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0.) Import and Clean data

In [52]:
```
# pip install google
```

```
Collecting google
  Obtaining dependency information for google from https://files.pythonhosted.org/packages/ac/35/17c9141c4ae21e9a29a43acdfd848e3e468a810517f862
cad07977bf8fe9/google-3.0.0-py2.py3-none-any.whl.metadata
  Downloading google-3.0.0-py2.py3-none-any.whl.metadata (627 bytes)
Requirement already satisfied: beautifulsoup4 in e:\..kacie\anacondakc\lib\site-packages (from google) (4.12.2)
Requirement already satisfied: soupsieve>1.2 in e:\..kacie\anacondakc\lib\site-packages (from beautifulsoup4->google) (2.4)
Downloading google-3.0.0-py2.py3-none-any.whl (45 kB)
   ---------------------------------------- 0.0/45.3 kB ? eta -:--:--
   --------- ------------------------------ 10.2/45.3 kB ? eta -:--:--
   ------------------------- ------------ 30.7/45.3 kB 262.6 kB/s eta 0:00:01
   ---------------------------------- --- 41.0/45.3 kB 326.8 kB/s eta 0:00:01
   ---------------------------------------- 45.3/45.3 kB 280.1 kB/s eta 0:00:00
Installing collected packages: google
Successfully installed google-3.0.0
Note: you may need to restart the kernel to use updated packages.
```

In [1]:
```
import pandas as pd
# from google.colab import drive
import matplotlib.pyplot as plt
import numpy as np
```

In [2]:
```
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import BaggingClassifier
from sklearn.datasets import make_classification
from sklearn.metrics import accuracy_score
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.tree import plot_tree
from sklearn.metrics import confusion_matrix
import seaborn as sns
```

In [ ]:
```
#drive.mount('/content/gdrive/', force_remount = True)
```

```
Mounted at /content/gdrive/
```

In [10]:
```
df = pd.read_csv('bank-additional-full.csv')
```

In [11]:
```
# can use df = pd.read_csv('bank-additional-full.csv', sep = ';')
```

In [12]:
```
df.head()
```

Out[12]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	poutcome	em
0	56	housemaid	married	basic.4y	no	no	no	telephone	may	mon	...	1	999	0	nonexistent	
1	57	services	married	high.school	unknown	no	no	telephone	may	mon	...	1	999	0	nonexistent	
2	37	services	married	high.school	no	yes	no	telephone	may	mon	...	1	999	0	nonexistent	
3	40	admin.	married	basic.6y	no	no	no	telephone	may	mon	...	1	999	0	nonexistent	
4	56	services	married	high.school	no	no	yes	telephone	may	mon	...	1	999	0	nonexistent	

5 rows × 21 columns

In [13]:
```
df = df.drop(["default", "pdays",       "previous",     "poutcome",     "emp.var.rate", "cons.price.idx",       "cons.conf.idx",        "euribo
df
```

Out[13]:

	age	job	marital	education	housing	loan	contact	month	day_of_week	duration	campaign	y
0	56	housemaid	married	basic.4y	no	no	telephone	may	mon	261	1	no
1	57	services	married	high.school	no	no	telephone	may	mon	149	1	no
2	37	services	married	high.school	yes	no	telephone	may	mon	226	1	no
3	40	admin.	married	basic.6y	no	no	telephone	may	mon	151	1	no
4	56	services	married	high.school	no	yes	telephone	may	mon	307	1	no
...	...	...	...	...	...	...	...	...	...	...	...	...
41183	73	retired	married	professional.course	yes	no	cellular	nov	fri	334	1	yes
41184	46	blue-collar	married	professional.course	no	no	cellular	nov	fri	383	1	no
41185	56	retired	married	university.degree	yes	no	cellular	nov	fri	189	2	no
41186	44	technician	married	professional.course	no	no	cellular	nov	fri	442	1	yes
41187	74	retired	married	professional.course	yes	no	cellular	nov	fri	239	3	no

41188 rows × 12 columns

In [14]:
```
df = pd.get_dummies(df, columns = ["loan", "job","marital","housing","contact","day_of_week", "campaign", "month", "education"],drop_first = T
```

In [8]:
```
df.head()
```

Out[8]:

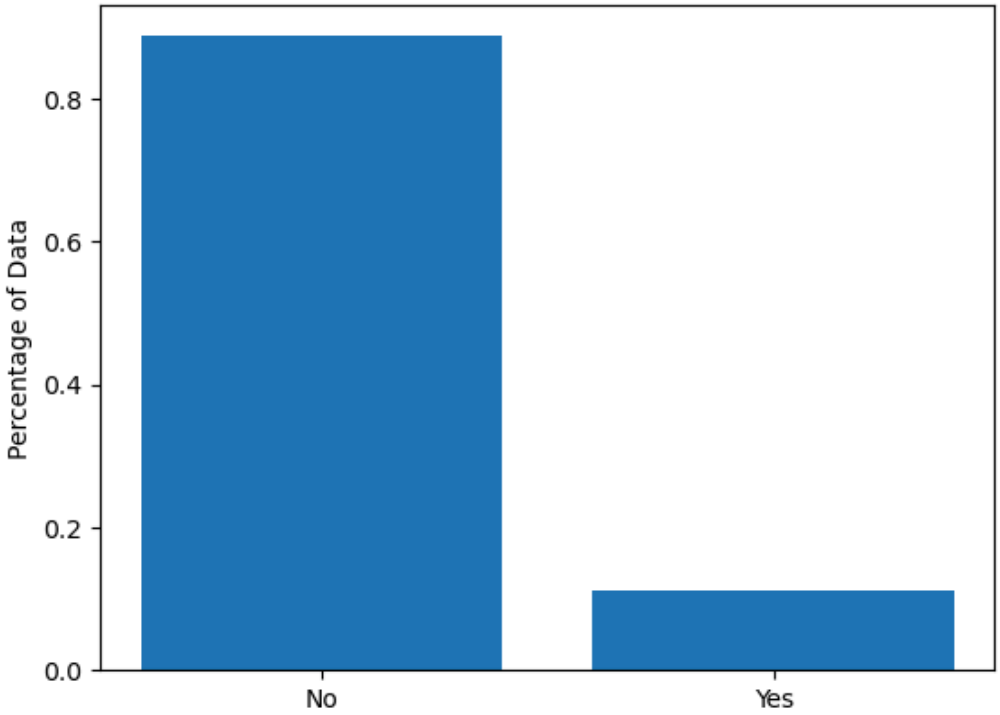
	age	duration	y	loan_unknown	loan_yes	job_blue-collar	job_entrepreneur	job_housemaid	job_management	job_retired	...	month_nov	month_
0	56	261	no	False	False	False	False	True	False	False	...	False	F
1	57	149	no	False	False	False	False	False	False	False	...	False	F
2	37	226	no	False	False	False	False	False	False	False	...	False	F
3	40	151	no	False	False	False	False	False	False	False	...	False	F
4	56	307	no	False	True	False	False	False	False	False	...	False	F

5 rows × 83 columns

In [15]:
```
y = pd.get_dummies(df["y"], drop_first = True)
X = df.drop(["y"], axis = 1)
```

In [ ]:
```
```

In [16]:
```
obs = len(y)
plt.bar(["No","Yes"],[len(y[y.yes==0])/obs,len(y[y.yes==1])/obs])
plt.ylabel("Percentage of Data")
plt.show()
```



1.) Based on the visualization above, use your expert opinion to transform the data based on what we learned this quarter

In [17]:
```
# Train Test Split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.3, random_state=42)
```

```
scaler = StandardScaler().fit(X_train)

X_scaled = scaler.transform(X_train)
X_test = scaler.transform(X_test)
```

In [18]:
```
###############
###TRANSFORM###
###############
#here we can notice that the data is highly imbalanced, therefore we need to use smote to balance the data.
from imblearn.over_sampling import RandomOverSampler
from imblearn.under_sampling import RandomUnderSampler
from imblearn.over_sampling import SMOTE

ros = RandomOverSampler()
over_X, over_y = ros.fit_resample(X_train, y_train)

X_scaled = over_X
y_train = over_y

#smote = SMOTE()
#smote_X, smote_y = smote.fit_resample(X_train, y_train)

#X_scaled = smote_X
#y_train = smote_y
```

2.) Build and visualize a decision tree of Max Depth 3. Show the confusion matrix.

In [ ]:
```
```

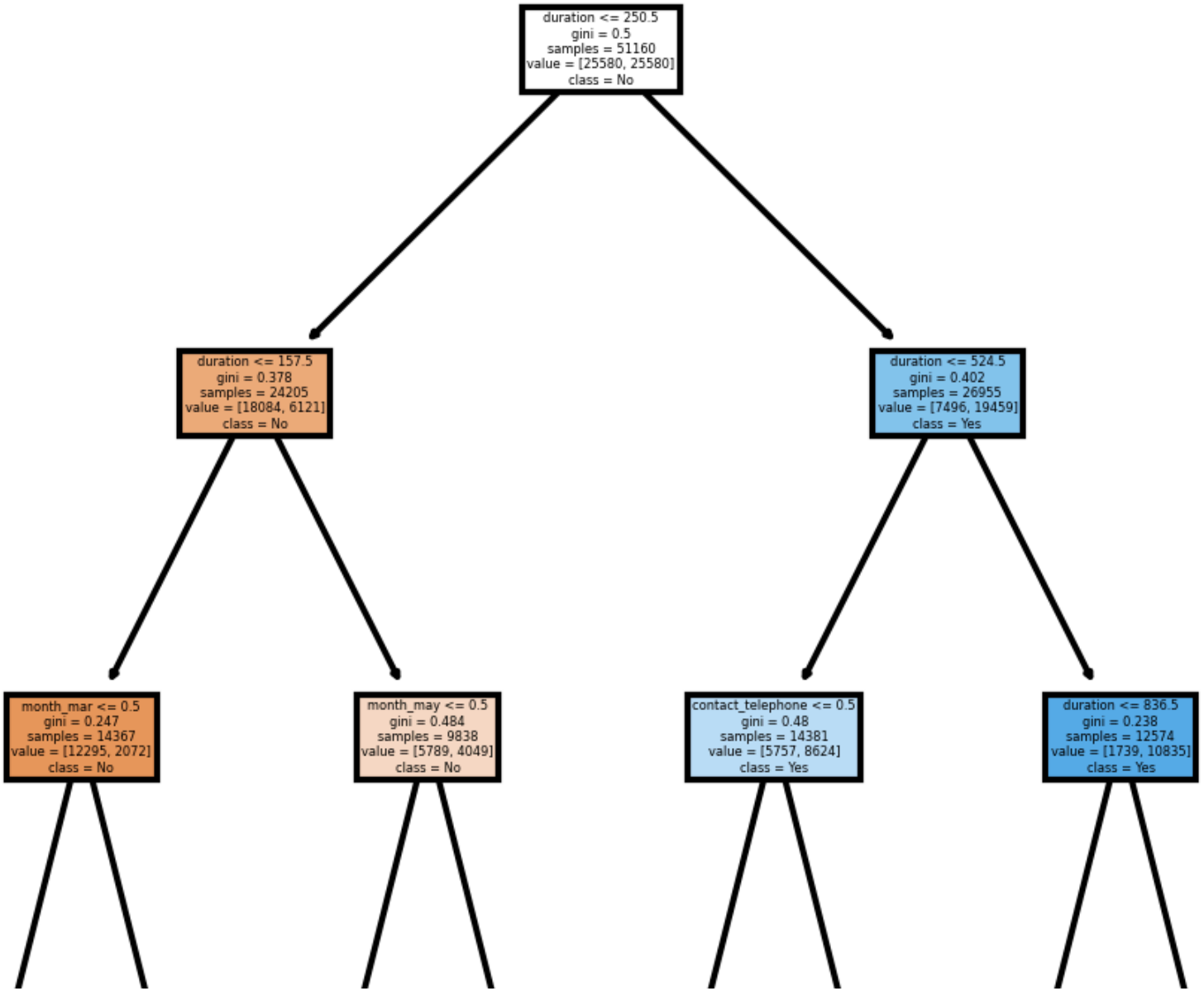
In [19]:
```
dtree_main = DecisionTreeClassifier(max_depth = 3)
dtree_main.fit(X_scaled, y_train)
```

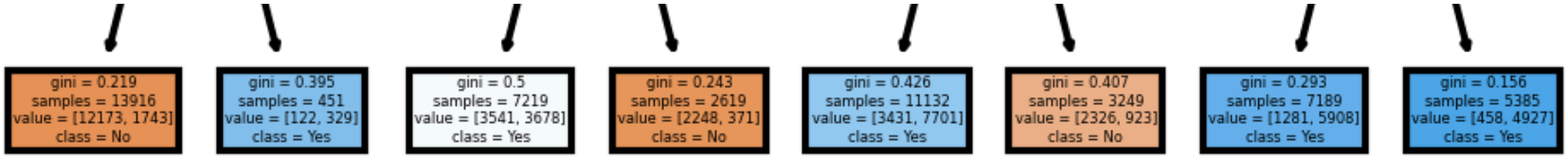
Out[19]:
```
▾ DecisionTreeClassifier
DecisionTreeClassifier(max_depth=3)
```

In [22]:
```
fig, axes = plt.subplots(nrows = 1,ncols = 1,figsize = (4,4), dpi=300)
feature_names = list(X.columns)
plot_tree(dtree_main, filled=True, feature_names=feature_names, class_names=["No", "Yes"])
```

Out[22]: [Text(0.5, 0.875, 'duration <= 250.5\ngini = 0.5\nsamples = 51160\nvalue = [25580, 25580]\nclass = No'),
Text(0.25, 0.625, 'duration <= 157.5\ngini = 0.378\nsamples = 24205\nvalue = [18084, 6121]\nclass = No'),
Text(0.125, 0.375, 'month_mar <= 0.5\ngini = 0.247\nsamples = 14367\nvalue = [12295, 2072]\nclass = No'),
Text(0.0625, 0.125, 'gini = 0.219\nsamples = 13916\nvalue = [12173, 1743]\nclass = No'),
Text(0.1875, 0.125, 'gini = 0.395\nsamples = 451\nvalue = [122, 329]\nclass = Yes'),
Text(0.375, 0.375, 'month_may <= 0.5\ngini = 0.484\nsamples = 9838\nvalue = [5789, 4049]\nclass = No'),
Text(0.3125, 0.125, 'gini = 0.5\nsamples = 7219\nvalue = [3541, 3678]\nclass = Yes'),
Text(0.4375, 0.125, 'gini = 0.243\nsamples = 2619\nvalue = [2248, 371]\nclass = No'),
Text(0.75, 0.625, 'duration <= 524.5\ngini = 0.402\nsamples = 26955\nvalue = [7496, 19459]\nclass = Yes'),
Text(0.625, 0.375, 'contact_telephone <= 0.5\ngini = 0.48\nsamples = 14381\nvalue = [5757, 8624]\nclass = Yes'),
Text(0.5625, 0.125, 'gini = 0.426\nsamples = 11132\nvalue = [3431, 7701]\nclass = Yes'),
Text(0.6875, 0.125, 'gini = 0.407\nsamples = 3249\nvalue = [2326, 923]\nclass = No'),
Text(0.875, 0.375, 'duration <= 836.5\ngini = 0.238\nsamples = 12574\nvalue = [1739, 10835]\nclass = Yes'),
Text(0.8125, 0.125, 'gini = 0.293\nsamples = 7189\nvalue = [1281, 5908]\nclass = Yes'),
Text(0.9375, 0.125, 'gini = 0.156\nsamples = 5385\nvalue = [458, 4927]\nclass = Yes')]

<Figure size 1000x800 with 0 Axes>


duration <= 250.5
gini = 0.5
samples = 51160
value = [25580, 25580]
class = No
duration <= 157.5
gini = 0.378
samples = 24205
value = [18084, 6121]
class = No
duration <= 524.5
gini = 0.402
samples = 26955
value = [7496, 19459]
class = Yes
month_mar <= 0.5
gini = 0.247
samples = 14367
value = [12295, 2072]
class = No
month_may <= 0.5
gini = 0.484
samples = 9838
value = [5789, 4049]
class = No
contact_telephone <= 0.5
gini = 0.48
samples = 14381
value = [5757, 8624]
class = Yes
duration <= 836.5
gini = 0.238
samples = 12574
value = [1739, 10835]
class = Yes



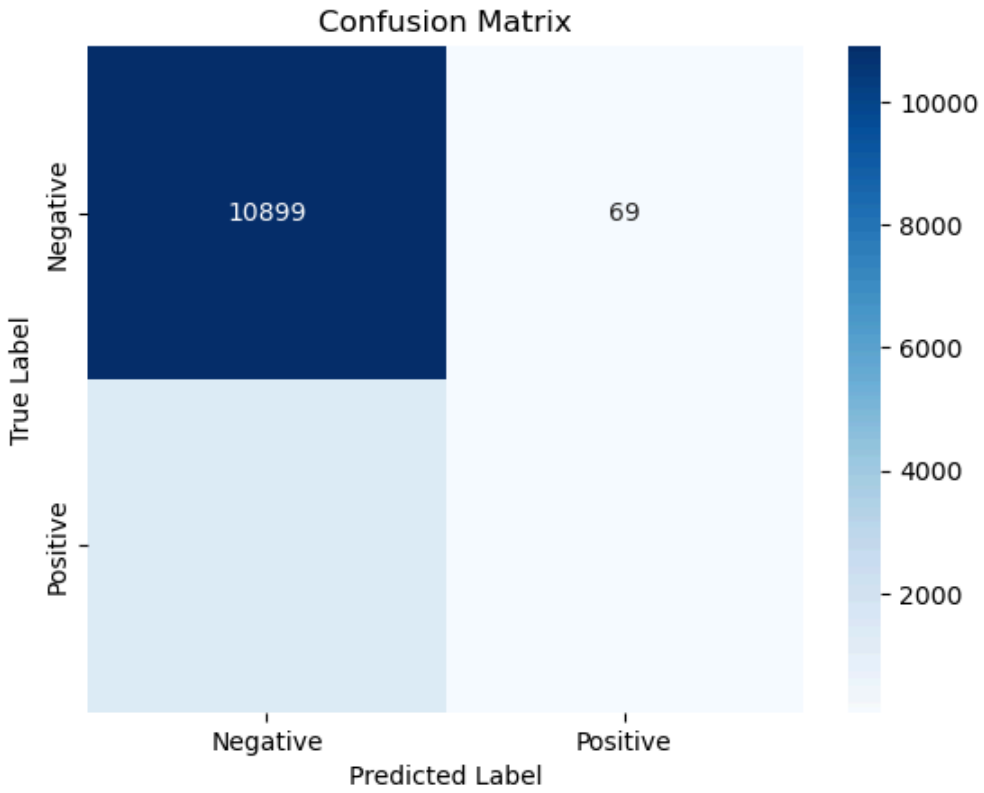
1b.) Confusion matrix on out of sample data. Visualize and store as variable

In [23]:
```
y_pred = dtree_main.predict(X_test)
y_true = y_test
cm_raw = confusion_matrix(y_true, y_pred)
```

```
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\base.py:464: UserWarning: X does not have valid feature names, but DecisionTreeClassifier was f
itted with feature names
  warnings.warn(
```

In [24]:
```
class_labels = ['Negative', 'Positive']

# Plot the confusion matrix as a heatmap
sns.heatmap(cm_raw, annot=True, fmt='d', cmap='Blues', xticklabels=class_labels, yticklabels=class_labels)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



3.) Use bagging on your descision tree

In [25]:
```
dtree = DecisionTreeClassifier(max_depth=3)
```

In [26]:
```
bagging = BaggingClassifier(estimator = dtree,
                            n_estimators=100,
                            max_samples=0.5,
                            max_features=1.0

)
```

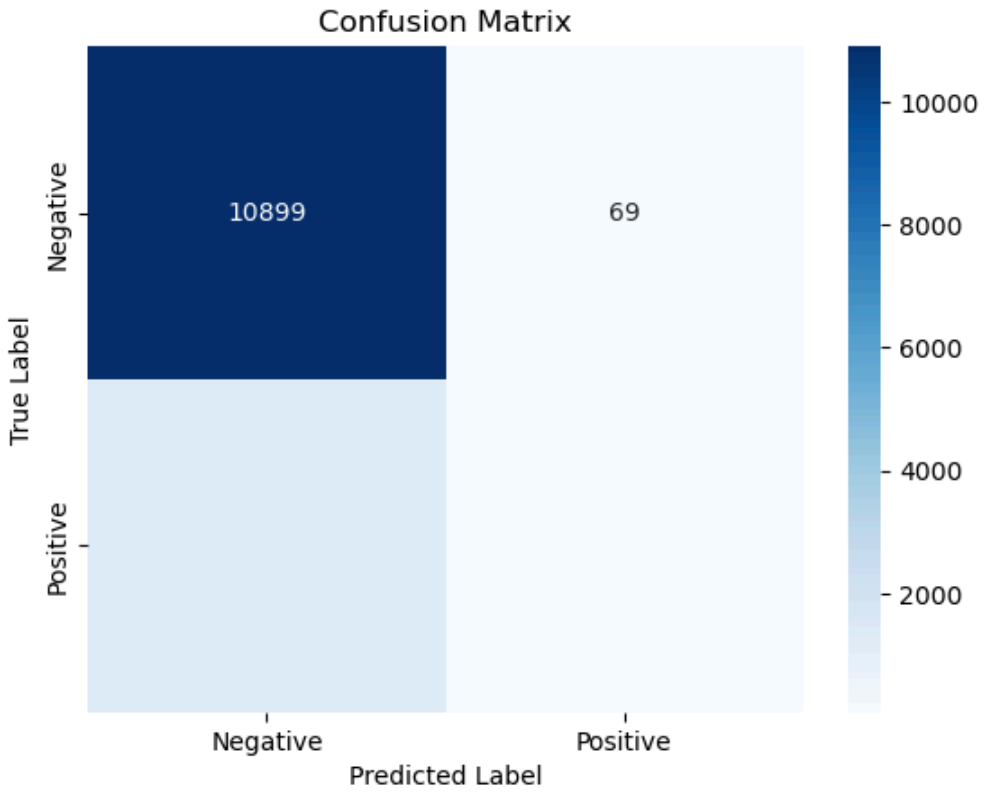
In [27]:
```
bagging.fit(X_scaled, y_train)
y_pred = bagging.predict(X_test)
```

```
y_true = y_test
cm_raw = confusion_matrix(y_true, y_pred)
```

```
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\ensemble\_bagging.py:802: DataConversionWarning: A column-vector y was passed when a 1d array w
as expected. Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\base.py:464: UserWarning: X does not have valid feature names, but BaggingClassifier was fitted
with feature names
  warnings.warn(
```

In [28]:
```
class_labels = ['Negative', 'Positive']

# Plot the confusion matrix as a heatmap
sns.heatmap(cm_raw, annot=True, fmt='d', cmap='Blues', xticklabels=class_labels, yticklabels=class_labels)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



In [ ]:

In [ ]:

4.) Boost your tree

In [29]:
```
from sklearn.ensemble import AdaBoostClassifier
```

In [30]:
```
dtree=DecisionTreeClassifier(max_depth=3)
```

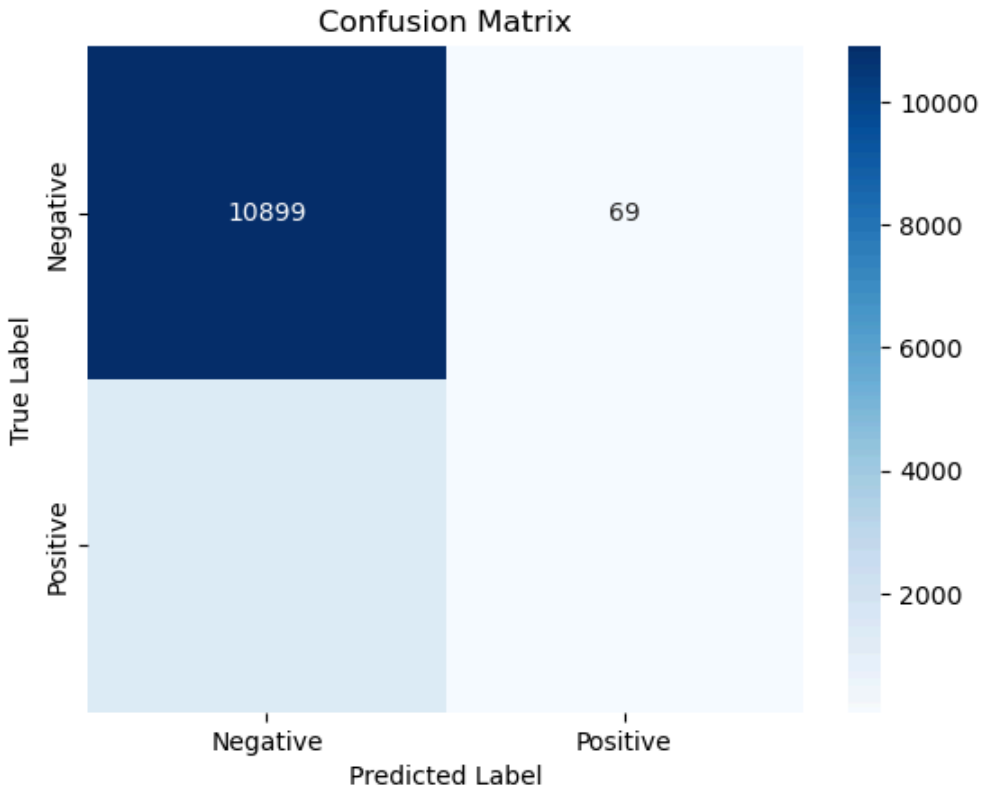
In [31]:
```
boost=AdaBoostClassifier(estimator= dtree,
                  n_estimators = 100,
                  learning_rate= 0.1)
```

In [32]:
```
boost.fit(X_scaled, y_train)
y_pred=bagging.predict(X_test)
y_true = y_test
cm_raw = confusion_matrix(y_true, y_pred)
```

```
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\utils\validation.py:1184: DataConversionWarning: A column-vector y was passed when a 1d array w
as expected. Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\base.py:464: UserWarning: X does not have valid feature names, but BaggingClassifier was fitted
with feature names
  warnings.warn(
```

In [33]:
```
class_labels = ['Negative', 'Positive']

# Plot the confusion matrix as a heatmap
sns.heatmap(cm_raw, annot=True, fmt='d', cmap='Blues', xticklabels=class_labels, yticklabels=class_labels)
plt.title('Confusion Matrix')
plt.xlabel('Predicted Label')
plt.ylabel('True Label')
plt.show()
```



5.) Create a superlearner with at least 4 base learner models. Use a logistic reg for your metalearner. Interpret your coefficients and save your CM.

In [42]:
```
# pip install mlens
```

```
Collecting mlens
  Downloading mlens-0.2.3-py2.py3-none-any.whl (227 kB)
     ---------------------------------------- 0.0/227.7 kB ? eta -:--:--
     - -------------------------------------- 10.2/227.7 kB ? eta -:--:--
     ------ --------------------------------- 41.0/227.7 kB 326.8 kB/s eta 0:00:01
     ----------------------------------  225.3/227.7 kB 1.5 MB/s eta 0:00:01
     ---------------------------------------- 227.7/227.7 kB 1.3 MB/s eta 0:00:00
Requirement already satisfied: numpy>=1.11 in e:\..kacie\anacondakc\lib\site-packages (from mlens) (1.24.3)
Requirement already satisfied: scipy>=0.17 in e:\..kacie\anacondakc\lib\site-packages (from mlens) (1.11.4)
Installing collected packages: mlens
Successfully installed mlens-0.2.3
Note: you may need to restart the kernel to use updated packages.
```

In [34]:
```
from sklearn.linear_model import LogisticRegression
# from sklearn.ensemble import RandomForestClassifier
# from sklearn.neighbors import KNeighborsClassifier
```

In [46]:
```
# from mlens.ensemble import SuperLearner
```

In [35]:
```
X_base_learners=[list(bagging.predict(X_scaled)),list(boost.predict(X_scaled)),list(dtree_main.predict(X_scaled))]
super_learner=LogisticRegression()
super_learner.fit(np.column_stack(X_base_learners), y_train)
```

```
e:\..Kacie\AnacondaKC\Lib\site-packages\sklearn\utils\validation.py:1184: DataConversionWarning: A column-vector y was passed when a 1d array w
as expected. Please change the shape of y to (n_samples, ), for example using ravel().
  y = column_or_1d(y, warn=True)
```

Out[35]:

▾ LogisticRegression

LogisticRegression()

In [36]:
```
super_learner.coef_
```

Out[36]:
```
array([[-0.06749077,  2.84611709,  1.0514362 ]])
```

In [ ]:

In [ ]:

In [ ]:

In [ ]:

6.)

In [ ]:

In [ ]:

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In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

In [ ]:

```
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
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  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
```

```
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
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/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
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/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
and will be removed in 1.4.
  warnings.warn(
/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
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and will be removed in 1.4.
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and will be removed in 1.4.
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/usr/local/lib/python3.8/dist-packages/sklearn/ensemble/_base.py:166: FutureWarning: `base_estimator` was renamed to `estimator` in version 1.2
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Best Hyperparameters: {'base_estimator': LogisticRegression(), 'max_features': 0.7, 'max_samples': 0.5, 'n_estimators': 50}
Best Accuracy Score: 0.9289999999999999
```

In [ ]: