In [30]:
```
import pandas as pd
import numpy as np
import matplotlib.pyplot as plt
import seaborn as sns

import warnings
warnings.filterwarnings('ignore')

%matplotlib inline
```

In [31]:
```
df = pd.read_csv(r"C:\Users\ADMIN\OneDrive\bank-additional.csv",delimiter=";")
df.rename(columns={'y':'deposit'}, inplace=True)
df.head()
```

Out[31]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_v
0	30	blue-collar	married	basic.9y	no	yes	no	cellular	may	
1	39	services	single	high.school	no	no	no	telephone	may	
2	25	services	married	high.school	no	yes	no	telephone	jun	
3	38	services	married	basic.9y	no	unknown	unknown	telephone	jun	
4	47	admin.	married	university.degree	no	yes	no	cellular	nov	

5 rows × 21 columns

In [32]:
```
df.head()
```

Out[32]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_v
0	30	blue-collar	married	basic.9y	no	yes	no	cellular	may	
1	39	services	single	high.school	no	no	no	telephone	may	
2	25	services	married	high.school	no	yes	no	telephone	jun	
3	38	services	married	basic.9y	no	unknown	unknown	telephone	jun	
4	47	admin.	married	university.degree	no	yes	no	cellular	nov	

5 rows × 21 columns

In [33]:
```
df.head()
```

Out[33]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_v
0	30	blue-collar	married	basic.9y	no	yes	no	cellular	may	
1	39	services	single	high.school	no	no	no	telephone	may	
2	25	services	married	high.school	no	yes	no	telephone	jun	
3	38	services	married	basic.9y	no	unknown	unknown	telephone	jun	
4	47	admin.	married	university.degree	no	yes	no	cellular	nov	

5 rows × 21 columns

In [34]:
```
df.tail()
```

Out[34]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_we
4114	30	admin.	married	basic.6y	no	yes	yes	cellular	jul	t
4115	39	admin.	married	high.school	no	yes	no	telephone	jul	
4116	27	student	single	high.school	no	no	no	cellular	may	m
4117	58	admin.	married	high.school	no	no	no	cellular	aug	
4118	34	management	single	high.school	no	yes	no	cellular	nov	w

5 rows × 21 columns

In [35]:
```
df.shape
```

Out[35]:
```
(4119, 21)
```

In [36]:
```
df.columns
```

Out[36]:
```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'emp.var.rate', 'cons.price.idx',
       'cons.conf.idx', 'euribor3m', 'nr.employed', 'deposit'],
      dtype='object')
```

In [37]:
```
df.dtypes
```

Out[37]:
```
age                 int64
job                object
marital            object
education          object
default            object
housing            object
loan               object
contact            object
month              object
day_of_week        object
duration            int64
campaign            int64
pdays               int64
previous            int64
poutcome           object
emp.var.rate      float64
cons.price.idx    float64
cons.conf.idx     float64
euribor3m         float64
nr.employed       float64
deposit            object
dtype: object
```

In [38]:
```
df.dtypes.value_counts()
```

Out[38]:
```
object     11
int64       5
float64     5
Name: count, dtype: int64
```

```
In [39]: df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 4119 entries, 0 to 4118
Data columns (total 21 columns):
 #   Column          Non-Null Count  Dtype  
---  ------          --------------  -----  
 0   age             4119 non-null   int64  
 1   job             4119 non-null   object 
 2   marital         4119 non-null   object 
 3   education       4119 non-null   object 
 4   default         4119 non-null   object 
 5   housing         4119 non-null   object 
 6   loan            4119 non-null   object 
 7   contact         4119 non-null   object 
 8   month           4119 non-null   object 
 9   day_of_week     4119 non-null   object 
 10  duration        4119 non-null   int64  
 11  campaign        4119 non-null   int64  
 12  pdays           4119 non-null   int64  
 13  previous        4119 non-null   int64  
 14  poutcome        4119 non-null   object 
 15  emp.var.rate    4119 non-null   float64
 16  cons.price.idx  4119 non-null   float64
 17  cons.conf.idx   4119 non-null   float64
 18  euribor3m       4119 non-null   float64
 19  nr.employed     4119 non-null   float64
 20  deposit         4119 non-null   object 
dtypes: float64(5), int64(5), object(11)
memory usage: 675.9+ KB
```

```
In [40]: df.duplicated().sum()
```

```
Out[40]: 0
```

In [41]:
```
df.isna().sum()
```

Out[41]:
```
age               0
job               0
marital           0
education         0
default           0
housing           0
loan              0
contact           0
month             0
day_of_week       0
duration          0
campaign          0
pdays             0
previous          0
poutcome          0
emp.var.rate      0
cons.price.idx    0
cons.conf.idx     0
euribor3m         0
nr.employed       0
deposit           0
dtype: int64
```

In [42]:
```
cat_cols = df.select_dtypes(include='object').columns
print(cat_cols)

num_cols = df.select_dtypes(exclude='object').columns
print(num_cols)
```

```
Index(['job', 'marital', 'education', 'default', 'housing', 'loan', 'contac
t',
       'month', 'day_of_week', 'poutcome', 'deposit'],
      dtype='object')
Index(['age', 'duration', 'campaign', 'pdays', 'previous', 'emp.var.rate',
       'cons.price.idx', 'cons.conf.idx', 'euribor3m', 'nr.employed'],
      dtype='object')
```

In [43]:
```
df.describe()
```

Out[43]:

	age	duration	campaign	pdays	previous	emp.var.rate	cons.price.
count	4119.000000	4119.000000	4119.000000	4119.000000	4119.000000	4119.000000	4119.0000
mean	40.113620	256.788055	2.537266	960.422190	0.190337	0.084972	93.5797
std	10.313362	254.703736	2.568159	191.922786	0.541788	1.563114	0.5793
min	18.000000	0.000000	1.000000	0.000000	0.000000	-3.400000	92.2010
25%	32.000000	103.000000	1.000000	999.000000	0.000000	-1.800000	93.0750
50%	38.000000	181.000000	2.000000	999.000000	0.000000	1.100000	93.7490
75%	47.000000	317.000000	3.000000	999.000000	0.000000	1.400000	93.9940
max	88.000000	3643.000000	35.000000	999.000000	6.000000	1.400000	94.7670

In [44]:

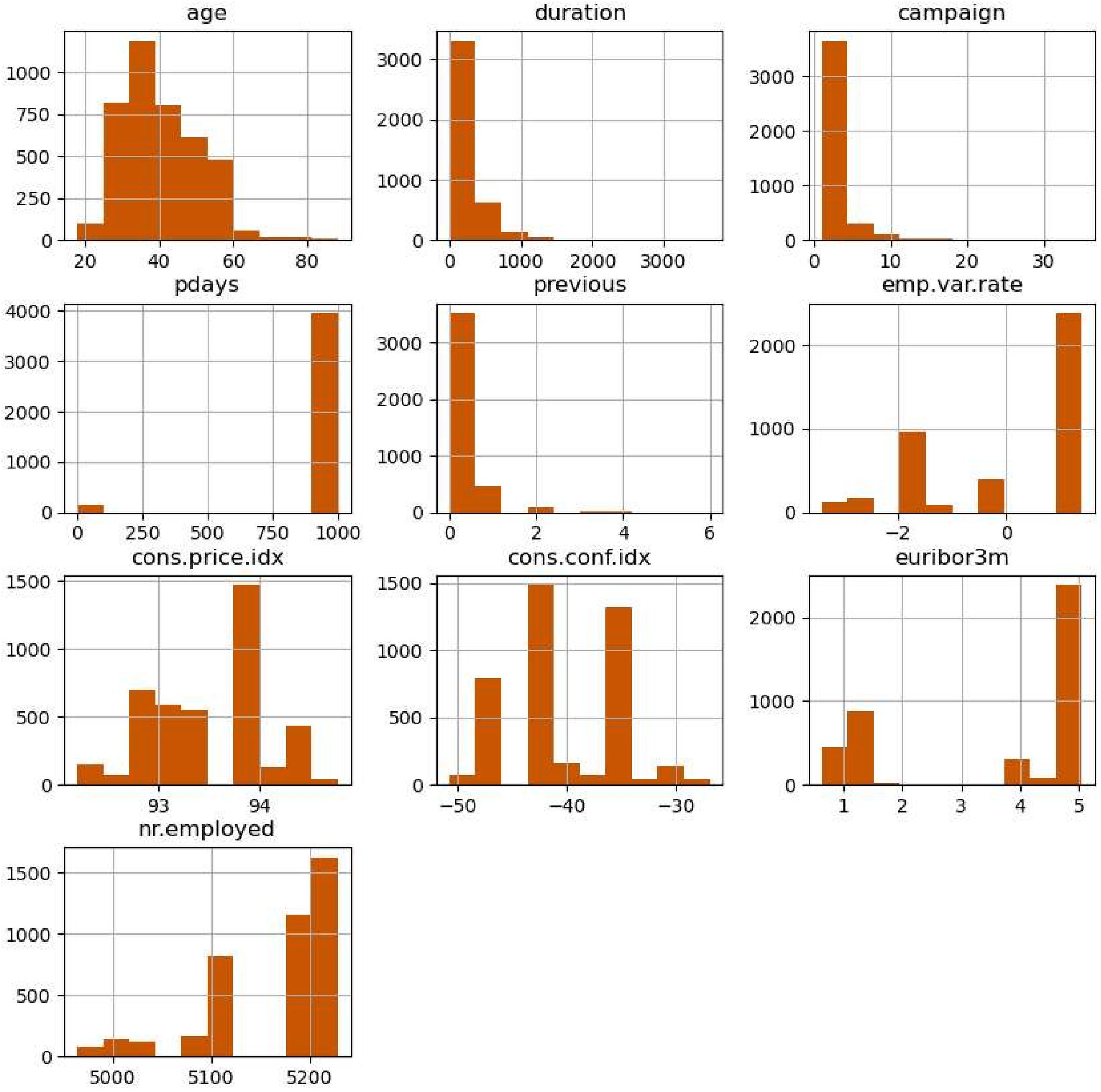
```
df.describe(include='object')
```

Out[44]:

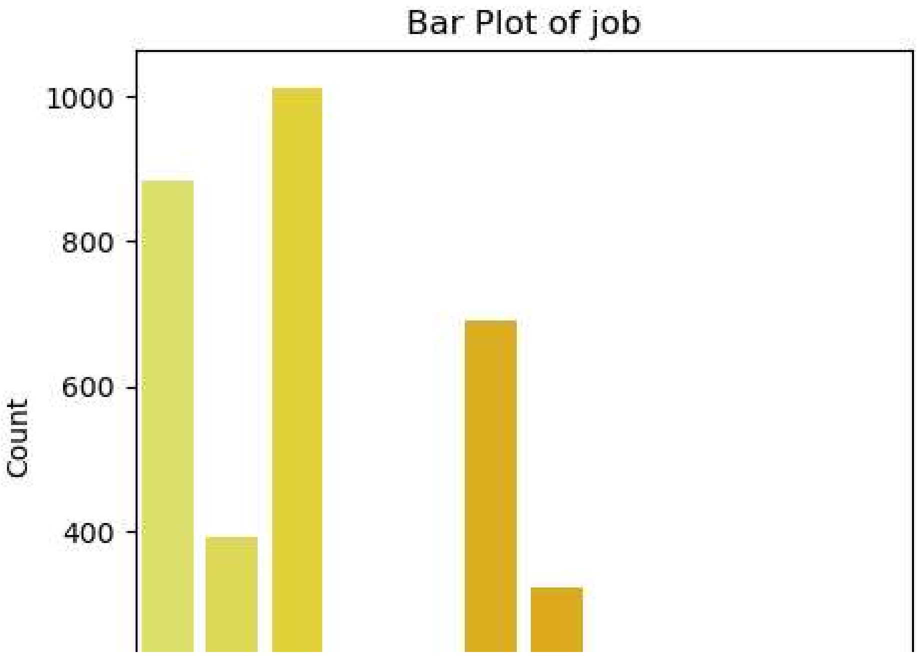
	job	marital	education	default	housing	loan	contact	month	day_of_week	
count	4119	4119	4119	4119	4119	4119	4119	4119	4119	
unique	12	4	8	3	3	3	2	10	5	
top	admin.	married	university.degree	no	yes	no	cellular	may	thu	r
freq	1012	2509	1264	3315	2175	3349	2652	1378	860	

In [45]:

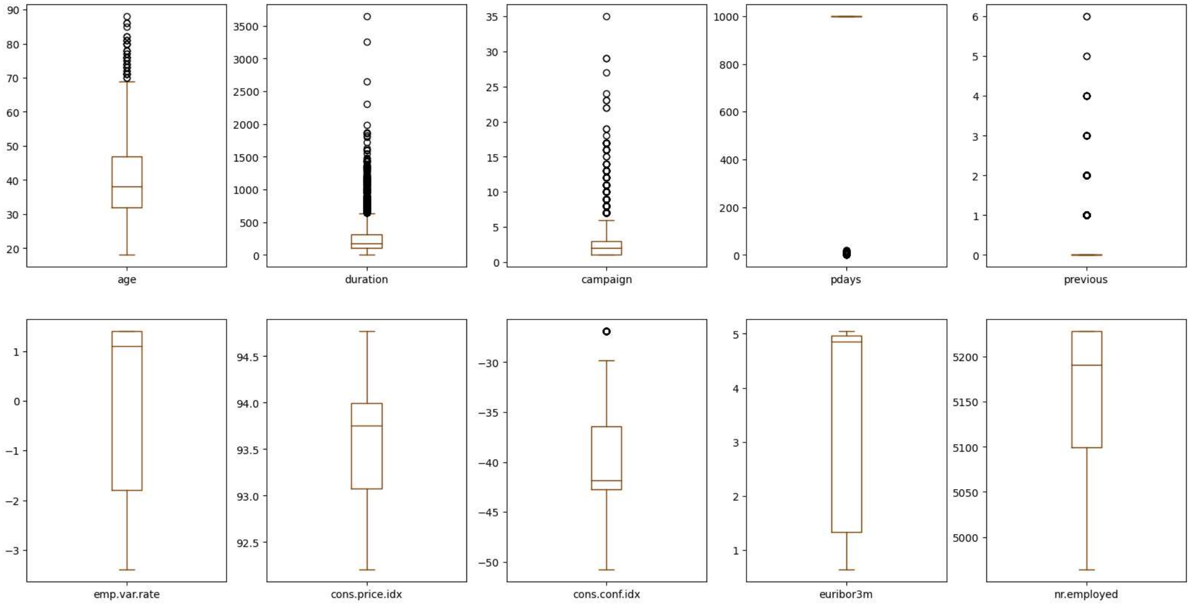
```
df.hist(figsize=(10,10),color='#cc5500')
plt.show()
```



In [46]:
```
for feature in cat_cols:
    plt.figure(figsize=(5,5))  # Adjust the figure size as needed
    sns.countplot(x=feature, data=df, palette='Wistia')
    plt.title(f'Bar Plot of {feature}')
    plt.xlabel(feature)
    plt.ylabel('Count')
    plt.xticks(rotation=90)
    plt.show()
```



In [47]:
```
df.plot(kind='box', subplots=True, layout=(2,5),figsize=(20,10),color='#7b3f00
plt.show()
```

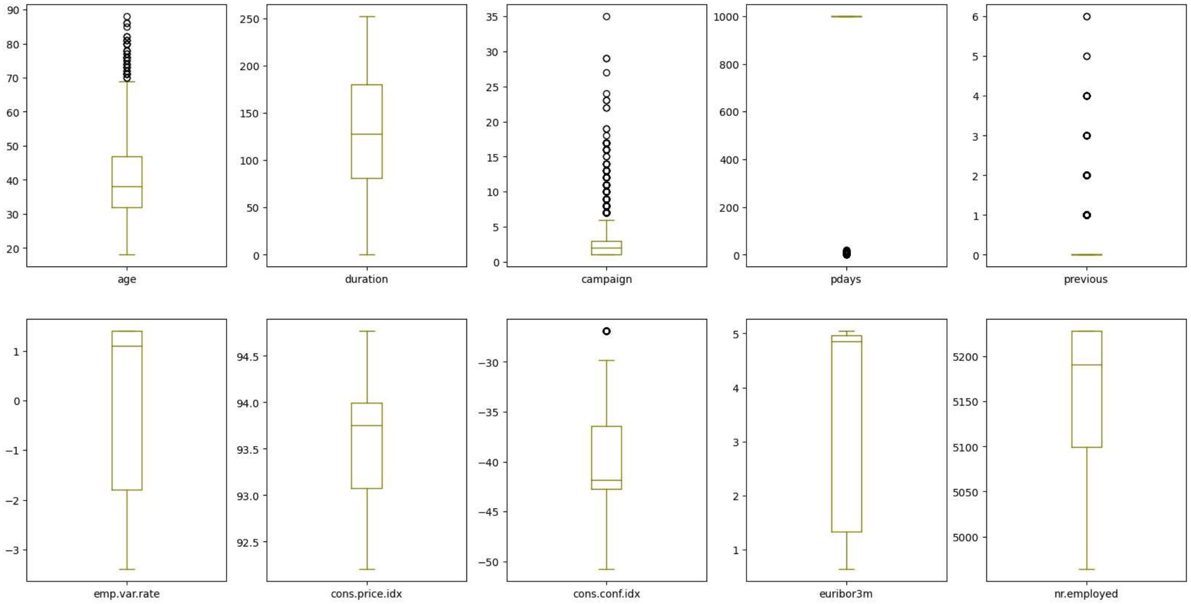


In [48]:

```
column = df[['age','campaign','duration']]
q1 = np.percentile(column, 25)
q3 = np.percentile(column, 75)
iqr = q3 - q1
lower_bound = q1 - 1.5 * iqr
upper_bound = q3 + 1.5 * iqr
df[['age','campaign','duration']] = column[(column > lower_bound) & (column <
```

In [49]:

```
df.plot(kind='box', subplots=True, layout=(2,5),figsize=(20,10),color='#808000
plt.show()
```



In [60]:

```
high_corr_cols = ['emp.var.rate','euribor3m','nr.employed']
```

In [61]:

```
df1 = df.copy()
df1.columns
```

Out[61]:

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'emp.var.rate', 'cons.price.idx',
       'cons.conf.idx', 'euribor3m', 'nr.employed', 'deposit'],
      dtype='object')
```

In [62]:

```
df1.drop(high_corr_cols,inplace=True,axis=1)  # axis=1 indicates columns
df1.columns
```

Out[62]:

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'cons.price.idx', 'cons.conf.idx', 'deposit'],
      dtype='object')
```

In [63]:

```
df1.shape
```

Out[63]:

```
(4119, 18)
```

In [64]:

```
from sklearn.preprocessing import LabelEncoder
lb = LabelEncoder()
df_encoded = df1.apply(lb.fit_transform)
df_encoded
```

Out[64]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	duratio
0	12	1	1	2	0	2	0	0	6	0	25
1	21	7	2	3	0	0	0	1	6	0	25
2	7	7	1	3	0	2	0	1	4	4	22
3	20	7	1	2	0	1	1	1	4	0	1
4	29	0	1	6	0	2	0	0	7	1	5
...	...	...	...	...	...	...	...	...	...	...	.
4114	12	0	1	1	0	2	2	0	3	2	5
4115	21	0	1	3	0	2	0	1	3	0	21
4116	9	8	2	3	0	0	0	0	6	1	6
4117	40	0	1	3	0	0	0	0	1	0	25
4118	16	4	2	3	0	2	0	0	7	4	17

4119 rows × 18 columns

In [65]:

```
df_encoded['deposit'].value_counts()
```

Out[65]:

```
deposit
0    3668
1     451
Name: count, dtype: int64
```

In [66]:

```
x = df_encoded.drop('deposit',axis=1)  # independent variable
y = df_encoded['deposit']              # dependent variable
print(x.shape)
print(y.shape)
print(type(x))
print(type(y))
```

```
(4119, 17)
(4119,)
<class 'pandas.core.frame.DataFrame'>
<class 'pandas.core.series.Series'>
```

In [67]:

```
from sklearn.model_selection import train_test_split

print(4119*0.25)
```

```
1029.75
```

In [68]:

```
x_train,x_test,y_train,y_test = train_test_split(x,y,test_size=0.25,random_stat
print(x_train.shape)
print(x_test.shape)
print(y_train.shape)
print(y_test.shape)
```

```
(3089, 17)
(1030, 17)
(3089,)
(1030,)
```

In [69]:

```
from sklearn.metrics import confusion_matrix,classification_report,accuracy_sc

def eval_model(y_test,y_pred):
    acc = accuracy_score(y_test,y_pred)
    print('Accuracy_Score',acc)
    cm = confusion_matrix(y_test,y_pred)
    print('Confusion Matrix\n',cm)
    print('Classification Report\n',classification_report(y_test,y_pred))

def mscore(model):
    train_score = model.score(x_train,y_train)
    test_score = model.score(x_test,y_test)
    print('Training Score',train_score)
    print('Testing Score',test_score)
```

In [70]:

```
from sklearn.tree import DecisionTreeClassifier

dt = DecisionTreeClassifier(criterion='gini',max_depth=5,min_samples_split=10)
dt.fit(x_train,y_train)
```

Out[70]:

```
DecisionTreeClassifier(max_depth=5, min_samples_split=10)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [71]:

```
mscore(dt)
```

```
Training Score 0.9148591777274199
Testing Score 0.8990291262135922
```

In [72]:

```
ypred_dt = dt.predict(x_test)
print(ypred_dt)
```

```
[0 0 1 ... 0 0 0]
```

In [73]:

```
eval_model(y_test,ypred_dt)
```

```
Accuracy_Score 0.8990291262135922
Confusion Matrix
 [[905  25]
 [ 79  21]]
Classification Report
               precision    recall  f1-score   support

           0       0.92      0.97      0.95       930
           1       0.46      0.21      0.29       100

    accuracy                           0.90      1030
   macro avg       0.69      0.59      0.62      1030
weighted avg       0.87      0.90      0.88      1030
```

In [74]:

```
from sklearn.tree import plot_tree
```

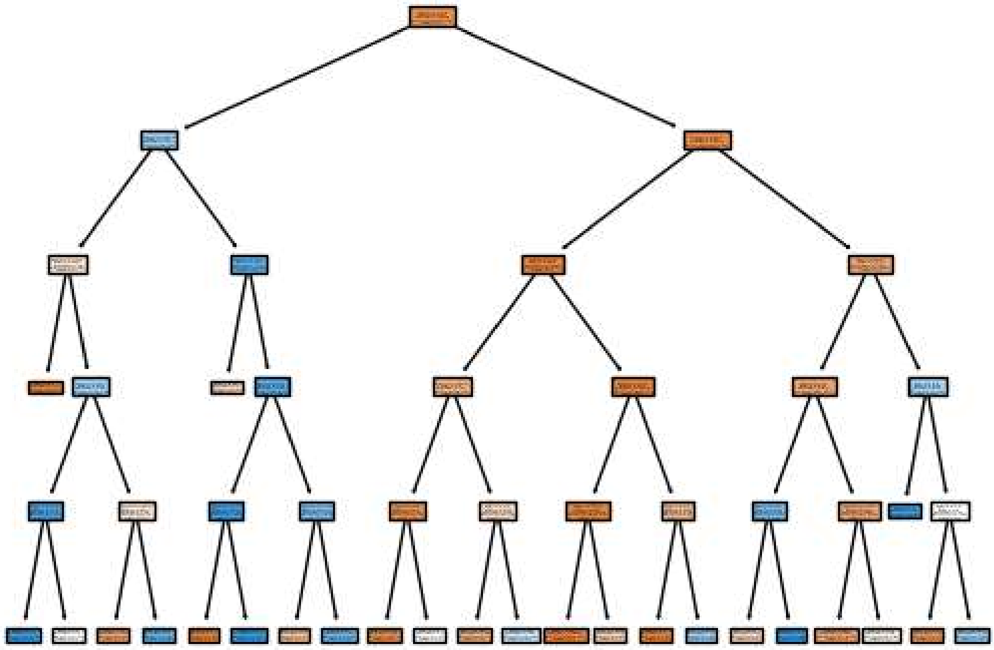
In [75]:

```
cn = ['no','yes']
fn = x_train.columns
print(fn)
print(cn)
```

```
Index(['age', 'job', 'marital', 'education', 'default', 'housing', 'loan',
       'contact', 'month', 'day_of_week', 'duration', 'campaign', 'pdays',
       'previous', 'poutcome', 'cons.price.idx', 'cons.conf.idx'],
      dtype='object')
['no', 'yes']
```

In [76]:

```
plot_tree(dt,class_names=cn,filled=True)
plt.show()
```



In [77]:

```
dt1 = DecisionTreeClassifier(criterion='entropy',max_depth=4,min_samples_split
dt1.fit(x_train,y_train)
```

Out[77]:

```
DecisionTreeClassifier(criterion='entropy', max_depth=4, min_samples_split=1
5)
```

In a Jupyter environment, please rerun this cell to show the HTML representation or trust the notebook.
On GitHub, the HTML representation is unable to render, please try loading this page with nbviewer.org.

In [78]:

```
mscore(dt1)
```

```
Training Score 0.9080608611201036
Testing Score 0.9048543689320389
```

In [79]:

```
ypred_dt1 = dt1.predict(x_test)
```

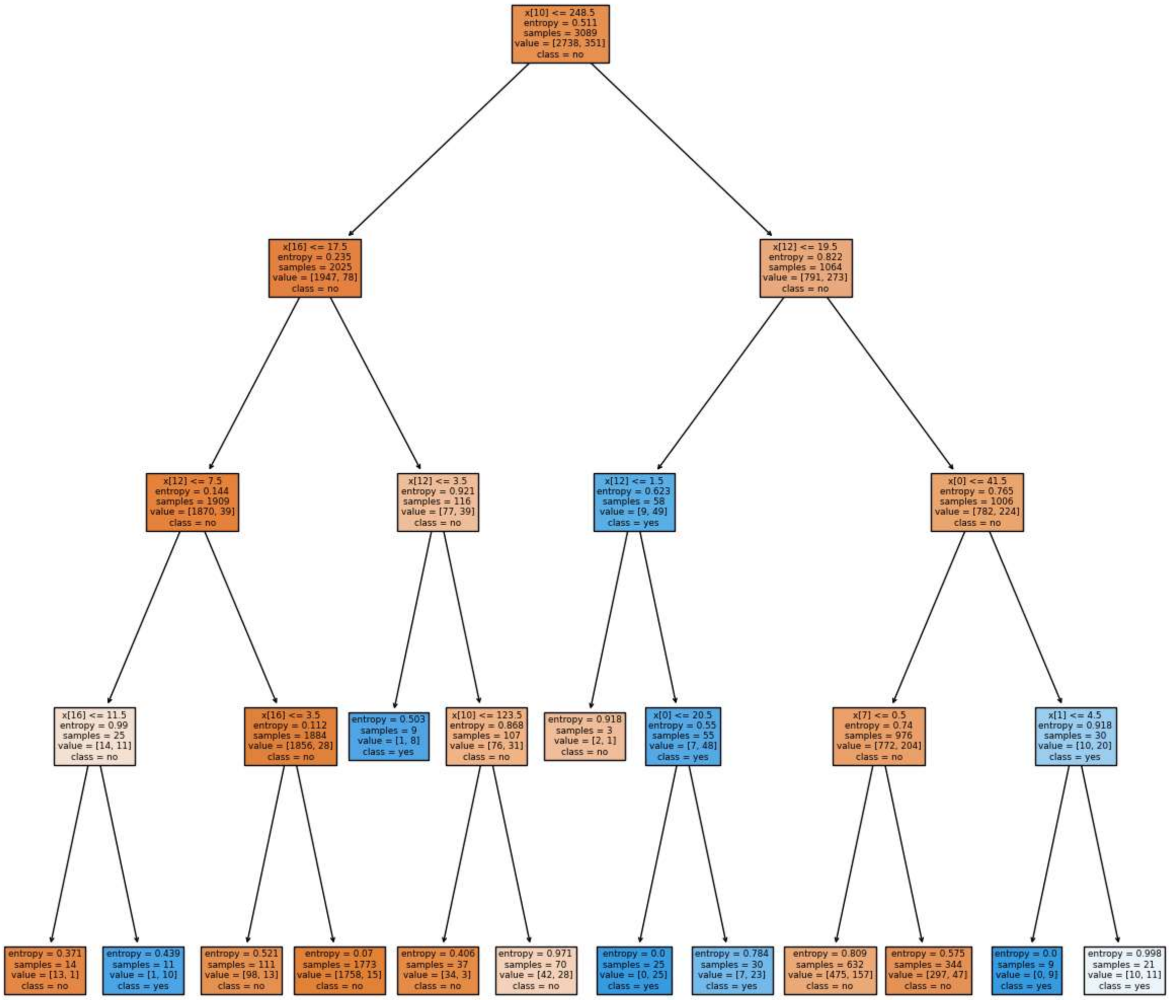
In [80]:
```
eval_model(y_test,ypred_dt1)
```

```
Accuracy_Score 0.9048543689320389
Confusion Matrix
 [[915  15]
 [ 83  17]]
Classification Report
               precision    recall  f1-score   support

           0       0.92      0.98      0.95       930
           1       0.53      0.17      0.26       100

    accuracy                           0.90      1030
   macro avg       0.72      0.58      0.60      1030
weighted avg       0.88      0.90      0.88      1030
```

In [81]:
```
plt.figure(figsize=(15,15))
plot_tree(dt1,class_names=cn,filled=True)
plt.show()
```



In [ ]: