In [118]:

```
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
from matplotlib import colors
from scipy.stats import norm
from sklearn.cluster import KMeans
from sklearn.preprocessing import LabelEncoder
from sklearn.preprocessing import StandardScaler
import datetime
import matplotlib.cm as cm
from sklearn.decomposition import PCA
import matplotlib as mpl
import missingno as missingno
from imblearn.over_sampling import SMOTE
from sklearn.ensemble import RandomForestClassifier
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.metrics import confusion_matrix, accuracy_score, recall_score,precision_score,f1_score
from sklearn.model_selection import cross_val_score
from sklearn.pipeline import Pipeline
from sklearn.model_selection import KFold
```

In [119]:

```
bankData= pd.read_csv('bank-additional-full.csv')
bankData.head(10)
```

Out[119]:

	age	job	marital	education	default	housing	loan	contact	month	day_of_week	...	campaign	pdays	previous	poutcome	emp.va
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	45	services	married	basic.9y	unknown	no	no	telephone	may	mon	...	1	999	0	nonexistent	
6	59	admin.	married	professional.course	no	no	no	telephone	may	mon	...	1	999	0	nonexistent	
7	41	blue-collar	married	unknown	unknown	no	no	telephone	may	mon	...	1	999	0	nonexistent	
8	24	technician	single	professional.course	no	yes	no	telephone	may	mon	...	1	999	0	nonexistent	
9	25	services	single	high.school	no	yes	no	telephone	may	mon	...	1	999	0	nonexistent	

10 rows × 21 columns

Checking Null values in the feature

In [120]:

```
bankData.isnull().sum()
```

Out[120]:

```
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
y                 0
dtype: int64
```

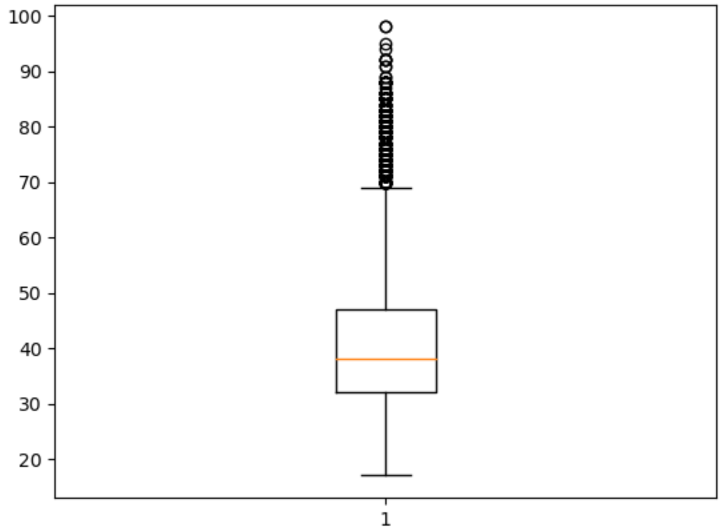
Plotting outliers of Age

In [121]:

```
plt.boxplot(bankData['age'])
```

Out[121]:

```
{'whiskers': [<matplotlib.lines.Line2D at 0x7fba31dd4340>,
  <matplotlib.lines.Line2D at 0x7fba31dd4610>],
 'caps': [<matplotlib.lines.Line2D at 0x7fba31dd48e0>,
  <matplotlib.lines.Line2D at 0x7fba31dd4bb0>],
 'boxes': [<matplotlib.lines.Line2D at 0x7fba31dd4070>],
 'medians': [<matplotlib.lines.Line2D at 0x7fba31dd4e80>],
 'fliers': [<matplotlib.lines.Line2D at 0x7fba31c13190>],
 'means': []}
```



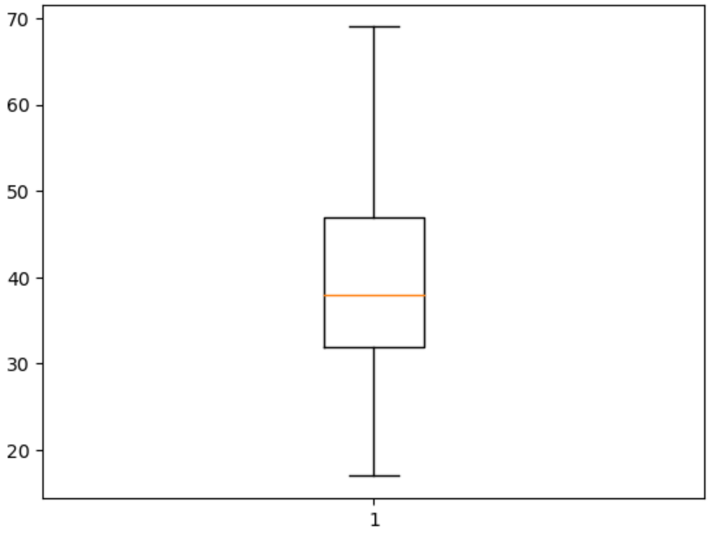
Removing Outliers of Age through quartile ranges

In [122]:

```
Q1Age= bankData['age'].quantile(0.25)

Q3Age= bankData['age'].quantile(0.75)
IQRAge= Q3Age-Q1Age
upperLimitAge=Q3Age+1.5*IQRAge
lowerLimitAge=Q1Age-1.5*IQRAge

filteredByAgeLimit = bankData['age'][bankData["age"] < upperLimitAge]
bankData['age']= filteredByAgeLimit
bankData=bankData.dropna()
bankData['age']=bankData['age'].astype(int)
```

In [123]:

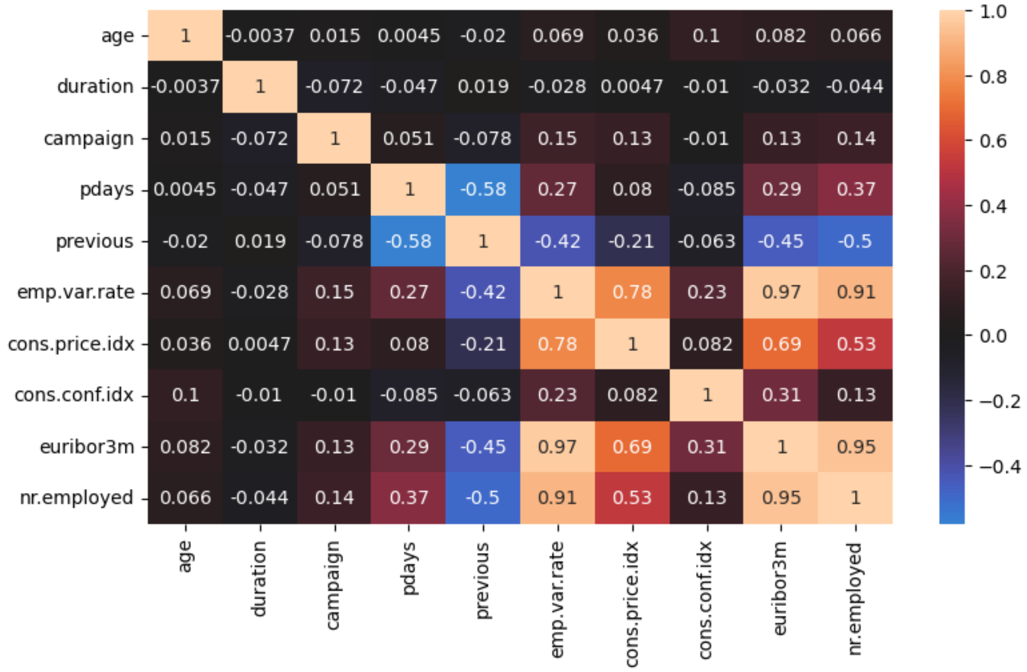
```
plt.boxplot(bankData['age'])
plt.show()
```



In [124]:

```
print(bankData.columns)
corrBankData= bankData.corr()
print(corrBankData)

plt.figure(figsize=(9,5))
sns.heatmap(corrBankData,annot=True, center=0)
plt.show()
```

```
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', 'y'],
      dtype='object')
                    age  duration  campaign     pdays  previous  \
age            1.000000 -0.003701  0.015121  0.004488 -0.020445
duration      -0.003701  1.000000 -0.071676 -0.047103  0.018825
campaign       0.015121 -0.071676  1.000000  0.051243 -0.078482
pdays          0.004488 -0.047103  0.051243  1.000000 -0.581228
previous      -0.020445  0.018825 -0.078482 -0.581228  1.000000
emp.var.rate   0.069054 -0.027587  0.148859  0.268187 -0.422639
cons.price.idx 0.035766  0.004684  0.126763  0.079729 -0.210886
cons.conf.idx  0.104528 -0.009966 -0.010400 -0.084935 -0.062803
euribor3m      0.081997 -0.032175  0.133190  0.293087 -0.454645
nr.employed    0.065929 -0.043622  0.142785  0.369401 -0.500594

               emp.var.rate  cons.price.idx  cons.conf.idx  euribor3m  \
age                0.069054        0.035766       0.104528   0.081997
duration          -0.027587        0.004684      -0.009966  -0.032175
campaign           0.148859        0.126763      -0.010400   0.133190
pdays              0.268187        0.079729      -0.084935   0.293087
previous          -0.422639       -0.210886      -0.062803  -0.454645
emp.var.rate       1.000000        0.777061       0.226648   0.972735
cons.price.idx     0.777061        1.000000       0.082435   0.693263
cons.conf.idx      0.226648        0.082435       1.000000   0.305651
euribor3m          0.972735        0.693263       0.305651   1.000000
nr.employed        0.908286        0.529384       0.127332   0.945180

               nr.employed
age               0.065929
duration         -0.043622
campaign          0.142785
pdays             0.369401
previous         -0.500594
emp.var.rate      0.908286
cons.price.idx    0.529384
cons.conf.idx     0.127332
euribor3m         0.945180
nr.employed       1.000000
```



In [125]:

```
ageGroup=[]

for age in bankData['age']:
    if age<25:
        ageGroup.append('Young')
    if age>=25 or age <60:
        ageGroup.append('Adult')
    if age>=60:
        ageGroup.append('Elderly')

dfAgeGroup= pd.DataFrame(ageGroup)
print(min(bankData['age']))
bankData['AgeGroup']= dfAgeGroup
bankData['AgeGroup'].unique()
print(bankData['AgeGroup'].value_counts())
bankData= bankData.drop('age',axis=1)
```

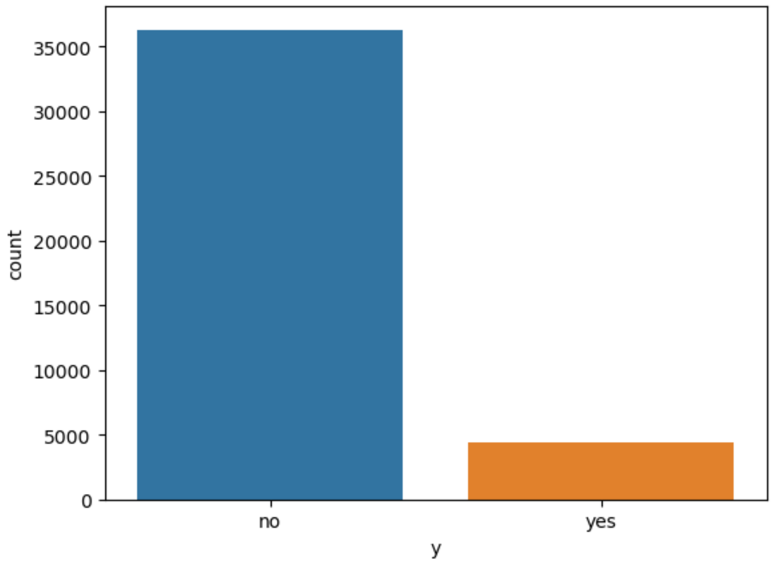
```
17
Adult      39189
Young        947
Elderly      583
Name: AgeGroup, dtype: int64
```

In [126]:

```
sns.countplot(x=bankData['y'])
```

Out[126]:

```
<AxesSubplot:xlabel='y', ylabel='count'>
```



In [138]:

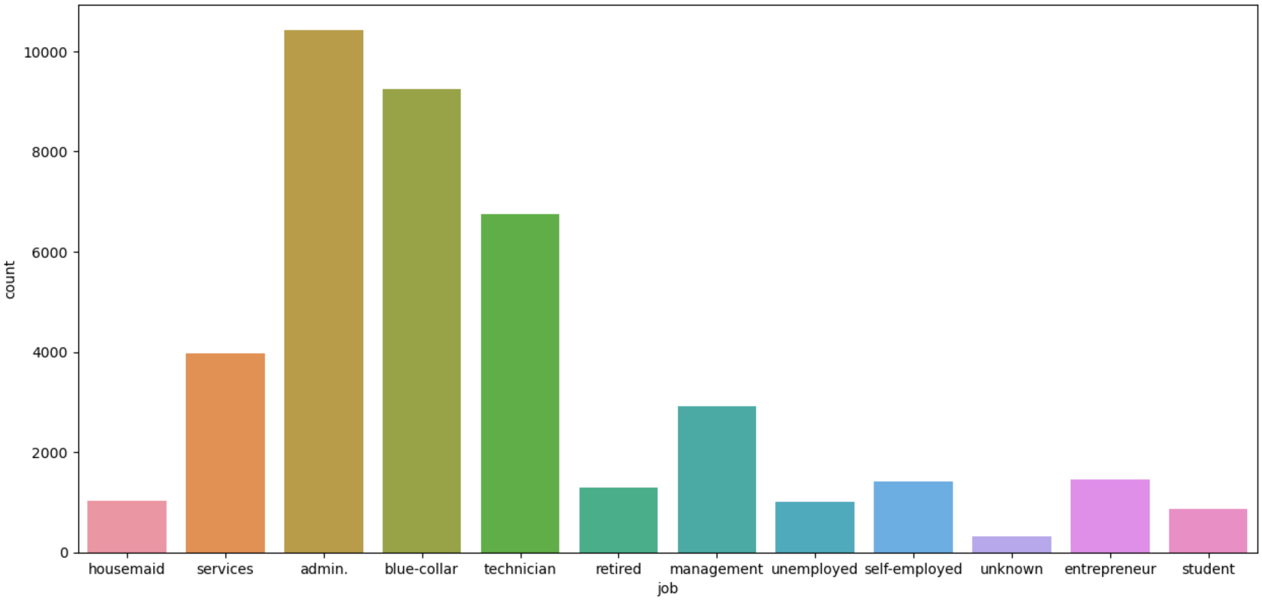
```
bankData.y.value_counts()
```

Out[138]:

```
no     36300
yes     4419
Name: y, dtype: int64
```

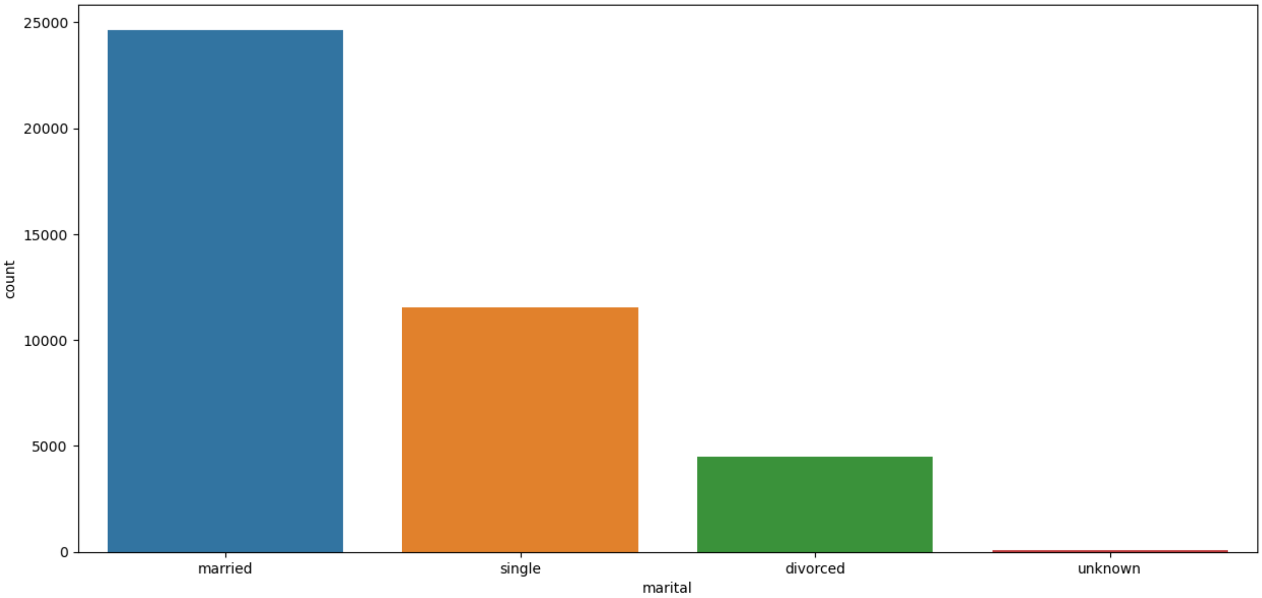
In [127]:

```
plt.figure(figsize=(15,7))
sns.countplot(x=bankData['job'])
plt.show()
```



