K Means Clustering Project

For this project we will attempt to use KMeans Clustering to cluster Universities into to two groups, Private and Public.

It is **very important to note, we actually have the labels for this data set, but we will NOT use them for the KMeans clustering algorithm, since that is an unsupervised learning algorithm.**

When using the Kmeans algorithm under normal circumstances, it is because you don't have labels. In this case we will use the labels to try to get an idea of how well the algorithm performed, but you won't usually do this for Kmeans, so the classification report and confusion matrix at the end of this project, don't truly make sense in a real world setting!.

The Data

We will use a data frame with 777 observations on the following 18 variables.

- Private A factor with levels No and Yes indicating private or public university
- Apps Number of applications received
- Accept Number of applications accepted
- Enroll Number of new students enrolled
- Top10perc Pct. new students from top 10% of H.S. class
- Top25perc Pct. new students from top 25% of H.S. class
- F.Undergrad Number of fulltime undergraduates
- P.Undergrad Number of parttime undergraduates
- Outstate Out-of-state tuition
- Room.Board Room and board costs
- Books Estimated book costs
- Personal Estimated personal spending
- PhD Pct. of faculty with Ph.D.'s
- Terminal Pct. of faculty with terminal degree
- S.F.Ratio Student/faculty ratio
- perc.alumni Pct. alumni who donate
- Expend Instructional expenditure per student
- Grad.Rate Graduation rate

Import Libraries

** Import the libraries you usually use for data analysis.**

In [2]:
```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as  plt
%matplotlib inline
```

Get the Data

** Read in the College_Data file using read_csv. Figure out how to set the first column as the index.**

In [4]:
```
df = pd.read_csv('College_Data',index_col=0)
```

Check the head of the data

In [5]:
```
df.head()
```

Out[5]:

	Private	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Underg
Abilene Christian University	Yes	1660	1232	721	23	52	2885	
Adelphi University	Yes	2186	1924	512	16	29	2683	
Adrian College	Yes	1428	1097	336	22	50	1036	
Agnes Scott College	Yes	417	349	137	60	89	510	
Alaska Pacific University	Yes	193	146	55	16	44	249	

** Check the info() and describe() methods on the data.**

In [6]:
```
df.info()
df.describe()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 777 entries, Abilene Christian University to York College of Pennsylvania
Data columns (total 18 columns):
 #   Column       Non-Null Count  Dtype  
---  ------       --------------  -----  
 0   Private      777 non-null    object 
 1   Apps         777 non-null    int64  
 2   Accept       777 non-null    int64  
 3   Enroll       777 non-null    int64  
 4   Top10perc    777 non-null    int64  
 5   Top25perc    777 non-null    int64  
 6   F.Undergrad  777 non-null    int64  
 7   P.Undergrad  777 non-null    int64  
 8   Outstate     777 non-null    int64  
 9   Room.Board   777 non-null    int64  
 10  Books        777 non-null    int64  
 11  Personal     777 non-null    int64  
 12  PhD          777 non-null    int64  
 13  Terminal     777 non-null    int64  
 14  S.F.Ratio    777 non-null    float64
 15  perc.alumni  777 non-null    int64  
 16  Expend       777 non-null    int64  
 17  Grad.Rate    777 non-null    int64  
dtypes: float64(1), int64(16), object(1)
memory usage: 115.3+ KB
```

Out[6]:

	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad
count	777.000000	777.000000	777.000000	777.000000	777.000000	777.000000
mean	3001.638353	2018.804376	779.972973	27.558559	55.796654	3699.907336
std	3870.201484	2451.113971	929.176190	17.640364	19.804778	4850.420531
min	81.000000	72.000000	35.000000	1.000000	9.000000	139.000000
25%	776.000000	604.000000	242.000000	15.000000	41.000000	992.000000
50%	1558.000000	1110.000000	434.000000	23.000000	54.000000	1707.000000
75%	3624.000000	2424.000000	902.000000	35.000000	69.000000	4005.000000
max	48094.000000	26330.000000	6392.000000	96.000000	100.000000	31643.000000

