Spring 2025 Data C100/C200 Midterm Reference Sheet

Pandas

Suppose `df` is a DataFrame; `s` is a Series. `import pandas as pd`

Function	Description
`df.shape`	Returns a tuple containing the number of rows and columns, in that order
`df[col]`	Returns the column labeled `col` from `df` as a Series.
`df[[col1, col2]]`	Returns a DataFrame containing the columns labeled `col1` and `col2`.
`s.loc[rows] / df.loc[rows, cols]`	Returns a Series/DataFrame with rows (and columns) selected by their index values.
`s.iloc[rows] / df.iloc[rows, cols]`	Returns a Series/DataFrame with rows (and columns) selected by their positions.
`s.isnull() / df.isnull() / s.isna() / df.isna()`	Returns boolean Series/DataFrame identifying missing values
`s.fillna(value) / df.fillna(value)`	Returns a Series/DataFrame where missing values are replaced by `value`
`s.isin(values) / df.isin(values)`	Returns a Series/DataFrame of booleans indicating if each element is in `values`.
`df.drop(labels, axis)`	Returns a DataFrame without the rows or columns named `labels` along `axis` (0 for rows, 1 for columns)
`df.dropna(axis)`	Returns a DataFrame without rows (default) or columns containing missing values along `axis` (0 for rows, 1 for columns)
`df.rename(index=None, columns=None)`	Returns a DataFrame with renamed columns from a dictionary `index` and/or `columns`
`df.sort_values(by, ascending=True)`	Returns a DataFrame where rows are sorted by the values in columns `by`
`s.sort_values(ascending=True)`	Returns a sorted Series.
`s.unique()`	Returns a NumPy array of the unique values of `s` in the order that they appear
`s.value_counts()`	Returns the number of times each unique value appears in a Series
`pd.merge(left, right, how='inner', left_on=col1, right_on=col2)`	Returns a DataFrame joining `left` and `right` on columns labeled `col1` and `col2`; the join is of type `inner`
`left.merge(right, left_on=col1, right_on=col2)`	Returns a DataFrame joining `left` and `right` on columns labeled `col1` and `col2`.
`df.pivot_table(values=None, index=None, columns=None, aggfunc='median', fill_value=None)`	Returns a DataFrame pivot table where columns are unique values from `columns` (column name or list), and rows are unique values from `index` (column name or list); cells are collected `values` using `aggfunc`. If `values` is not provided, cells are collected for each remaining column with multi-level column indexing.
`df.set_index(col)`	Returns a DataFrame that uses the values in the column labeled `col` as the row index.
`df.reset_index()`	Returns a DataFrame that has row index 0, 1, etc., and adds the current index as a column.
`s.dropna()`	Return a new Series with missing values removed.
`s.astype(dtype), df.astype(dtype)`	Converts a Series or DataFrame to the specified data type `dtype`. Common data types include `'int'`, `'float'`, or `'str'`.

Let `grouped = df.groupby(by)` where `by` can be a column label or a list of labels.

Function	Description
`grouped.count()`	Return a DataFrame containing the number of non-missing values in each column for each group.
`grouped.size()`	Return a Series containing the total number of rows in each group, including those with missing values.
`grouped.mean()`/`.median()`/`.min()`/`.max()`	Return a Series/DataFrame containing mean/min/max of each group for each column, excluding missing values
`grouped.first()`/`.last()`	Return a Series/DataFrame containing first/last entry of each group for each column, excluding missing values
`grouped.filter(f)` `grouped.agg(f)`	Filters or aggregates using the given function `f`
`grouped.agg({column : f})`	Applies the given function/string `f` to `column` in the grouped DataFrame. Each entry is a `column : f` pair.

