 0.5, 0.75, 0.95]
q = df.quantile(quants)
r = df.rank()
```

### Histogram binning

```
count, bins = np.histogram(df['col1'])
count, bins = np.histogram(df['col'],
              bins=5)
count, bins = np.histogram(df['col1'],
              bins=[-3,-2,-1,0,1,2,3,4])
```

### Regression

```
import statsmodels.formula.api as sm
result = sm.ols(formula="col1 ~ col2 +
          col3", data=df).fit()
print (result.params)
print (result.summary())
```

### Smoothing example using rolling_apply

```
k3x5 = np.array([1,2,3,3,3,2,1]) / 15.0
s = pd.rolling_apply(df['col1'],
       window=7,
         func=lambda x: (x * k3x5).sum(),
          min_periods=7, center=True)
```

## Cautionary note

This cheat sheet was cobbled together by bots roaming the dark recesses of the Internet seeking ursine and pythonic myths. There is no guarantee the narratives were captured and transcribed accurately. You use these notes at your own risk. You have been warned.

**Version**: This cheat sheet was last updated with Python 3.5 and pandas 0.18.0 in mind.

**Errors**: If you find any errors, please email me at markthegraph@gmail.com; (but please do not correct my use of Australian-English spelling conventions).