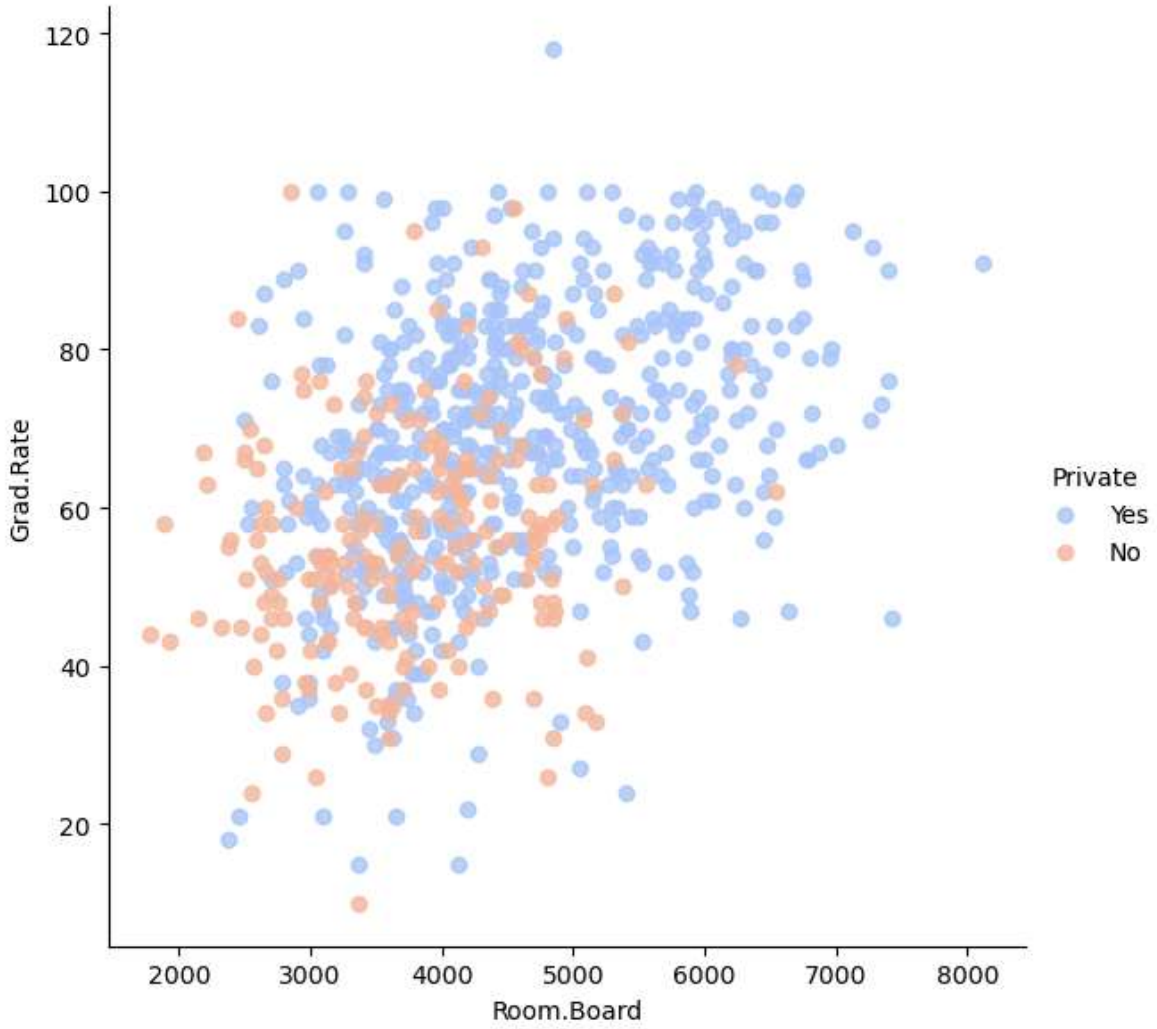
EDA

It's time to create some data visualizations!

** Create a scatterplot of Grad.Rate versus Room.Board where the points are colored by the Private column. **

In [16]:
```
sns.lmplot(x='Room.Board',y='Grad.Rate',data=df,hue='Private',fit_reg=False,pale
```

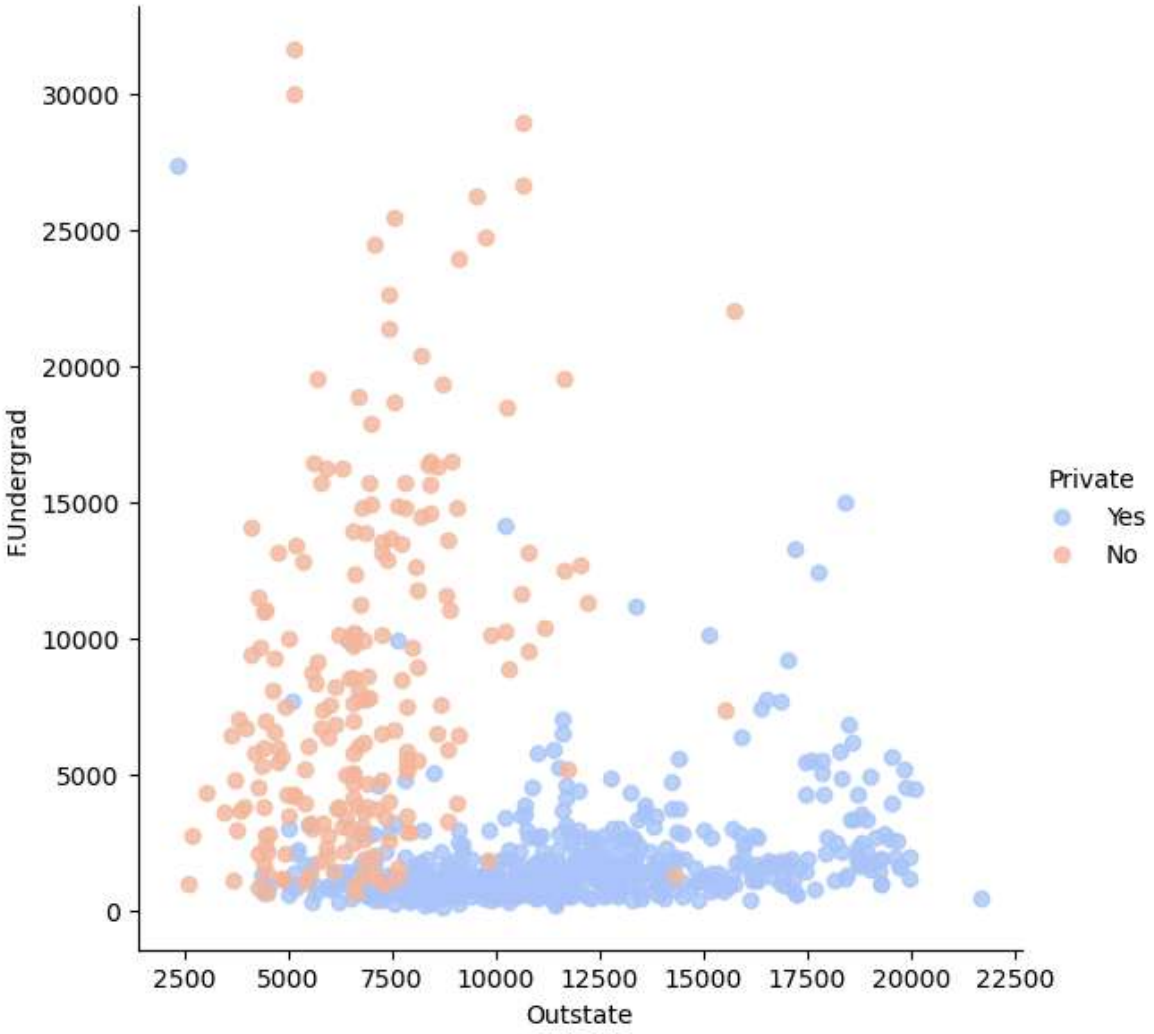
Out[16]:
```
<seaborn.axisgrid.FacetGrid at 0x7d1dac5dce30>
```



Create a scatterplot of F.Undergrad versus Outstate where the points are colored by the Private column.

In [17]:
```
sns.lmplot(x='Outstate',y='F.Undergrad',data=df,hue='Private',fit_reg=False,pale
```

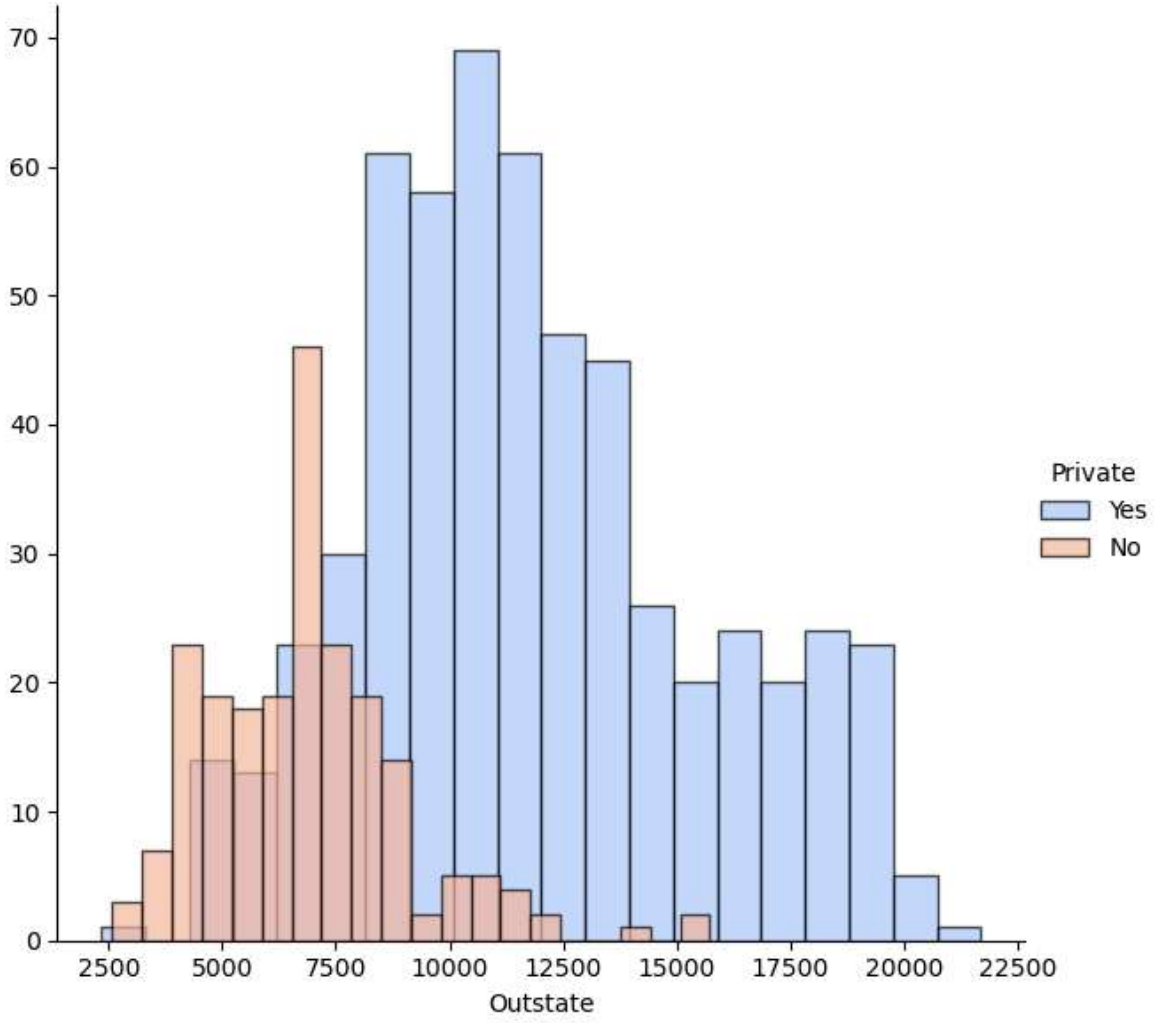
Out[17]:
```
<seaborn.axisgrid.FacetGrid at 0x7d1dac5e8740>
```



** Create a stacked histogram showing Out of State Tuition based on the Private column. Try doing this using sns.FacetGrid. If that is too tricky, see if you can do it just by using two instances of pandas.plot(kind='hist'). **

In [22]:
```
g = sns.FacetGrid(df, hue='Private', palette='coolwarm',height=6)
g = g.map(plt.hist,  'Outstate', bins=20, alpha=0.7, edgecolor="black")
g.add_legend()
```

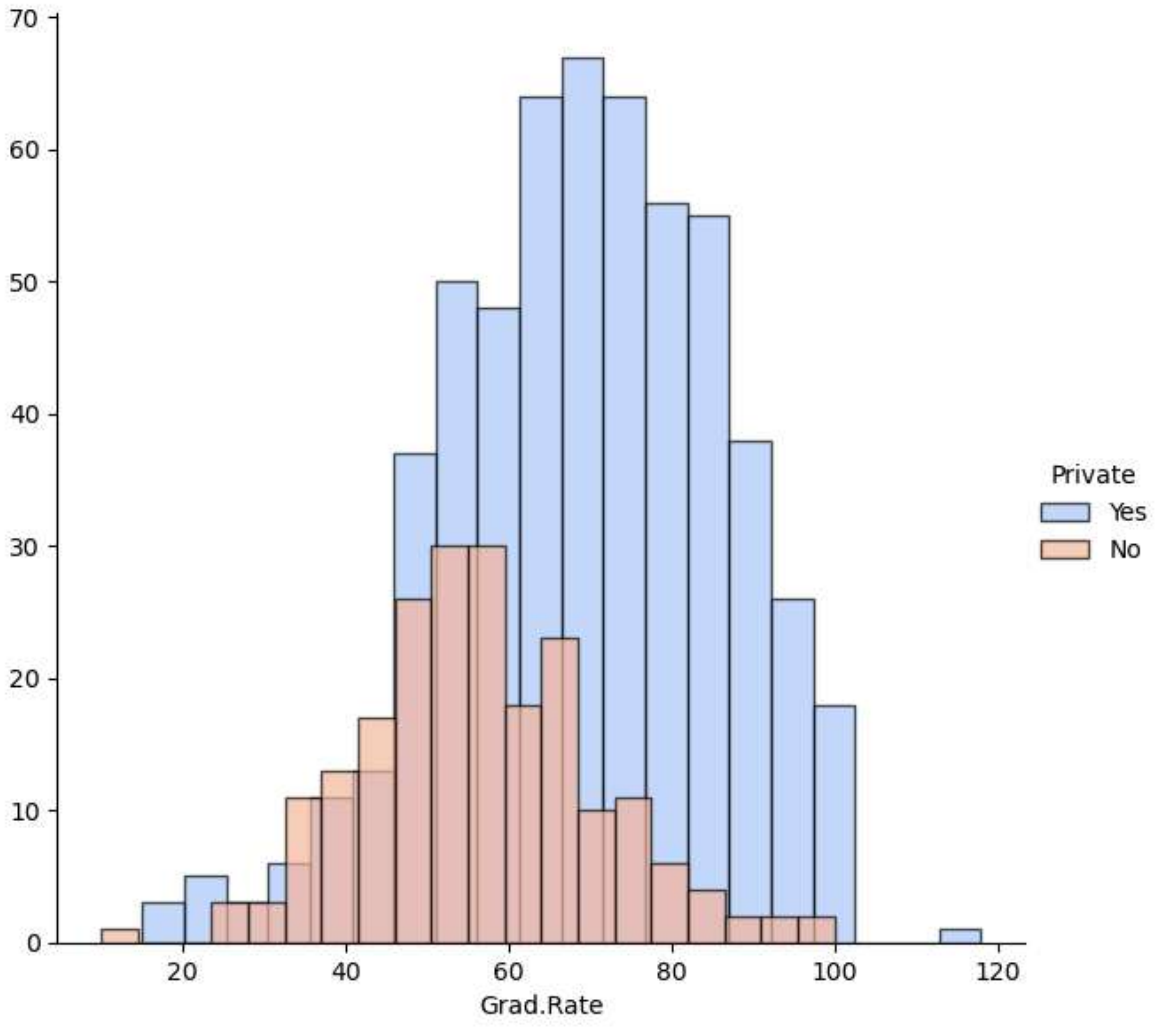
Out[22]:
```
<seaborn.axisgrid.FacetGrid at 0x7d1da275a870>
```



Create a similar histogram for the Grad.Rate column.

In [23]:
```
g = sns.FacetGrid(df, hue='Private', palette='coolwarm',height=6)
g = g.map(plt.hist,  'Grad.Rate', bins=20, alpha=0.7, edgecolor="black")
g.add_legend()
```

Out[23]: <seaborn.axisgrid.FacetGrid at 0x7d1dac5f73b0>



** Notice how there seems to be a private school with a graduation rate of higher than 100%.What is the name of that school?**

In [24]:
```
df[df['Grad.Rate']>100]
```

Out[24]:

	Private	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undery
Cazenovia College	Yes	3847	3433	527	9	35	1010	

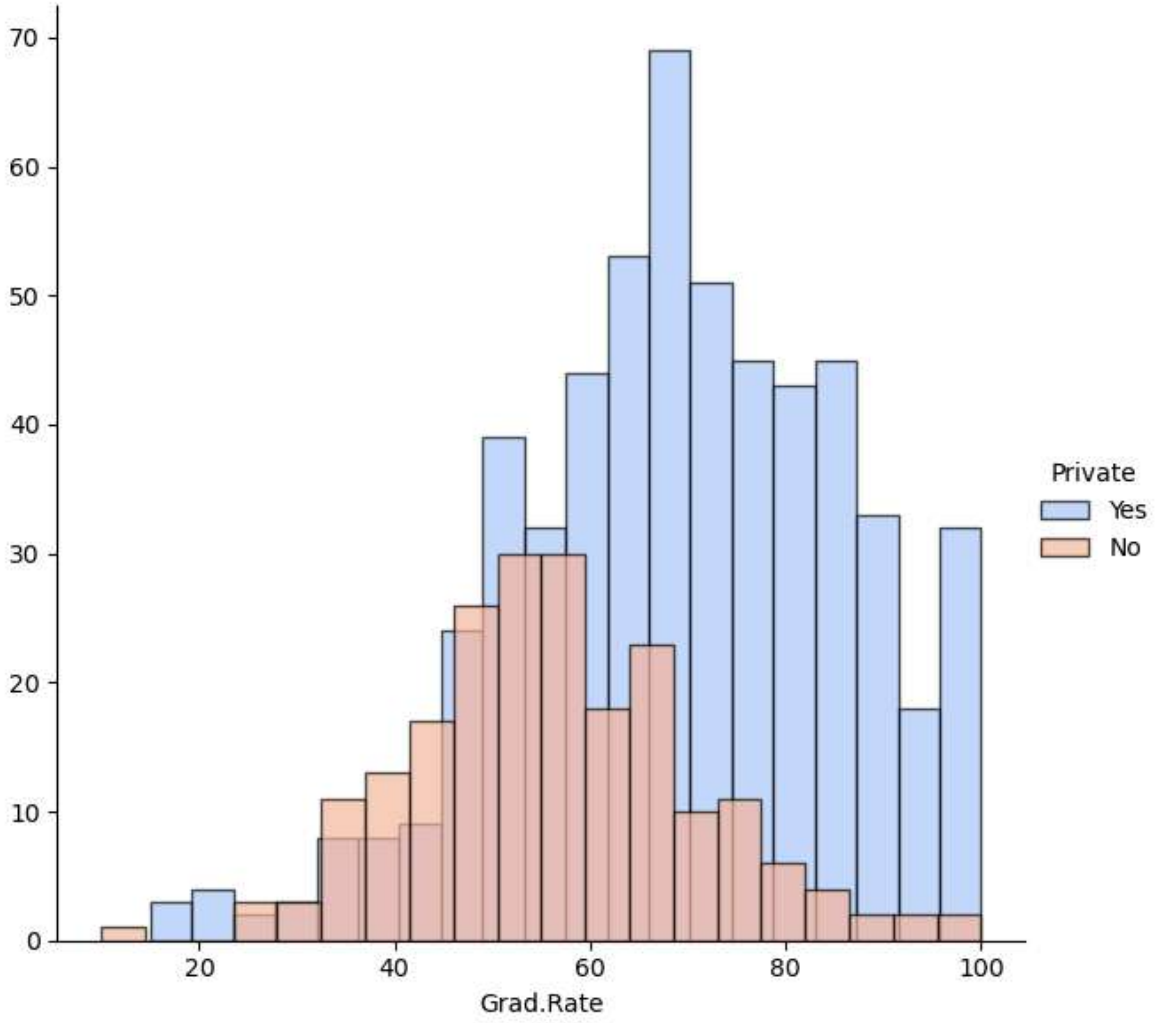
** Set that school's graduation rate to 100 so it makes sense. You may get a warning not an error) when doing this operation, so use dataframe operations or just re-do the histogram visualization to make sure it actually went through.**

In [25]:
```
df['Grad.Rate']['Cazenovia College'] = 100
```

```
/tmp/ipykernel_14312/2087630962.py:1: FutureWarning: ChainedAssignmentError: beha
viour will change in pandas 3.0!
You are setting values through chained assignment. Currently this works in certai
n cases, but when using Copy-on-Write (which will become the default behaviour in
pandas 3.0) this will never work to update the original DataFrame or Series, beca
use the intermediate object on which we are setting values will behave as a copy.
A typical example is when you are setting values in a column of a DataFrame, lik
e:

df["col"][row_indexer] = value

Use `df.loc[row_indexer, "col"] = values` instead, to perform the assignment in a
single step and ensure this keeps updating the original `df`.

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy

  df['Grad.Rate']['Cazenovia College'] = 100
/tmp/ipykernel_14312/2087630962.py:1: SettingWithCopyWarning:
A value is trying to be set on a copy of a slice from a DataFrame

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stabl
e/user_guide/indexing.html#returning-a-view-versus-a-copy
  df['Grad.Rate']['Cazenovia College'] = 100
```

In [26]:
```
g = sns.FacetGrid(df, hue='Private', palette='coolwarm',height=6)
g = g.map(plt.hist,  'Grad.Rate', bins=20, alpha=0.7, edgecolor="black")
g.add_legend()
```

Out[26]:
```
<seaborn.axisgrid.FacetGrid at 0x7d1da241e690>
```



K Means Cluster Creation

Now it is time to create the Cluster labels!

** Import KMeans from SciKit Learn.**

In [27]:
```
from sklearn.cluster import KMeans
```

** Create an instance of a K Means model with 2 clusters.**

In [30]:
```
kmeans = KMeans(n_clusters=2)
```

Fit the model to all the data except for the Private label.

In [31]:
```
kmeans.fit(df.drop('Private', axis=1))
```

Out[31]:
```
KMeans
▶ Parameters
```

** What are the cluster center vectors?**

In [32]:
```
kmeans.cluster_centers_
```

Out[32]:
```
array([[1.81323468e+03, 1.28716592e+03, 4.91044843e+02, 2.53094170e+01,
        5.34708520e+01, 2.18854858e+03, 5.95458894e+02, 1.03957085e+04,
        4.31136472e+03, 5.41982063e+02, 1.28033632e+03, 7.04424514e+01,
        7.78251121e+01, 1.40997010e+01, 2.31748879e+01, 8.93204634e+03,
        6.50926756e+01],
       [1.03631389e+04, 6.55089815e+03, 2.56972222e+03, 4.14907407e+01,
        7.02037037e+01, 1.30619352e+04, 2.46486111e+03, 1.07191759e+04,
        4.64347222e+03, 5.95212963e+02, 1.71420370e+03, 8.63981481e+01,
        9.13333333e+01, 1.40277778e+01, 2.00740741e+01, 1.41705000e+04,
        6.75925926e+01]])
```

Evaluation

There is no perfect way to evaluate clustering if you don't have the labels, however since this is just an exercise, we do have the labels, so we take advantage of this to evaluate our clusters, keep in mind, you usually won't have this luxury in the real world.

** Create a new column for df called 'Cluster', which is a 1 for a Private school, and a 0 for a public school.**

In [34]:
```
def converter(private):
    if private == 'Yes':
        return 1
    else:
        return 0
```

In [35]:
```
df['Cluster'] = df['Private'].apply(converter)
```

In [36]:
```
df.head()
```

Out[36]:

	Private	Apps	Accept	Enroll	Top10perc	Top25perc	F.Undergrad	P.Undere
Abilene Christian University	Yes	1660	1232	721	23	52	2885	
Adelphi University	Yes	2186	1924	512	16	29	2683	
Adrian College	Yes	1428	1097	336	22	50	1036	
Agnes Scott College	Yes	417	349	137	60	89	510	
Alaska Pacific University	Yes	193	146	55	16	44	249	

** Create a confusion matrix and classification report to see how well the Kmeans clustering worked without being given any labels.**

In [37]:
```
from sklearn.metrics import confusion_matrix, classification_report
```

In [38]:
```
print(confusion_matrix(df['Cluster'],kmeans.labels_))
print('\n')
print(classification_report(df['Cluster'],kmeans.labels_))
```

```
[[138  74]
 [531  34]]


              precision    recall  f1-score   support

           0       0.21      0.65      0.31       212
           1       0.31      0.06      0.10       565

    accuracy                           0.22       777
   macro avg       0.26      0.36      0.21       777
weighted avg       0.29      0.22      0.16       777
```

Not so bad considering the algorithm is purely using the features to cluster the universities into 2 distinct groups! Hopefully you can begin to see how K Means is useful for clustering un-labeled data!

Great Job!