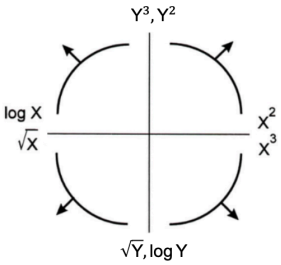
Function	Description
`s.str.len()`	Returns a Series containing length of each string
`s.str[a:b]`	Returns a Series where each element is a slice of the corresponding string indexed from `a` (inclusive, optional) to `b` (non-inclusive, optional)
`s.str.lower()`/`s.str.upper()`	Returns a Series of lowercase/uppercase versions of each string
`s.str.replace(pat, repl, regex=False)`	Returns a Series that replaces occurences of substrings matching `pat` with string `repl`. When `regex=False`, `pat` is treated as a literal string; when `regex=True`, `pat` is treated as a RegEx pattern.
`s.str.contains(pat)`	Returns a boolean Series indicating if a substring matching the regex `pat` is contained in each string
`s.str.extract(pat)`	Returns a Series of the first subsequence of each string that matches the regex `pat`. If `pat` contains one group, then only the substring matching the group is extracted
`s.str.split(pat=" ")`	Splits the strings in `s` at the delimiter `pat` (defaults to a whitespace). Returns a Series of lists, where each list contains strings of the characters before and after the split.
`s.str.startswith(pat)`	Returns a `Series` where the element is `True` if the corresponding `string` element in `s` starts with the pattern `pat`

Visualization

Matplotlib: `x` and `y` are sequences of values. `import matplotlib.pyplot as plt`

Function	Description
`plt.plot(x, y)`	Creates a line plot of `x` against `y`
`plt.scatter(x, y)`	Creates a scatter plot of `x` against `y`
`plt.hist(x, bins=None)`	Creates a histogram of `x`; `bins` can be an integer or a sequence
`plt.title(x)`	Sets the title of the current plot to `x`

Tukey-Mosteller Bulge Diagram.



Seaborn: `x` and `y` are column names in a DataFrame `data`. `import seaborn as sns`

Function	Description
`sns.countplot(data=None, x=None)`	Create a barplot of value counts of variable `x` from `data`
`sns.histplot(data=None, x=None, stat='count', kde=False)` `sns.displot(data=None, x=None, kind='hist', rug=False)`	Creates a histogram of `x` from `data`, where bin statistics `stat` is one of `'count'`, `'frequency'`, `'probability'`, `'percent'`, and `'density'`; optionally overlay a kernel density estimator. `displot` is similar but can optionally overlay a rug plot and/or a KDE plot
`sns.rugplot(data=None, x=None)`	Adds a rug plot on the x-axis of variable `x` from `data`
`sns.boxplot(data=None, x=None, y=None, hue=None)` `sns.violinplot(data=None, x=None, y=None, hue=None)`	Create a boxplot of a numeric feature (e.g., `y`), optionally factoring by a category (e.g., `x`), from `data`. `violinplot` is similar but also draws a kernel density estimator of the numeric feature. `hue` groups data points by a categorical variable
`sns.scatterplot(data=None, x=None, y=None)`	Create a scatterplot of `x` versus `y` from `data`
`sns.lmplot(data=None, x=None, y=None, fit_reg=True)`	Create a scatterplot of `x` versus `y` from `data`, and by default overlay a least-squares regression line
`sns.jointplot(data=None, x=None, y=None, kind='scatter')`	Combine a bivariate scatterplot of `x` versus `y` from `data`, with univariate density plots of each variable overlaid on the axes; `kind` determines the visualization type for the distribution plot, can be `scatter`, `kde` or `hist`

Regular Expressions

Operator	Description	Operator	Description
`.`	Matches any character except `\n`	`*`	Matches preceding character/group zero or more times
`\`	Escapes metacharacters	`?`	Matches preceding character/group zero or one times
`|`	Matches expression on either side of expression; has lowest priority of any operator	`+`	Matches preceding character/group one or more times

Operator	Description	Operator	Description
`\d`, `\w`, `\s`	Predefined character group of digits (0-9), alphanumerics (a-z, A-Z, 0-9, and underscore), or whitespace, respectively	`^`, `$`	Matches the beginning and end of the line, respectively
`\D`, `\W`, `\S`	Inverse sets of `\d`, `\w`, `\s`, respectively	`( )`	Capturing group used to create a sub-expression
`{m}`	Matches preceding character/group exactly `m` times	`[ ]`	Character class used to match any of the specified characters or range (e.g. `[abcde]` is equivalent to `[a-e]`)
`{m, n}`	Matches preceding character/group at least `m` times and at most `n` times. If either `m` or `n` are omitted, set lower/upper bounds to 0 and ∞, respectively	`[^ ]`	Invert character class; e.g. `[^a-c]` matches all characters except `a`, `b`, `c`

Modified lecture example for capture groups:

```
import re
lines = '169.237.46.168 - - [26/Jan/2014:10:47:58 -0800] "GET ... HTTP/1.1"'
re.findall(r'\[\d+\/(\w+)\/\d+:\d+:\d+:\d+ .+\]', line) # returns ['Jan']
```

Function	Description
`re.match(pattern, string)`	Returns a match if one or more characters at beginning of `string` matches `pattern`, else None
`re.search(pattern, string)`	Returns a match if zero or more characters anywhere in `string` matches `pattern`, else None
`re.findall(pattern, string)`	Returns a list of all non-overlapping matches of `pattern` in `string` (if none, returns empty list)
`re.sub(pattern, repl, string)`	Returns `string` after replacing all occurrences of `pattern` with `repl`

Modeling

Concept	Formula	Concept	Formula
Variance, σ_x^2	$\frac{1}{n}\sum_{i=1}^{n}(x_i-\bar{x})^2$	Correlation r	$r=\frac{1}{n}\sum_{i=1}^{n}\frac{x_i-\bar{x}}{\sigma_x}\frac{y_i-\bar{y}}{\sigma_y}$
L_1 loss	$L_1(y,\hat{y})=\mid y-\hat{y} \mid$	Linear regression estimate of y	$\hat{y}=\theta_0+\theta_1 x$
L_2 loss	$L_2(y,\hat{y})=(y-\hat{y})^2$	Least squares linear regression	$\hat{\theta}_0=\bar{y}-\hat{\theta}_1\bar{x}$ $\hat{\theta}_1=r\frac{\sigma_y}{\sigma_x}$
Empirical risk with loss L	$R(\theta)=\frac{1}{n}\sum_{i=1}^{n}L(y_i,\hat{y}_i)$		

Ordinary Least Squares

Multiple Linear Regression Model: $\hat{\mathbb{Y}}=\mathbb{X}\theta$ with design matrix $\mathbb{X}$, response vector $\mathbb{Y}$, and predicted vector $\hat{\mathbb{Y}}$. If there are p features plus a bias/intercept, then the vector of parameters $\theta=[\theta_0,\theta_1,\ldots,\theta_p]^T\in\mathbb{R}^{p+1}$. The vector of estimates $\hat{\theta}$ is obtained from fitting the model to the sample $(\mathbb{X},\mathbb{Y})$.

Concept	Formula	Concept	Formula
Mean squared error	$R(\theta)=\frac{1}{n}\|\|\mathbb{Y}-\mathbb{X}\theta\|\|_2^2$	Normal equation	$\mathbb{X}^T\mathbb{X}\hat{\theta}=\mathbb{X}^T\mathbb{Y}$
Least squares estimate, if $\mathbb{X}$ is full rank	$\hat{\theta}=(\mathbb{X}^T\mathbb{X})^{-1}\mathbb{X}^T\mathbb{Y}$	Residual vector, e	$e=\mathbb{Y}-\hat{\mathbb{Y}}$
		Multiple R^2 (coefficient of determination)	$R^2=\frac{\text{variance of fitted values}}{\text{variance of } y}$