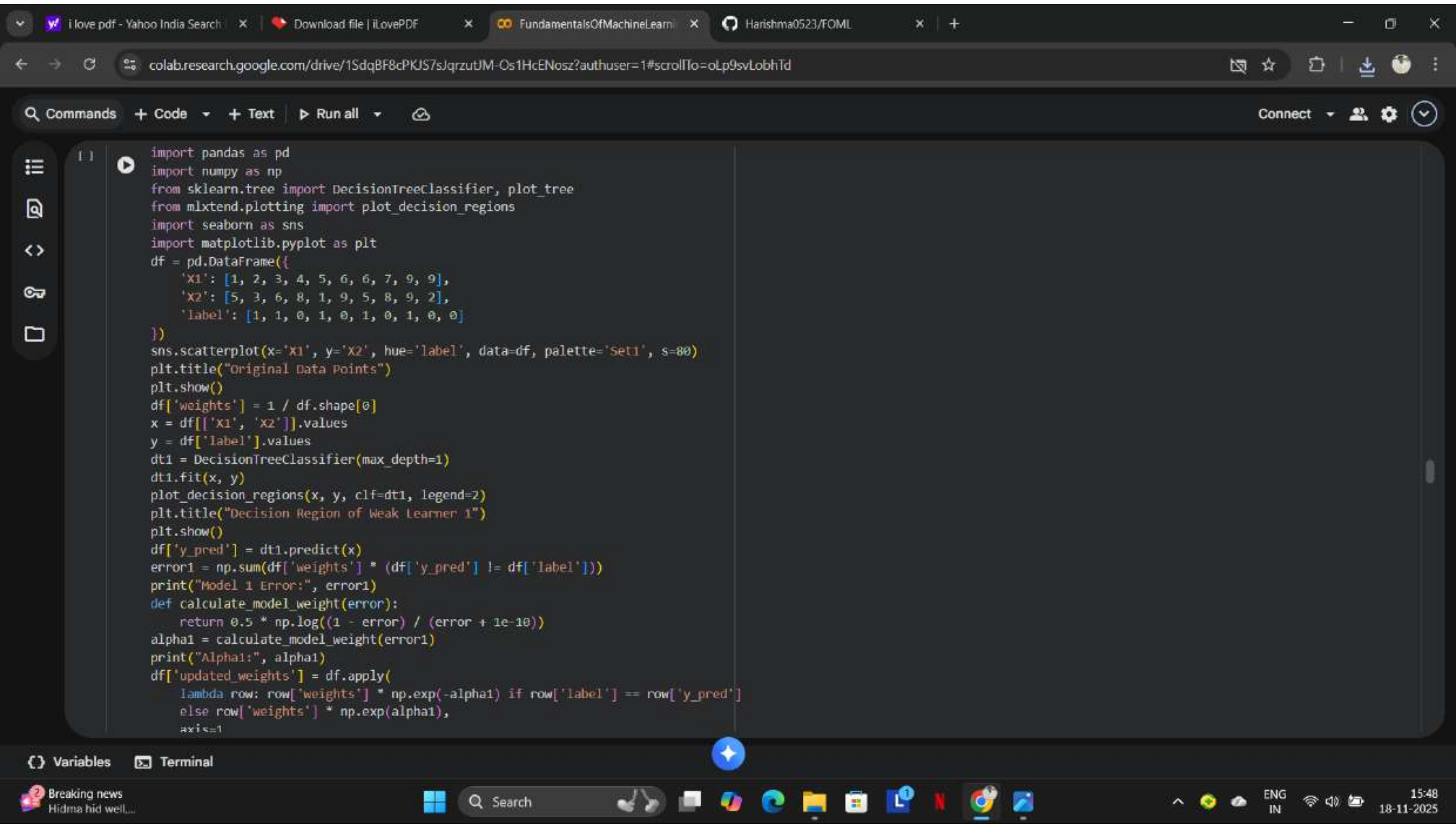

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FundamentalsOfMachineLearni
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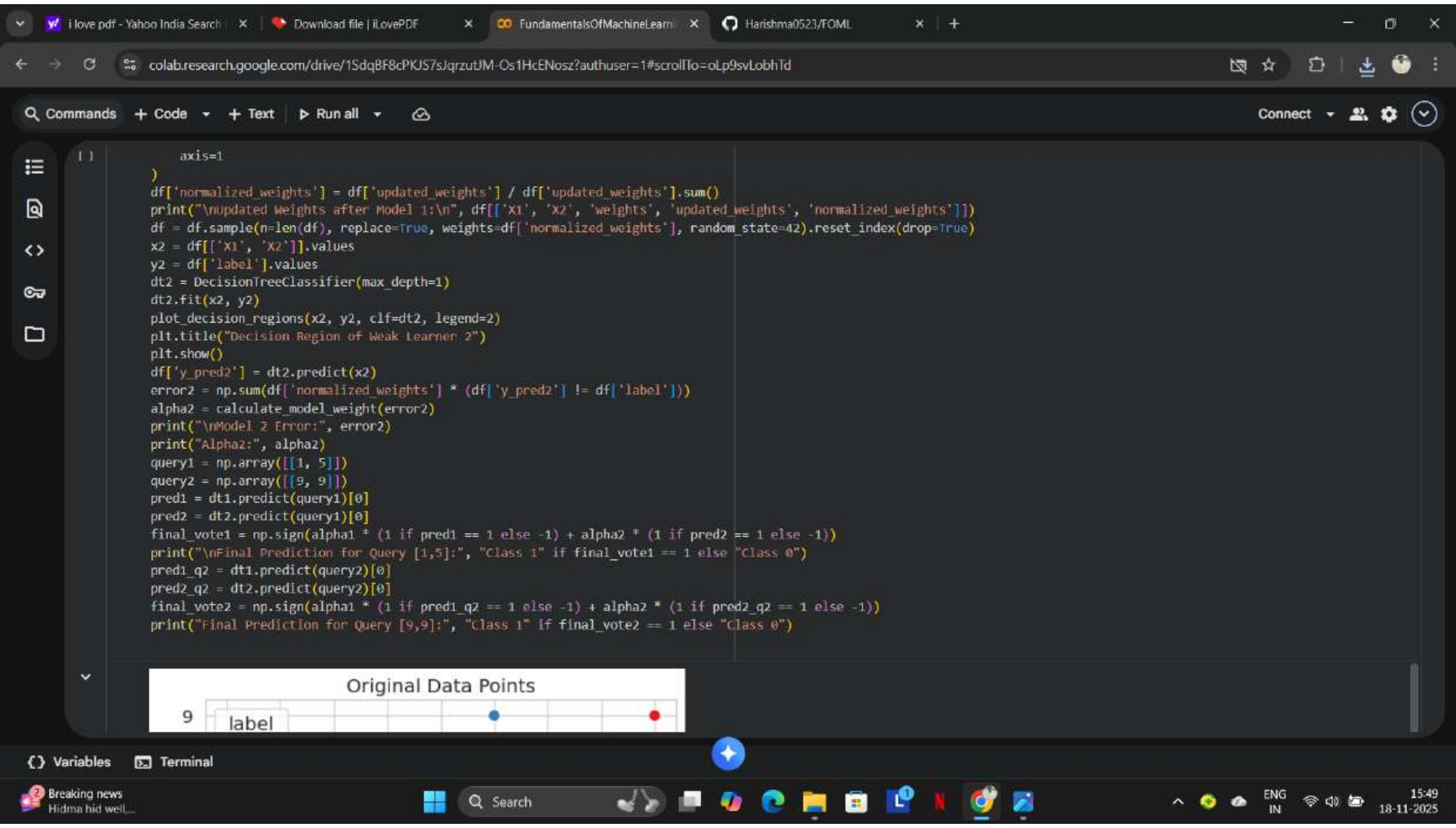
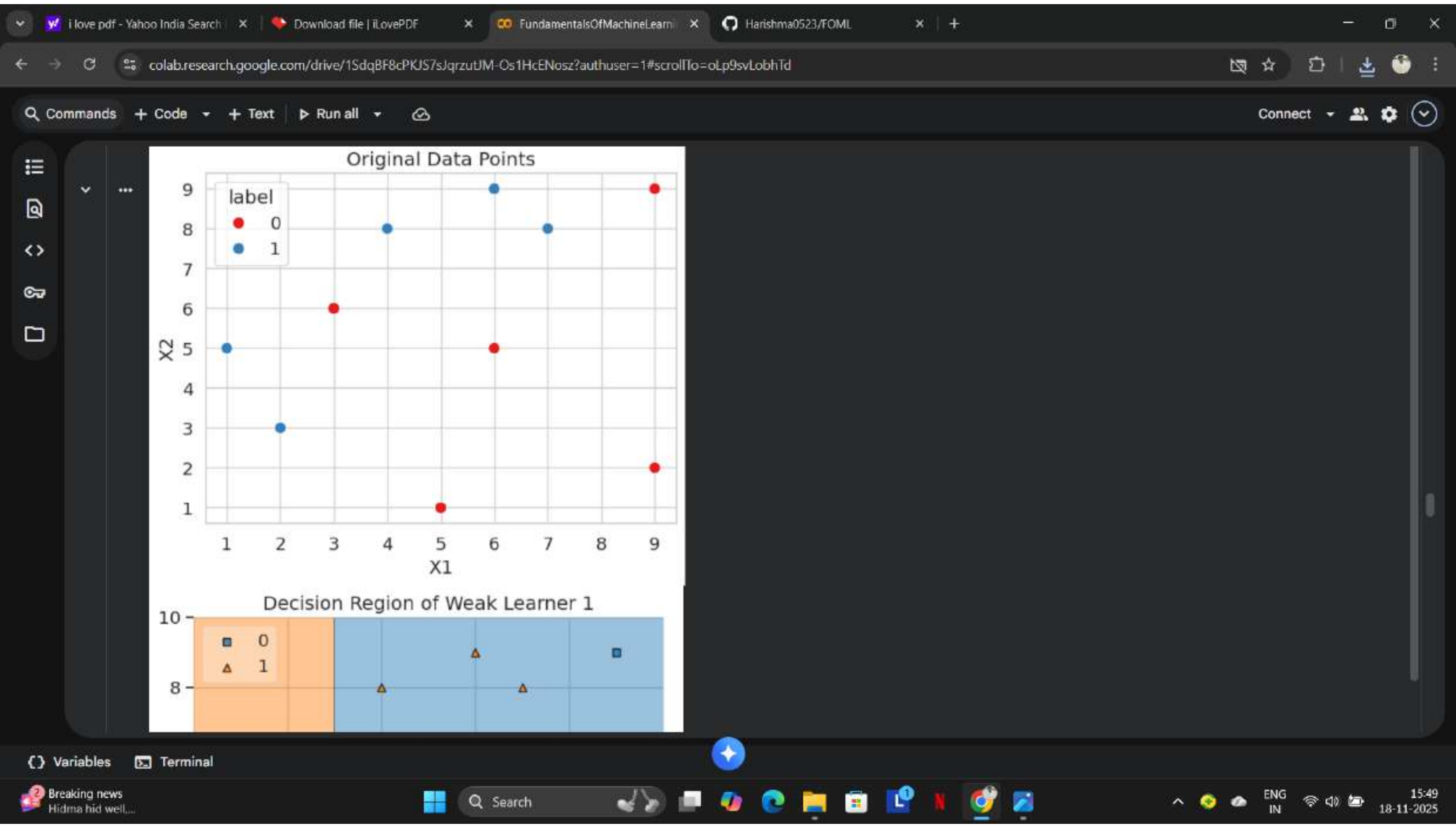
```
import pandas as pd
import numpy as np
from sklearn.tree import DecisionTreeClassifier, plot_tree
from mlxtend.plotting import plot_decision_regions
import seaborn as sns
import matplotlib.pyplot as plt
df = pd.DataFrame({
    'X1': [1, 2, 3, 4, 5, 6, 6, 7, 9, 9],
    'X2': [5, 3, 6, 8, 1, 9, 5, 8, 9, 2],
    'label': [1, 1, 0, 1, 0, 1, 0, 1, 0, 0]
})
sns.scatterplot(x='X1', y='X2', hue='label', data=df, palette='Set1', s=80)
plt.title("Original Data Points")
plt.show()
df['weights'] = 1 / df.shape[0]
x = df[['X1', 'X2']].values
y = df['label'].values
dt1 = DecisionTreeClassifier(max_depth=1)
dt1.fit(x, y)
plot_decision_regions(x, y, clf=dt1, legend=2)
plt.title("Decision Region of Weak Learner 1")
plt.show()
df['y_pred'] = dt1.predict(x)
error1 = np.sum(df['weights'] * (df['y_pred'] != df['label']))
print("Model 1 Error:", error1)
def calculate_model_weight(error):
    return 0.5 * np.log((1 - error) / (error + 1e-10))
alpha1 = calculate_model_weight(error1)
print("Alpha1:", alpha1)
df['updated_weights'] = df.apply(
    lambda row: row['weights'] * np.exp(-alpha1) if row['label'] == row['y_pred']
    else row['weights'] * np.exp(alpha1),
    axis=1
```



```
        axis=1
    )
    df['normalized_weights'] = df['updated_weights'] / df['updated_weights'].sum()
    print("\nUpdated Weights after Model 1:\n", df[['X1', 'X2', 'weights', 'updated_weights', 'normalized_weights']])
    df = df.sample(n=len(df), replace=True, weights=df['normalized_weights'], random_state=42).reset_index(drop=True)
    x2 = df[['X1', 'X2']].values
    y2 = df['label'].values
    dt2 = DecisionTreeClassifier(max_depth=1)
    dt2.fit(x2, y2)
    plot_decision_regions(x2, y2, clf=dt2, legend=2)
    plt.title("Decision Region of Weak Learner 2")
    plt.show()
    df['y_pred2'] = dt2.predict(x2)
    error2 = np.sum(df['normalized_weights'] * (df['y_pred2'] != df['label']))
    alpha2 = calculate_model_weight(error2)
    print("\nModel 2 Error:", error2)
    print("Alpha2:", alpha2)
    query1 = np.array([[1, 5]])
    query2 = np.array([[9, 9]])
    pred1 = dt1.predict(query1)[0]
    pred2 = dt2.predict(query1)[0]
    final_vote1 = np.sign(alpha1 * (1 if pred1 == 1 else -1) + alpha2 * (1 if pred2 == 1 else -1))
    print("\nFinal Prediction for Query [1,5]:", "Class 1" if final_vote1 == 1 else "Class 0")
    pred1_q2 = dt1.predict(query2)[0]
    pred2_q2 = dt2.predict(query2)[0]
    final_vote2 = np.sign(alpha1 * (1 if pred1_q2 == 1 else -1) + alpha2 * (1 if pred2_q2 == 1 else -1))
    print("Final Prediction for Query [9,9]:", "Class 1" if final_vote2 == 1 else "Class 0")
```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Original Data Points
label
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9
8
7
6
5
4
3
2
1
X2
1 2 3 4 5 6 7 8 9
X1
Decision Region of Weak Learner 1
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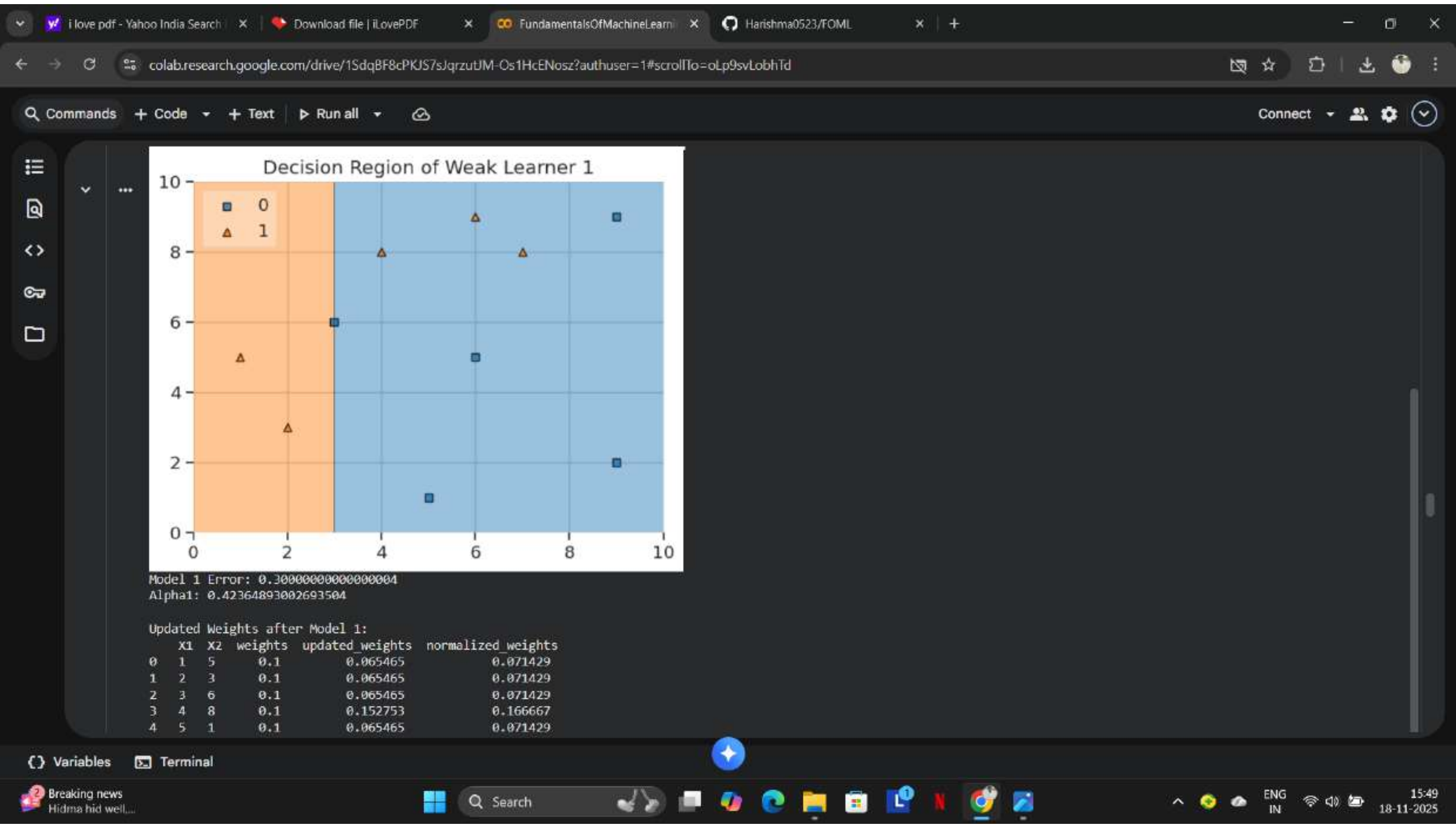
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Decision Region of Weak Learner 1
0
1
10
8
6
4
2
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2
4
6
8
10
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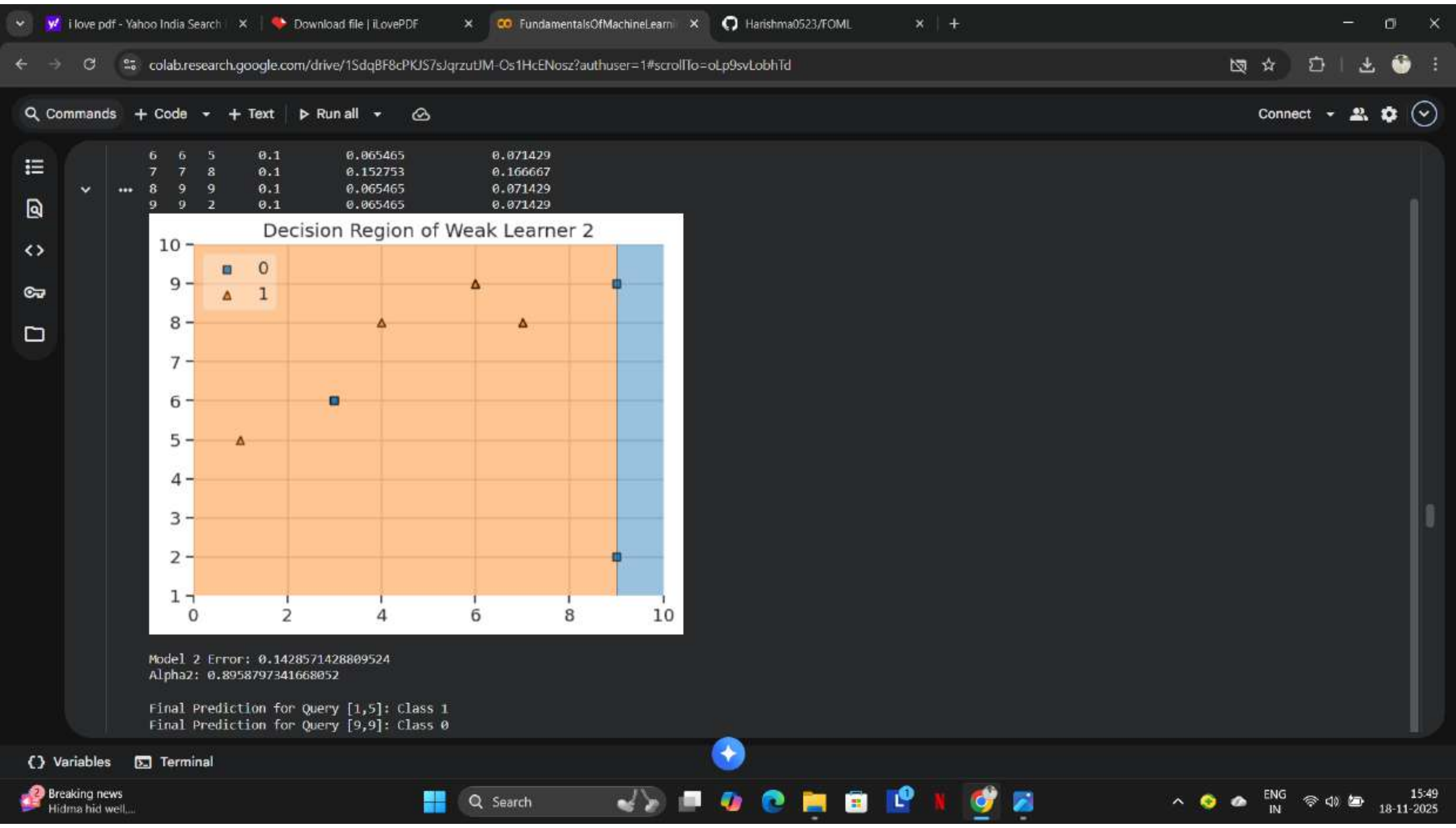
```
Model 1 Error: 0.30000000000000004
Alpha1: 0.42364893002693504

Updated Weights after Model 1:
    X1  X2  weights  updated_weights  normalized_weights
0   1   5      0.1         0.065465            0.071429
1   2   3      0.1         0.065465            0.071429
2   3   6      0.1         0.065465            0.071429
3   4   8      0.1         0.152753            0.166667
4   5   1      0.1         0.065465            0.071429
```



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```
6   6   5     0.1      0.065465        0.071429
7   7   8     0.1      0.152753        0.166667
8   9   9     0.1      0.065465        0.071429
9   9   2     0.1      0.065465        0.071429
```

Decision Region of Weak Learner 2

```
Model 2 Error: 0.1428571428809524
Alpha2: 0.8958797341668052

Final Prediction for Query [1,5]: Class 1
Final Prediction for Query [9,9]: Class 0
```