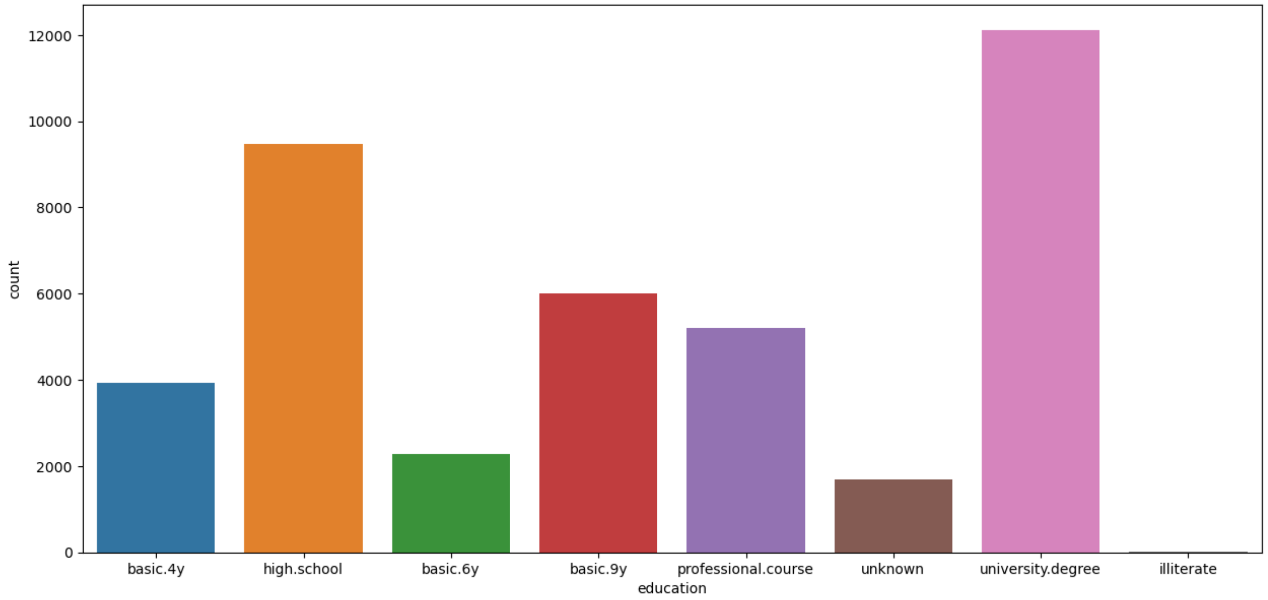
In [128]:

```
plt.figure(figsize=(15,7))
sns.countplot(x=bankData['marital'])
plt.show()
```



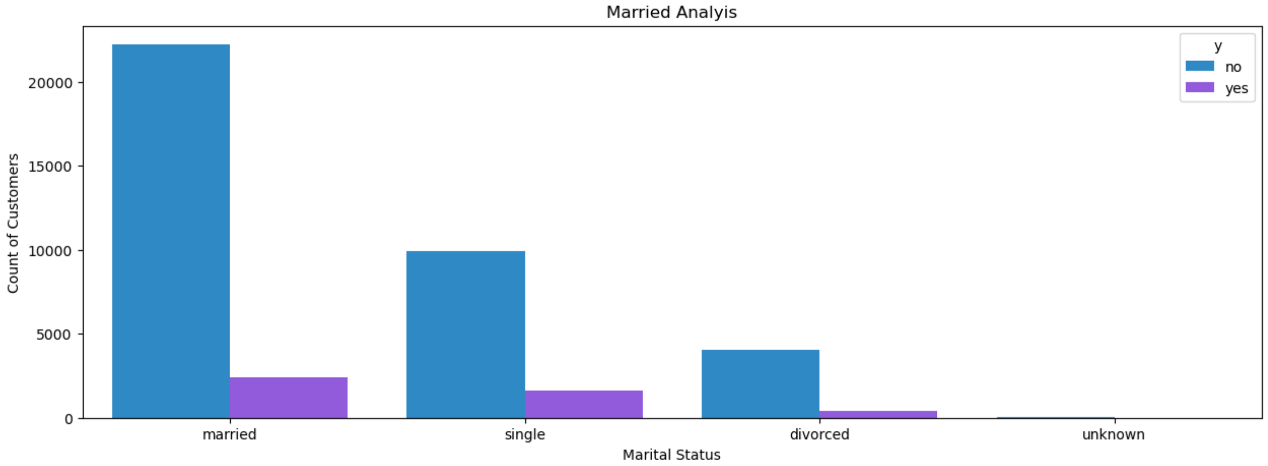
In [129]:

```
plt.figure(figsize=(15,7))
sns.countplot(x=bankData['education'])
plt.show()
```



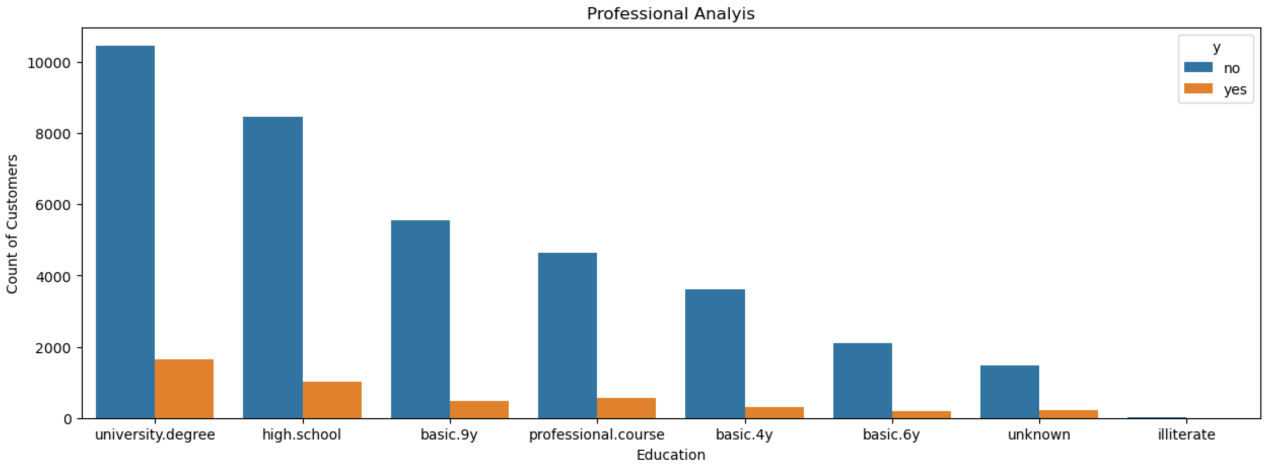
In [144]:

```
plt.figure(figsize=(15,5))
plotMaried = sns.countplot(x=bankData["marital"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order=
plotMaried.set_title("Married Analyis")
plotMaried.set_xlabel("Marital Status")
plotMaried.set_ylabel("Count of Customers")


plt.show()
```



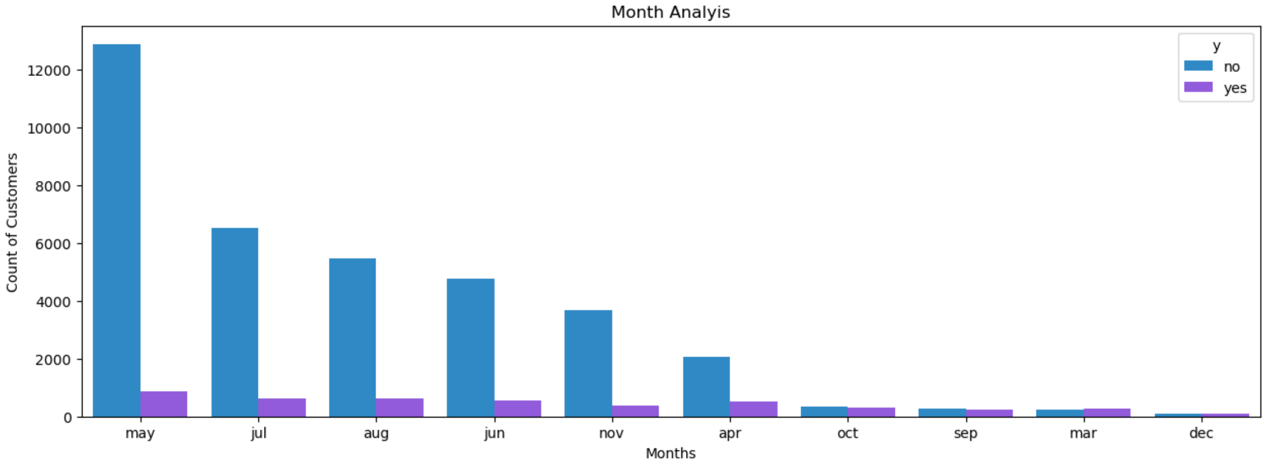
In [145]:

```
plt.figure(figsize=(15,5))
plotProf = sns.countplot(x=bankData["education"],hue=bankData["y"], order= bankData['education'].value_counts().index)
plotProf.set_title("Professional Analyis")
plotProf.set_xlabel("Education")
plotProf.set_ylabel("Count of Customers")


plt.show()
```



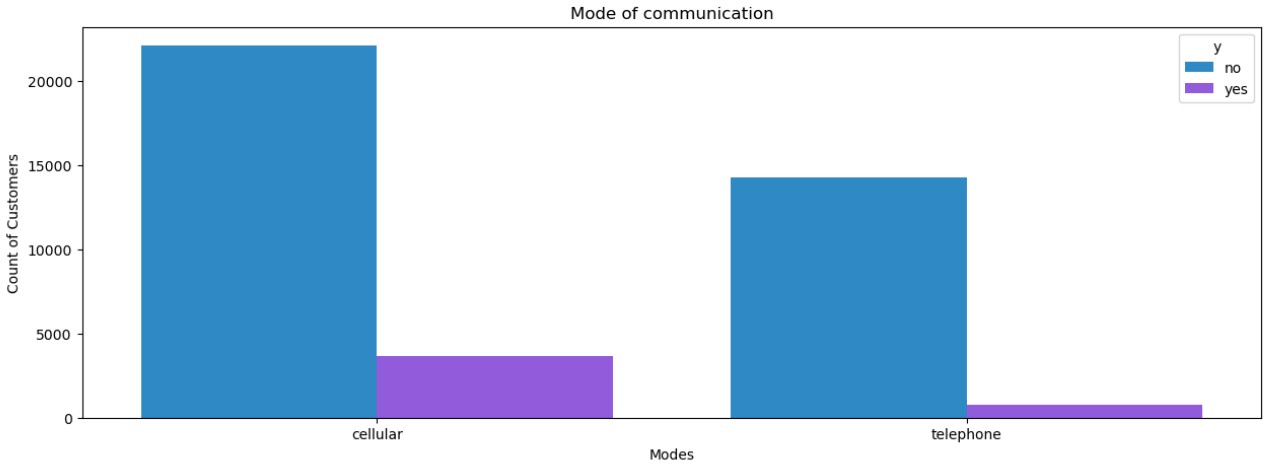
In [147]:

```
plt.figure(figsize=(15,5))
plotmon = sns.countplot(x=bankData["month"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order= bankI
plotmon.set_title("Month Analysis")
plotmon.set_xlabel("Months")
plotmon.set_ylabel("Count of Customers")
plt.show()
```



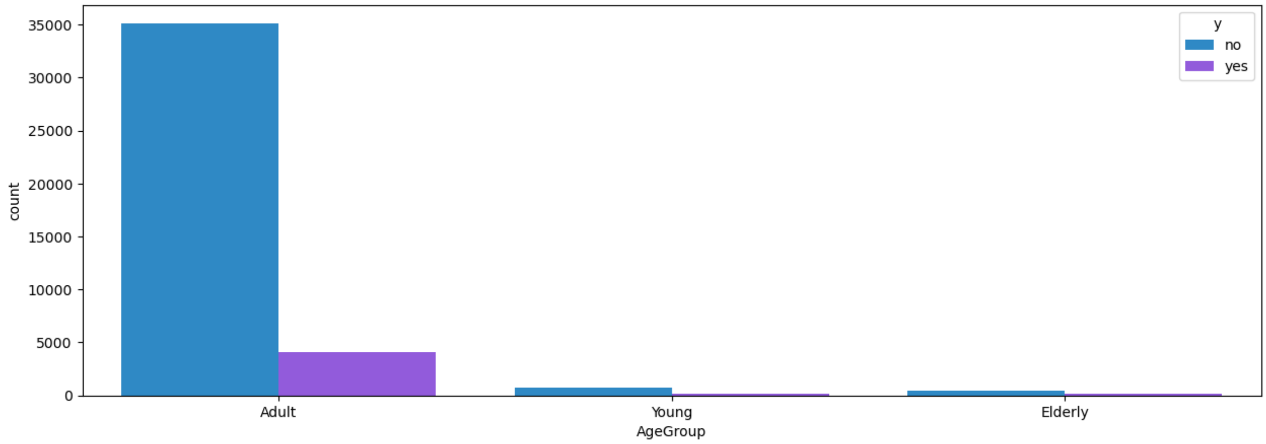
In [149]:

```
plt.figure(figsize=(15,5))
plotCell = sns.countplot(x=bankData["contact"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order= ba
plotCell.set_title("Mode of communication")
plotCell.set_xlabel("Modes")
plotCell.set_ylabel("Count of Customers")


plt.show()
```



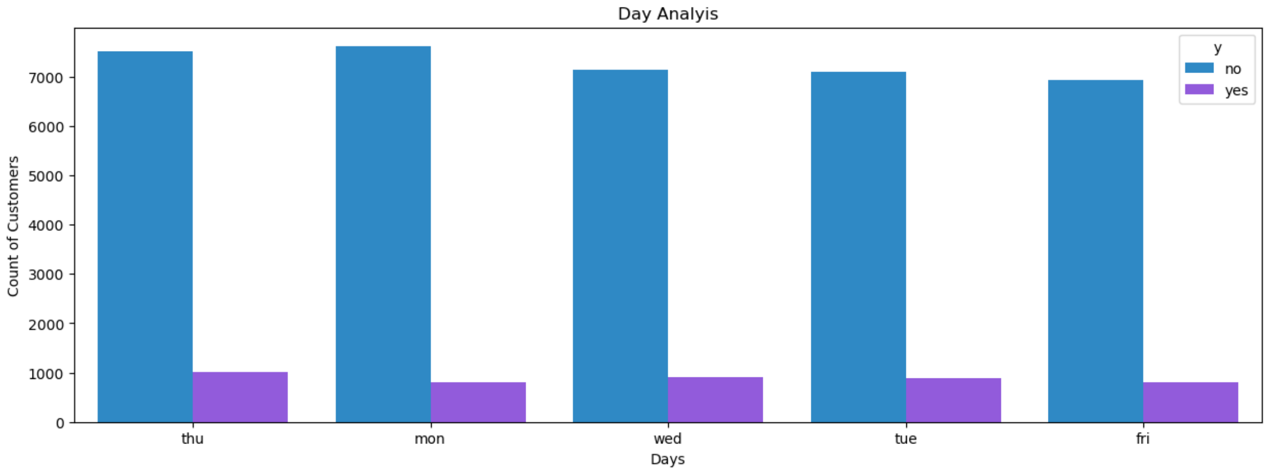
In [140]:

```
plt.figure(figsize=(15,5))
plotChurned = sns.countplot(x=bankData["AgeGroup"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order
```



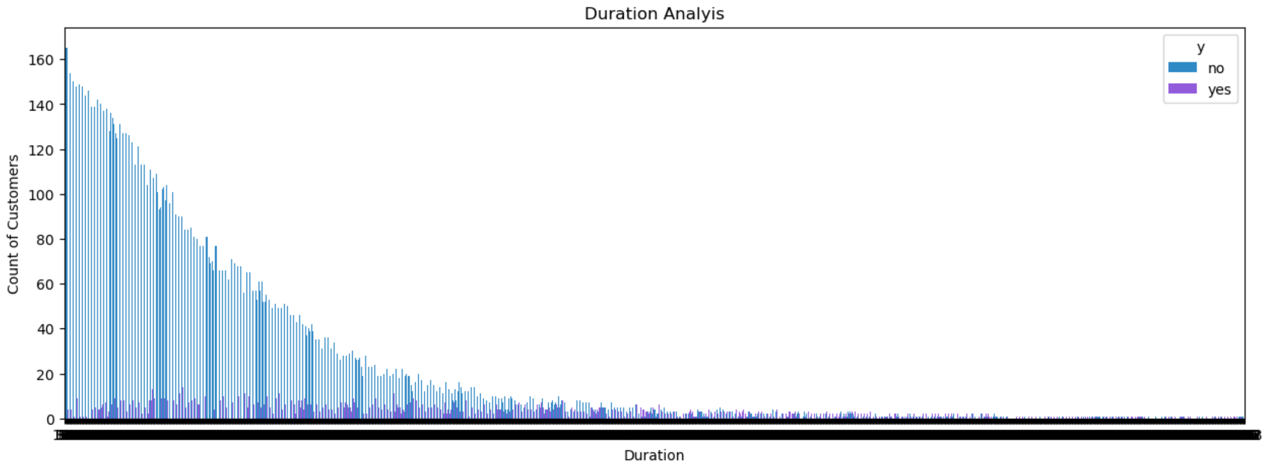
In [151]:

```
plt.figure(figsize=(15,5))
plotday = sns.countplot(x=bankData["day_of_week"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order=
plotday.set_title("Day Analyis")
plotday.set_xlabel("Days")
plotday.set_ylabel("Count of Customers")


plt.show()
```



In [152]:

```
plt.figure(figsize=(15,5))
plotdur = sns.countplot(x=bankData["duration"],hue=bankData["y"], palette= ['#168ede','#8f46f0','#d989aa','#d5ed87'], order= ba
plotdur.set_title("Duration Analyis")
plotdur.set_xlabel("Duration")
plotdur.set_ylabel("Count of Customers")


plt.show()
```



In [98]:

```
bankData['contact'].value_counts()
```

Out[98]:

```
cellular     25724
telephone    14995
Name: contact, dtype: int64
```

In [99]:

```
bankData['y'].value_counts()
```

Out[99]:

```
no     36300
yes     4419
Name: y, dtype: int64
```

In [ ]:

```

```

Encoding through Label Encoder and one hot encoding using get_dummies

In [100]:

```
labelEncoderBankData = LabelEncoder()
# bankData['job']      = labelEncoderBankData.fit_transform(bankData['job'])
# bankData['marital']  = labelEncoderBankData.fit_transform(bankData['marital'])
# bankData['education']= labelEncoderBankData.fit_transform(bankData['education'])


# bankData.head(10)


bankData['loan']=bankData['loan'].replace({'unknown':'unknown_loan'})

bankData['education']=bankData['education'].replace({'unknown':'unknown_education'})
bankData['marital']=bankData['marital'].replace({'unknown':'unknown_marital'})
bankData['job']=bankData['job'].replace({'unknown':'unknown_job'})


jobCol = pd.get_dummies(bankData['job'], drop_first=False)
bankData= bankData.join(jobCol)
bankData= bankData.drop('job', axis=1)


maritalCol = pd.get_dummies(bankData['marital'], drop_first=False)
bankData= bankData.join(maritalCol)
bankData= bankData.drop('marital', axis=1)

educationCol = pd.get_dummies(bankData['education'], drop_first=False)
bankData= bankData.join(educationCol)
bankData= bankData.drop('education', axis=1)


contactCol = pd.get_dummies(bankData['contact'], drop_first=False)
bankData= bankData.join(contactCol)
bankData= bankData.drop('contact', axis=1)

ageGroupCol = pd.get_dummies(bankData['AgeGroup'], drop_first=False)
bankData= bankData.join(ageGroupCol)
bankData= bankData.drop('AgeGroup', axis=1)
bankData['default']  = labelEncoderBankData.fit_transform(bankData['default'])
bankData['housing']  = labelEncoderBankData.fit_transform(bankData['housing'])
bankData['loan']     = labelEncoderBankData.fit_transform(bankData['loan'])
```

In [101]:

```
bankData.columns
```

Out[101]:

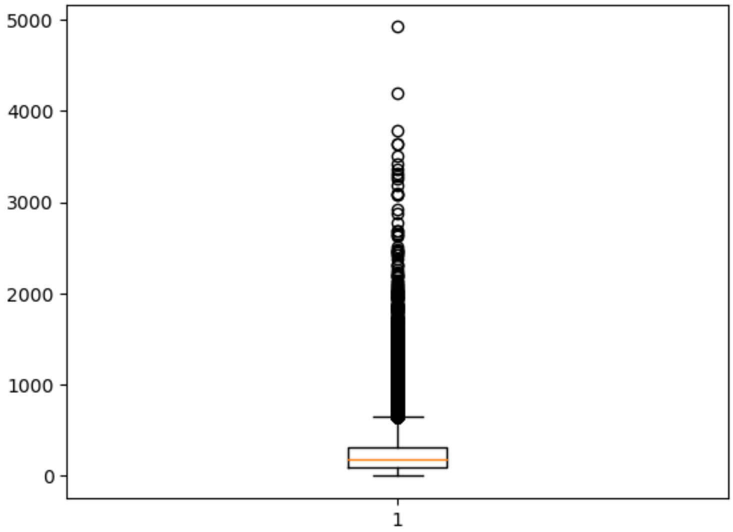
```
Index(['default', 'housing', 'loan', 'month', 'day_of_week', 'duration',
       'campaign', 'pdays', 'previous', 'poutcome', 'emp.var.rate',
       'cons.price.idx', 'cons.conf.idx', 'euribor3m', 'nr.employed', 'y',
       'admin.', 'blue-collar', 'entrepreneur', 'housemaid', 'management',
       'retired', 'self-employed', 'services', 'student', 'technician',
       'unemployed', 'unknown_job', 'divorced', 'married', 'single',
       'unknown_marital', 'basic.4y', 'basic.6y', 'basic.9y', 'high.school',
       'illiterate', 'professional.course', 'university.degree',
       'unknown_education', 'cellular', 'telephone', 'Adult', 'Elderly',
       'Young'],
      dtype='object')
```

In [102]:

```
plt.boxplot(bankData['duration'])
```

Out[102]:

```
{'whiskers': [<matplotlib.lines.Line2D at 0x7fba33a96310>,
  <matplotlib.lines.Line2D at 0x7fba34c7d850>],
 'caps': [<matplotlib.lines.Line2D at 0x7fba32a04cd0>,
  <matplotlib.lines.Line2D at 0x7fba32a045b0>],
 'boxes': [<matplotlib.lines.Line2D at 0x7fba784b6e80>],
 'medians': [<matplotlib.lines.Line2D at 0x7fba32a043d0>],
 'fliers': [<matplotlib.lines.Line2D at 0x7fba32a04fa0>],
 'means': []}
```



Duration of call should be greater than 0

In [103]:

```
durationZero=bankData['duration'][bankData['duration']>0]
bankData['duration']= durationZero
```

In [104]:

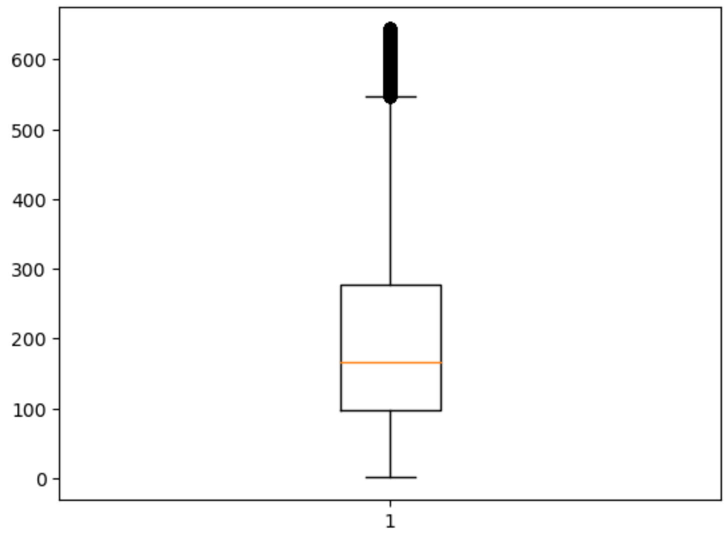
```
Q1Duration= bankData['duration'].quantile(0.25)

Q3Duration= bankData['duration'].quantile(0.75)
IQRDuration= Q3Duration-Q1Duration
upperLimitDuration=Q3Duration+1.5*IQRDuration
lowerLimitDuration=Q1Duration-1.5*IQRDuration


filteredByDurationLimit = bankData['duration'][bankData["duration"] < upperLimitDuration]
bankData['duration']= filteredByDurationLimit
bankData=bankData.dropna()
bankData['duration']=bankData['duration'].astype(int)
```

In [105]:

```
plt.boxplot(bankData['duration'])
```

Out[105]:

```
{'whiskers': [<matplotlib.lines.Line2D at 0x7fba3222b940>,
  <matplotlib.lines.Line2D at 0x7fba3222b520>],
 'caps': [<matplotlib.lines.Line2D at 0x7fba3aa30580>,
  <matplotlib.lines.Line2D at 0x7fba3aa30f40>],
 'boxes': [<matplotlib.lines.Line2D at 0x7fba3222b730>],
 'medians': [<matplotlib.lines.Line2D at 0x7fba3aa30af0>],
 'fliers': [<matplotlib.lines.Line2D at 0x7fba3aa30b50>],
 'means': []}
```



In [107]:

```
monthCol = pd.get_dummies(bankData['month'], drop_first=False)
bankData= bankData.join(monthCol)
bankData= bankData.drop('month', axis=1)

dayCol = pd.get_dummies(bankData['day_of_week'], drop_first=False)
bankData= bankData.join(dayCol)
bankData= bankData.drop('day_of_week', axis=1)

bankData['poutcome']= labelEncoderBankData.fit_transform(bankData['poutcome'])
bankData['y']= labelEncoderBankData.fit_transform(bankData['y'])
bankData.head(10)
```

Out[107]:

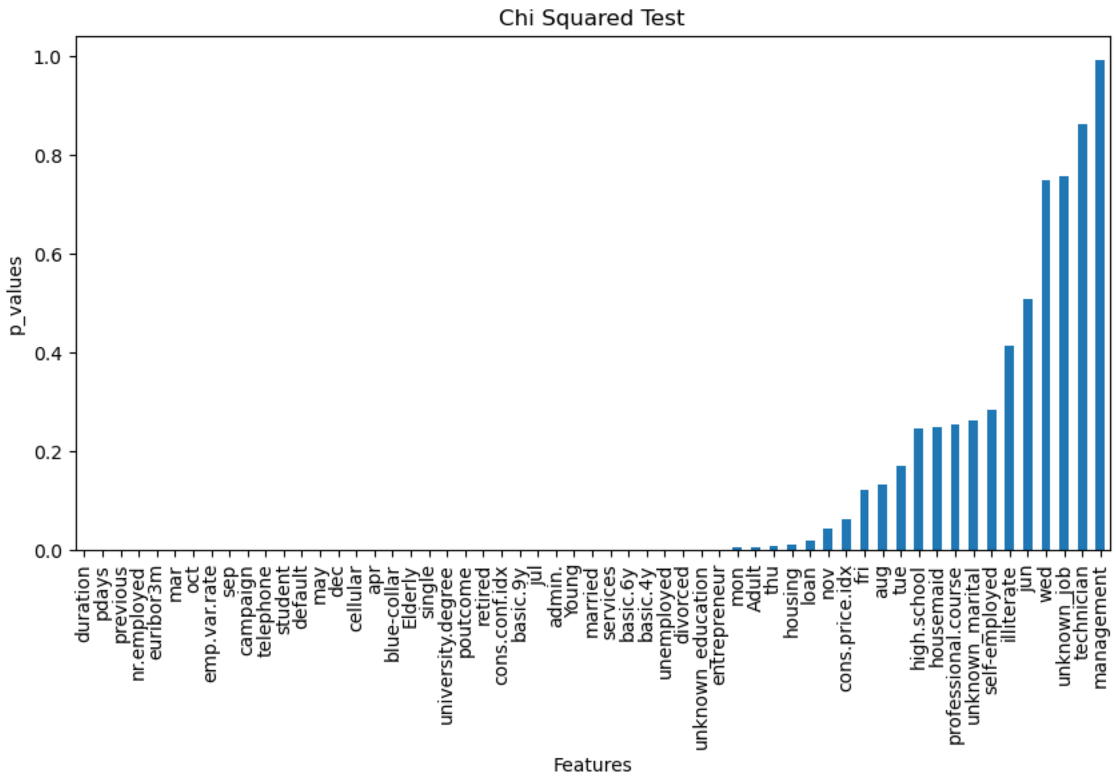
	default	housing	loan	duration	campaign	pdays	previous	poutcome	emp.var.rate	cons.price.idx	...	mar	may	nov	oct	sep	fri	mon	thu	tue
0	0	0	0	261	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
1	1	0	0	149	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
2	0	2	0	226	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
3	0	0	0	151	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
4	0	0	2	307	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
5	1	0	0	198	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
6	0	0	0	139	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
7	1	0	0	217	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
8	0	2	0	380	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0
9	0	2	0	50	1	999	0	1	1.1	93.994	...	0	1	0	0	0	0	1	0	0

10 rows × 58 columns

In [110]:

```
from sklearn.feature_selection import SelectKBest
from sklearn.feature_selection import chi2
y= bankData['y']
X= bankData.drop('y',axis=1)

print(y.value_counts())

from imblearn.under_sampling import RandomUnderSampler

rus = RandomUnderSampler(random_state=42, replacement=True)# fit predictor and target variable
X_Rus, y_Rus = rus.fit_resample(X, y)

print(y_Rus.value_counts())
X_train, X_test, y_train, y_test = train_test_split(X_Rus, y_Rus, test_size = 0.30, random_state = 101)


  #Target variable
f_score=chi2(abs(X),y)   #returns f score and p value

p_value=pd.Series(f_score[1],index=X.columns)
p_value.sort_values(ascending=True,inplace=True)
discardList=[]

for key,val in p_value.iteritems():
    if val >= 0.05:
        discardList.append(key)
plt.figure(figsize=(10,5))
p_value.plot(kind="bar")
plt.xlabel("Features")
plt.ylabel("p_values")
plt.title("Chi Squared Test")
plt.show()
```

```
0    34867
1     2913
Name: y, dtype: int64
0    2913
1    2913
Name: y, dtype: int64
```



In [59]:

```
bankData=bankData.drop(['cons.price.idx', 'fri', 'aug', 'tue', 'high.school', 'housemaid', 'professional.course', 'unknown_mar:
```

Saving CSV for Training Models

In [60]:

```
bankData.to_csv(r'Documents\OneDrive\Documents\City University of London\Term1\Machine Learning\CousrseWorkML\BankMarketingFor
```

In [ ]: