Problem 2

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```
In [1]: import numpy as np
        import pandas as pd
        import matplotlib.pyplot as plt
        import seaborn as sns
        sns.set(style="white")
        sns.set(style="whitegrid", color_codes=True)
```

```
In [2]: df_train = pd.read_csv('dataset2/train2.csv')
```

0.1 Dataset

0.1.1 Description

Dataset 2 berikut merupakan data loan 1000 nasabah bank dengan variabel target pada data ini adalah `default`, variabel biner yang menjadi indikasi loan/ pinjaman lunas (berhasil dilunasi pembayarannya) atau tidak.

0.1.2 Variables Glossary

- `checking_balance` dan `savings_balance`: Status dari account checking/saving
- `credit_history`: kategori histori kredit meliputi critical, good, perfect, poor atau very good
- `purpose`: tujuan kredit untuk car(new), car(used), education, furniture atau renovations
- `employment_duration`: lama bekerja
- `percent_of_income`: Installment rate dalam persentase disposable income
- `years_at_residence`: lama tinggal
- `age`: usia nasabah
- `other_credit`: installment/ cicilan lainnya
- `housing`: kategori status tempat tinggal meliputi rent, own, atau free
- `job`: jenis perkerjaan masuk dalam kategori management, skilled, unskilled atau unemployed
- `dependents`: banyaknya tanggungan
- `phone`: status registrasi nomer telefon
- **default**: status pembayaran default or non-default

```
In [3]: df_train.head()
```

```
Out[3]:    Unnamed: 0 checking_balance  months_loan_duration credit_history  \
        0         508       1 - 200 DM                    15      very good   
        1         307          unknown                    30           good   
        2         427          unknown                    28       critical   
        3         692       1 - 200 DM                    15           good   
        4          85           < 0 DM                    10           good   

                        purpose  amount savings_balance employment_duration  \
        0                   car    6850    100 - 500 DM          unemployed   
        1                   car    4811         unknown         4 - 7 years   
        2  furniture/appliances    2743        < 100 DM           > 7 years   
        3            renovations    2631    100 - 500 DM         1 - 4 years   
        4  furniture/appliances    2315        < 100 DM           > 7 years   

           percent_of_income  years_at_residence  age other_credit housing  \
        0                  1                   2   34         none     own   
        1                  2                   4   24        store    rent   
        2                  4                   2   29         none     own   
        3                  3                   2   25         none     own   
        4                  3                   4   52         none     own   

           existing_loans_count         job  dependents phone default  
        0                     1  management           2   yes     yes  
        1                     1   unskilled           1    no      no  
        2                     2     skilled           1    no      no  
        3                     1   unskilled           1    no      no  
        4                     1   unskilled           1    no      no  
```

```
In [4]: df_train.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 900 entries, 0 to 899
Data columns (total 18 columns):
Unnamed: 0              900 non-null int64
checking_balance        900 non-null object
months_loan_duration    900 non-null int64
credit_history          900 non-null object
purpose                 900 non-null object
amount                  900 non-null int64
savings_balance         900 non-null object
employment_duration     900 non-null object
percent_of_income       900 non-null int64
years_at_residence      900 non-null int64
age                     900 non-null int64
other_credit            900 non-null object
housing                 900 non-null object
existing_loans_count    900 non-null int64
job                     900 non-null object
```

```
dependents              900 non-null int64
phone                   900 non-null object
default                 900 non-null object
dtypes: int64(8), object(10)
memory usage: 126.6+ KB
```

0.2 Question 7

Variabel apa yang menjadi variabel paling tidak penting (most unimportant variable) dalam menentukan status default nasabah dalam model decision tree tersebut?

Answer: `existing_loans_count`

```
In [5]: df_train['checking_balance'].value_counts()
```

```
Out[5]: unknown       360
        1 - 200 DM    242
        < 0 DM        238
        > 200 DM       60
        Name: checking_balance, dtype: int64
```

```
In [6]: df_train['other_credit'].value_counts()
```

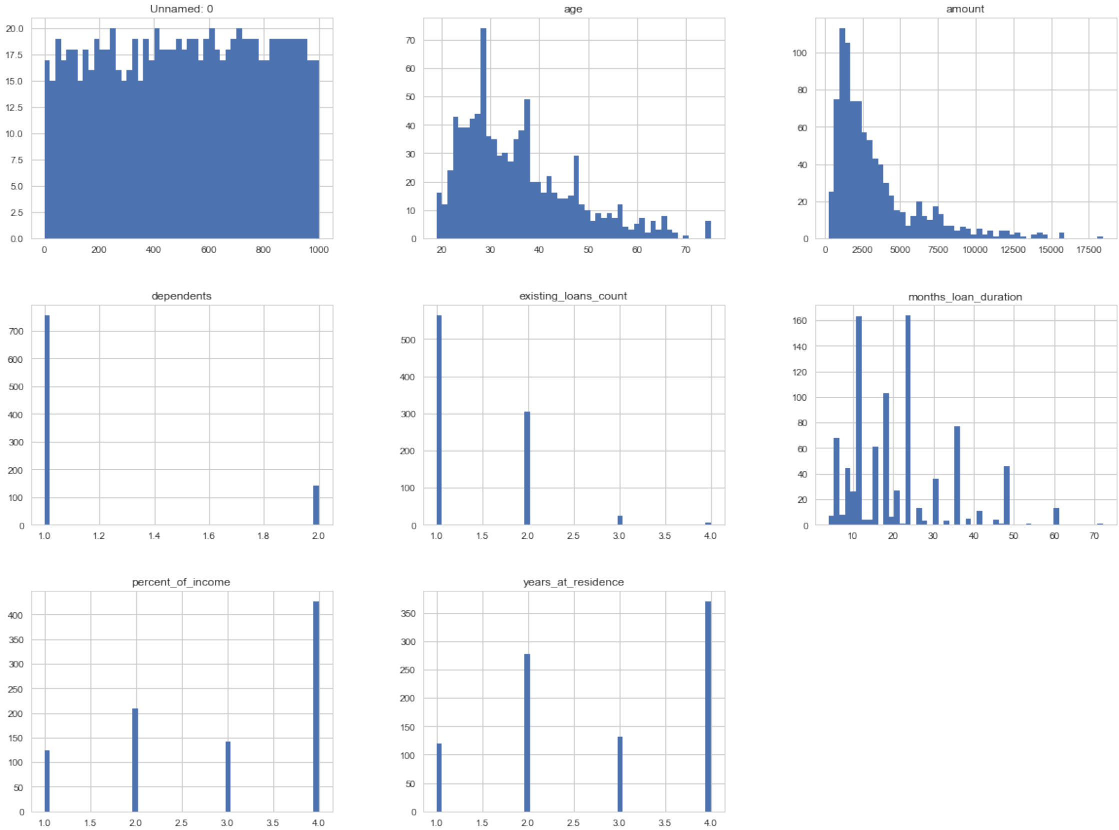
```
Out[6]: none     732
        bank     127
        store     41
        Name: other_credit, dtype: int64
```

```
In [7]: df_train['existing_loans_count'].describe()
```

```
Out[7]: count    900.000000
        mean       1.411111
        std        0.575635
        min        1.000000
        25%        1.000000
        50%        1.000000
        75%        2.000000
        max        4.000000
        Name: existing_loans_count, dtype: float64
```

1 Explore Dataset

```
In [8]: %matplotlib inline
        df_train.hist(bins=50, figsize=(20,15))
        plt.show()
```



```
In [9]: used_variables = ['checking_balance', 'savings_balance', 'credit_history', 'purpose',
                           'years_at_residence', 'age', 'other_credit', 'housing', 'job', 'deper

        nasabah = df_train[used_variables]

In [10]: nasabah.head()

Out[10]:   checking_balance savings_balance credit_history               purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                   car
         1          unknown         unknown           good                   car
         2          unknown        < 100 DM       critical  furniture/appliances
         3       1 - 200 DM    100 - 500 DM           good           renovations
         4           < 0 DM        < 100 DM           good  furniture/appliances

           employment_duration  percent_of_income  years_at_residence  age  \
         0          unemployed                  1                   2   34
         1         4 - 7 years                  2                   4   24
         2           > 7 years                  4                   2   29
         3         1 - 4 years                  3                   2   25
         4           > 7 years                  3                   4   52
```

```
  other_credit housing         job  dependents phone default
0         none     own  management           2   yes     yes
1        store    rent   unskilled           1    no      no
2         none     own     skilled           1    no      no
3         none     own   unskilled           1    no      no
4         none     own   unskilled           1    no      no
```

```
In [11]: nasabah.isnull().sum()
```

```
Out[11]: checking_balance       0
         savings_balance        0
         credit_history         0
         purpose                0
         employment_duration    0
         percent_of_income      0
         years_at_residence     0
         age                    0
         other_credit           0
         housing                0
         job                    0
         dependents             0
         phone                  0
         default                0
         dtype: int64
```

```
In [12]: nasabah.describe()
```

```
Out[12]:        percent_of_income  years_at_residence         age  dependents
         count         900.000000          900.000000  900.000000  900.000000
         mean            2.964444            2.835556   35.514444    1.158889
         std             1.122558            1.107996   11.306962    0.365776
         min             1.000000            1.000000   19.000000    1.000000
         25%             2.000000            2.000000   27.000000    1.000000
         50%             3.000000            3.000000   33.000000    1.000000
         75%             4.000000            4.000000   42.000000    1.000000
         max             4.000000            4.000000   75.000000    2.000000
```

2 Preprocessing Data Train

Note: Preprocessing can be optimize using Pipeline for simplicty of codes

2.1 Categorical Data

```
In [13]: cat_nasabah = nasabah.select_dtypes(include=['object']).copy()
         cat_nasabah.head()
```

```
Out[13]:   checking_balance savings_balance credit_history                purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                    car
```

```
1          unknown        unknown          good                   car
2          unknown       < 100 DM      critical  furniture/appliances
3       1 - 200 DM   100 - 500 DM          good           renovations
4           < 0 DM       < 100 DM          good  furniture/appliances

  employment_duration other_credit housing         job phone default
0          unemployed         none     own  management   yes     yes
1         4 - 7 years        store    rent   unskilled    no      no
2           > 7 years         none     own     skilled    no      no
3         1 - 4 years         none     own   unskilled    no      no
4           > 7 years         none     own   unskilled    no      no
```

```
In [14]: list_cat_nasabah = list(cat_nasabah)
         list_cat_nasabah.remove('purpose')
         list_cat_nasabah.remove('other_credit')
         list_cat_nasabah.remove('housing')
         list_cat_nasabah.remove('job')
         list_cat_nasabah
```

```
Out[14]: ['checking_balance',
          'savings_balance',
          'credit_history',
          'employment_duration',
          'phone',
          'default']
```

2.1.1 Data interval

Change data into numerical using Label Encoding

```
In [15]: cat_nasabah['checking_balance'].value_counts()
```

```
Out[15]: unknown       360
         1 - 200 DM    242
         < 0 DM        238
         > 200 DM       60
         Name: checking_balance, dtype: int64
```

```
In [16]: # change 'unknown' = 0, '< 0 DM' = 1, '1 - 200 DM' = 2, '> 200 DM' = 3
         cat_nasabah['checking_balance_num'] = cat_nasabah['checking_balance'].map({'unknown':
         cat_nasabah.head()
```

```
Out[16]:   checking_balance savings_balance credit_history               purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                   car
         1          unknown         unknown           good                   car
         2          unknown        < 100 DM       critical  furniture/appliances
         3       1 - 200 DM    100 - 500 DM           good           renovations
         4           < 0 DM        < 100 DM           good  furniture/appliances
```

```
           employment_duration other_credit housing         job phone default  \
         0          unemployed         none     own  management   yes     yes
         1         4 - 7 years        store    rent   unskilled    no      no
         2           > 7 years         none     own     skilled    no      no
         3         1 - 4 years         none     own   unskilled    no      no
         4           > 7 years         none     own   unskilled    no      no

            checking_balance_num
         0                     2
         1                     0
         2                     0
         3                     2
         4                     1
```

```
In [17]: cat_nasabah['savings_balance'].value_counts()
```

```
Out[17]: < 100 DM         530
         unknown          174
         100 - 500 DM      95
         500 - 1000 DM     56
         > 1000 DM         45
         Name: savings_balance, dtype: int64
```

```
In [18]: # change 'unknown' = 0, '< 100 DM' = 1, '100 - 500 DM' = 2, '500 - 1000 DM' = 3, '> 1
         cat_nasabah['savings_balance_num'] = cat_nasabah['savings_balance'].map({'unknown': 0
                                                                                 '100 - 500 D
                                                                                 '> 1000 DM':

         cat_nasabah.head()
```

```
Out[18]:   checking_balance savings_balance credit_history                purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                   car
         1          unknown         unknown           good                   car
         2          unknown        < 100 DM       critical  furniture/appliances
         3       1 - 200 DM    100 - 500 DM           good           renovations
         4           < 0 DM        < 100 DM           good  furniture/appliances

           employment_duration other_credit housing         job phone default  \
         0          unemployed         none     own  management   yes     yes
         1         4 - 7 years        store    rent   unskilled    no      no
         2           > 7 years         none     own     skilled    no      no
         3         1 - 4 years         none     own   unskilled    no      no
         4           > 7 years         none     own   unskilled    no      no

            checking_balance_num  savings_balance_num
         0                     2                    2
         1                     0                    0
         2                     0                    1
         3                     2                    2
         4                     1                    1
```

```
In [19]: cat_nasabah['credit_history'].value_counts()

Out[19]: good         473
         critical     260
         poor          84
         very good     45
         perfect       38
         Name: credit_history, dtype: int64

In [20]: # change 'critical' = 0, 'poor' = 1, 'good' = 2, 'very good' = 3, 'perfect' =  4
         cat_nasabah['credit_history_num'] = cat_nasabah['credit_history'].map({'critical': 0,
                                                                                  'good': 2, '
                                                                                  'perfect': 4

         cat_nasabah.head()

Out[20]:   checking_balance savings_balance credit_history                purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                    car
         1          unknown         unknown           good                    car
         2          unknown        < 100 DM       critical   furniture/appliances
         3       1 - 200 DM    100 - 500 DM           good            renovations
         4           < 0 DM        < 100 DM           good   furniture/appliances

           employment_duration other_credit housing         job phone default  \
         0          unemployed         none     own  management   yes     yes
         1         4 - 7 years        store    rent   unskilled    no      no
         2           > 7 years         none     own     skilled    no      no
         3         1 - 4 years         none     own   unskilled    no      no
         4           > 7 years         none     own   unskilled    no      no

            checking_balance_num  savings_balance_num  credit_history_num
         0                     2                    2                   3
         1                     0                    0                   2
         2                     0                    1                   0
         3                     2                    2                   2
         4                     1                    1                   2

In [21]: cat_nasabah['employment_duration'].value_counts()

Out[21]: 1 - 4 years    304
         > 7 years      227
         4 - 7 years    157
         < 1 year       155
         unemployed      57
         Name: employment_duration, dtype: int64

In [22]: # change 'unemployed' = 0, '< 1 year' = 1, '1 - 4 years' = 2, '4 - 7 years' = 3, '> 7
         cat_nasabah['employment_duration_num'] = cat_nasabah['employment_duration'].map({'une
                                                                                  '1 - 4 years
                                                                                  '> 7 years':

         cat_nasabah.head()
```

```
Out[22]:   checking_balance savings_balance credit_history               purpose  \
         0       1 - 200 DM    100 - 500 DM      very good                   car
         1          unknown         unknown           good                   car
         2          unknown        < 100 DM       critical  furniture/appliances
         3       1 - 200 DM    100 - 500 DM           good           renovations
         4           < 0 DM        < 100 DM           good  furniture/appliances

           employment_duration other_credit housing         job phone default  \
         0          unemployed         none     own  management   yes     yes
         1         4 - 7 years        store    rent   unskilled    no      no
         2           > 7 years         none     own     skilled    no      no
         3         1 - 4 years         none     own   unskilled    no      no
         4           > 7 years         none     own   unskilled    no      no

            checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    2                   3
         1                     0                    0                   2
         2                     0                    1                   0
         3                     2                    2                   2
         4                     1                    1                   2

            employment_duration_num
         0                        0
         1                        3
         2                        4
         3                        2
         4                        4
```

2.1.2 Data Categorical

Change data into numerical using One Hot Encoding

```
In [23]: cat_nasabah['purpose'].value_counts()
```

```
Out[23]: furniture/appliances    419
         car                     315
         business                 88
         education                48
         renovations              21
         car0                      9
         Name: purpose, dtype: int64
```

```
In [24]: cat_nasabah = pd.get_dummies(cat_nasabah, columns=['purpose'], prefix=['purpose'])
         cat_nasabah.head()
```

```
Out[24]:   checking_balance savings_balance credit_history employment_duration  \
         0       1 - 200 DM    100 - 500 DM      very good          unemployed
         1          unknown         unknown           good         4 - 7 years
         2          unknown        < 100 DM       critical           > 7 years
```

```
3       1 - 200 DM    100 - 500 DM           good         1 - 4 years
4           < 0 DM        < 100 DM           good           > 7 years

  other_credit housing         job phone default  checking_balance_num  \
0         none     own  management   yes     yes                     2
1        store    rent   unskilled    no      no                     0
2         none     own     skilled    no      no                     0
3         none     own   unskilled    no      no                     2
4         none     own   unskilled    no      no                     1

   savings_balance_num  credit_history_num  employment_duration_num  \
0                    2                   3                        0
1                    0                   2                        3
2                    1                   0                        4
3                    2                   2                        2
4                    1                   2                        4

   purpose_business  purpose_car  purpose_car0  purpose_education  \
0                 0            1             0                  0
1                 0            1             0                  0
2                 0            0             0                  0
3                 0            0             0                  0
4                 0            0             0                  0

   purpose_furniture/appliances  purpose_renovations
0                             0                    0
1                             0                    0
2                             1                    0
3                             0                    1
4                             1                    0
```

```
In [25]: cat_nasabah['other_credit'].value_counts()
```

```
Out[25]: none     732
         bank     127
         store     41
         Name: other_credit, dtype: int64
```

```
In [26]: cat_nasabah = pd.get_dummies(cat_nasabah, columns=['other_credit'], prefix=['other_cre
         cat_nasabah.head()
```

```
Out[26]:   checking_balance savings_balance credit_history employment_duration housing  \
         0       1 - 200 DM    100 - 500 DM      very good          unemployed     own
         1          unknown         unknown           good         4 - 7 years    rent
         2          unknown        < 100 DM       critical           > 7 years     own
         3       1 - 200 DM    100 - 500 DM           good         1 - 4 years     own
         4           < 0 DM        < 100 DM           good           > 7 years     own

                   job phone default  checking_balance_num  savings_balance_num  \
0  management   yes     yes                     2                    2
1   unskilled    no      no                     0                    0
2     skilled    no      no                     0                    1
3   unskilled    no      no                     2                    2
4   unskilled    no      no                     1                    1

          ...          employment_duration_num  purpose_business  purpose_car  \
0         ...                                0                 0            1
1         ...                                3                 0            1
2         ...                                4                 0            0
3         ...                                2                 0            0
4         ...                                4                 0            0

   purpose_car0  purpose_education  purpose_furniture/appliances  \
0             0                  0                             0
1             0                  0                             0
2             0                  0                             1
3             0                  0                             0
4             0                  0                             1

   purpose_renovations  other_credit_bank  other_credit_none  \
0                    0                  0                  1
1                    0                  0                  0
2                    0                  0                  1
3                    1                  0                  1
4                    0                  0                  1

   other_credit_store
0                   0
1                   1
2                   0
3                   0
4                   0

[5 rows x 21 columns]
```

```
In [27]: cat_nasabah['housing'].value_counts()
```

```
Out[27]: own      639
         rent     163
         other     98
         Name: housing, dtype: int64
```

```
In [28]: cat_nasabah = pd.get_dummies(cat_nasabah, columns=['housing'], prefix=['housing'])
         cat_nasabah.head()
```

```
Out[28]:   checking_balance savings_balance credit_history employment_duration  \
         0       1 - 200 DM    100 - 500 DM      very good           unemployed
         1          unknown         unknown           good          4 - 7 years
```

```
2          unknown        < 100 DM       critical           > 7 years
3       1 - 200 DM    100 - 500 DM           good         1 - 4 years
4           < 0 DM        < 100 DM           good           > 7 years

          job phone default  checking_balance_num  savings_balance_num  \
0  management   yes     yes                     2                    2
1   unskilled    no      no                     0                    0
2     skilled    no      no                     0                    1
3   unskilled    no      no                     2                    2
4   unskilled    no      no                     1                    1

   credit_history_num      ...       purpose_car0  purpose_education  \
0                   3      ...                  0                  0
1                   2      ...                  0                  0
2                   0      ...                  0                  0
3                   2      ...                  0                  0
4                   2      ...                  0                  0

   purpose_furniture/appliances  purpose_renovations  other_credit_bank  \
0                             0                    0                  0
1                             0                    0                  0
2                             1                    0                  0
3                             0                    1                  0
4                             1                    0                  0

   other_credit_none  other_credit_store  housing_other  housing_own  \
0                  1                   0              0            1
1                  0                   1              0            0
2                  1                   0              0            1
3                  1                   0              0            1
4                  1                   0              0            1

   housing_rent
0             0
1             1
2             0
3             0
4             0

[5 rows x 23 columns]
```

```
In [29]: cat_nasabah['job'].value_counts()
```

```
Out[29]: skilled       567
         unskilled     186
         management    126
         unemployed     21
         Name: job, dtype: int64
```

```
In [30]: cat_nasabah = pd.get_dummies(cat_nasabah, columns=['job'], prefix=['job'])
         cat_nasabah.head()
```

```
Out[30]:   checking_balance savings_balance credit_history employment_duration phone  \
         0       1 - 200 DM    100 - 500 DM      very good          unemployed   yes
         1          unknown         unknown           good         4 - 7 years    no
         2          unknown        < 100 DM       critical           > 7 years    no
         3       1 - 200 DM    100 - 500 DM           good         1 - 4 years    no
         4           < 0 DM        < 100 DM           good           > 7 years    no

           default  checking_balance_num  savings_balance_num  credit_history_num  \
         0     yes                     2                    2                   3
         1      no                     0                    0                   2
         2      no                     0                    1                   0
         3      no                     2                    2                   2
         4      no                     1                    1                   2

            employment_duration_num      ...        other_credit_bank  \
         0                        0      ...                        0
         1                        3      ...                        0
         2                        4      ...                        0
         3                        2      ...                        0
         4                        4      ...                        0

            other_credit_none  other_credit_store  housing_other  housing_own  \
         0                  1                   0              0            1
         1                  0                   1              0            0
         2                  1                   0              0            1
         3                  1                   0              0            1
         4                  1                   0              0            1

            housing_rent  job_management  job_skilled  job_unemployed  job_unskilled
         0             0               1            0               0              0
         1             1               0            0               0              1
         2             0               0            1               0              0
         3             0               0            0               0              1
         4             0               0            0               0              1

         [5 rows x 26 columns]
```

2.1.3 Data Boolean

Change 'yes' into 1 and 'no' into 0

```
In [31]: cat_nasabah['phone'].value_counts()
```

```
Out[31]: no     542
         yes    358
         Name: phone, dtype: int64
```

```
In [32]: # change 'yes' = 1, 'no' = 0
         cat_nasabah['phone_num'] = cat_nasabah['phone'].map({'yes': 1, 'no': 0}).astype(int)
         cat_nasabah.head()
```

```
Out[32]:   checking_balance savings_balance credit_history employment_duration phone  \
         0       1 - 200 DM    100 - 500 DM      very good          unemployed   yes
         1          unknown         unknown           good         4 - 7 years    no
         2          unknown        < 100 DM       critical           > 7 years    no
         3       1 - 200 DM    100 - 500 DM           good         1 - 4 years    no
         4           < 0 DM        < 100 DM           good           > 7 years    no

           default  checking_balance_num  savings_balance_num  credit_history_num  \
         0     yes                     2                    2                   3
         1      no                     0                    0                   2
         2      no                     0                    1                   0
         3      no                     2                    2                   2
         4      no                     1                    1                   2

            employment_duration_num    ...      other_credit_none  other_credit_store  \
         0                        0    ...                      1                   0
         1                        3    ...                      0                   1
         2                        4    ...                      1                   0
         3                        2    ...                      1                   0
         4                        4    ...                      1                   0

            housing_other  housing_own  housing_rent  job_management  job_skilled  \
         0              0            1             0               1            0
         1              0            0             1               0            0
         2              0            1             0               0            1
         3              0            1             0               0            0
         4              0            1             0               0            0

            job_unemployed  job_unskilled  phone_num
         0               0              0          1
         1               0              1          0
         2               0              0          0
         3               0              1          0
         4               0              1          0

         [5 rows x 27 columns]
```

```
In [33]: cat_nasabah['default'].value_counts()
```

```
Out[33]: no     627
         yes    273
         Name: default, dtype: int64
```

```
In [34]: # change 'yes' = 1, 'no' = 0
         cat_nasabah['default_num'] = cat_nasabah['default'].map({'yes': 1, 'no': 0}).astype(i
         cat_nasabah.head()
```

Out[34]:
```
  checking_balance savings_balance credit_history employment_duration phone  \
0       1 - 200 DM    100 - 500 DM      very good          unemployed   yes
1          unknown         unknown           good         4 - 7 years    no
2          unknown        < 100 DM       critical           > 7 years    no
3       1 - 200 DM    100 - 500 DM           good         1 - 4 years    no
4           < 0 DM        < 100 DM           good           > 7 years    no

  default  checking_balance_num  savings_balance_num  credit_history_num  \
0     yes                     2                    2                   3
1      no                     0                    0                   2
2      no                     0                    1                   0
3      no                     2                    2                   2
4      no                     1                    1                   2

   employment_duration_num     ...       other_credit_store  housing_other  \
0                        0     ...                        0              0
1                        3     ...                        1              0
2                        4     ...                        0              0
3                        2     ...                        0              0
4                        4     ...                        0              0

   housing_own  housing_rent  job_management  job_skilled  job_unemployed  \
0            1             0               1            0               0
1            0             1               0            0               0
2            1             0               0            1               0
3            1             0               0            0               0
4            1             0               0            0               0

   job_unskilled  phone_num  default_num
0              0          1            1
1              1          0            0
2              0          0            0
3              1          0            0
4              1          0            0

[5 rows x 28 columns]
```

In [35]:
```
cat_nasabah_train = cat_nasabah.drop(list_cat_nasabah, axis=1)
cat_nasabah_train.head()
```

Out[35]:
```
   checking_balance_num  savings_balance_num  credit_history_num  \
0                     2                    2                   3
1                     0                    0                   2
2                     0                    1                   0
3                     2                    2                   2
4                     1                    1                   2

   employment_duration_num  purpose_business  purpose_car  purpose_car0  \
0                        0                 0            1             0
1                        3                 0            1             0
2                        4                 0            0             0
3                        2                 0            0             0
4                        4                 0            0             0

   purpose_education  purpose_furniture/appliances  purpose_renovations  \
0                  0                             0                    0
1                  0                             0                    0
2                  0                             1                    0
3                  0                             0                    1
4                  0                             1                    0

      ...       other_credit_store  housing_other  housing_own  housing_rent  \
0     ...                        0              0            1             0
1     ...                        1              0            0             1
2     ...                        0              0            1             0
3     ...                        0              0            1             0
4     ...                        0              0            1             0

   job_management  job_skilled  job_unemployed  job_unskilled  phone_num  \
0               1            0               0              0          1
1               0            0               0              1          0
2               0            1               0              0          0
3               0            0               0              1          0
4               0            0               0              1          0

   default_num
0            1
1            0
2            0
3            0
4            0

[5 rows x 22 columns]
```

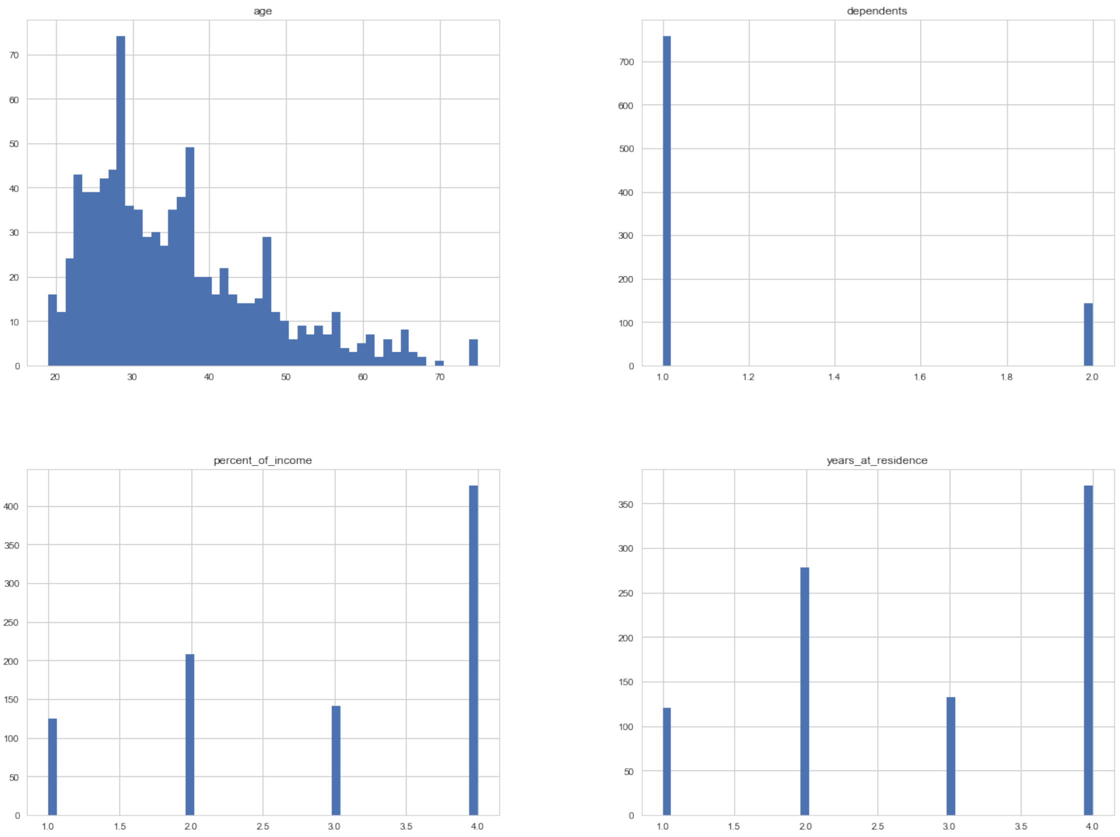
2.2 Numerical Data

```
In [36]: num_nasabah = nasabah.select_dtypes(include=['int64']).copy()
         num_nasabah.head()
```

```
Out[36]:    percent_of_income  years_at_residence  age  dependents
         0                  1                   2   34           2
         1                  2                   4   24           1
         2                  4                   2   29           1
         3                  3                   2   25           1
         4                  3                   4   52           1
```

```
In [37]: num_nasabah.hist(bins=50, figsize=(20,15))
```

```
Out[37]: array([[<matplotlib.axes._subplots.AxesSubplot object at 0x0000012798A9F588>,
                 <matplotlib.axes._subplots.AxesSubplot object at 0x0000012799C56748>],
                [<matplotlib.axes._subplots.AxesSubplot object at 0x0000012799C65E48>,
                 <matplotlib.axes._subplots.AxesSubplot object at 0x0000012799C8C588>]],
               dtype=object)
```

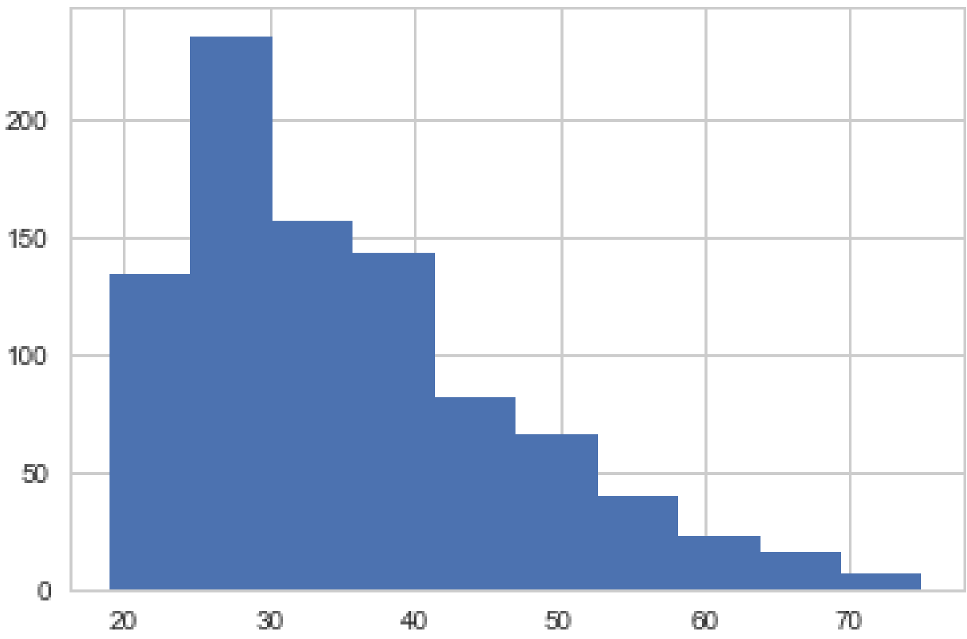


2.2.1 Age

Change into categorical data

```
In [38]: num_nasabah['age'].hist()
```

```
Out[38]: <matplotlib.axes._subplots.AxesSubplot at 0x12799cf6470>
```



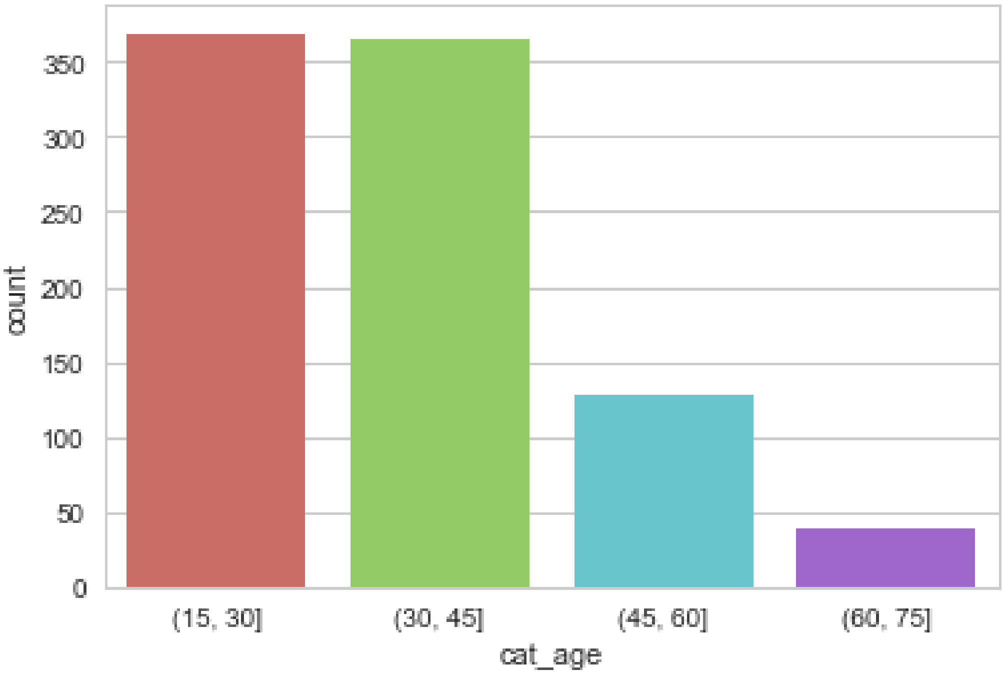
```
In [39]: # set up bins
         bin = [15, 30, 45, 60, 75]

         # use pd.cut
         cat_age = pd.cut(num_nasabah['age'], bin)
         cat_age = cat_age.to_frame()
         cat_age.columns = ['cat_age']

         # concatenate age and its bin
         num_nasabah = pd.concat([num_nasabah, cat_age], axis=1)

In [40]: # draw histogram plot
         sns.countplot(x ='cat_age', data=num_nasabah, palette='hls')
         plt.show()
```

```
c:\users\yasir\anaconda3\lib\site-packages\seaborn\categorical.py:1428: FutureWarning: remove_n
  stat_data = remove_na(group_data)
```



```
In [41]: num_nasabah['cat_age'].value_counts()

Out[41]: (15, 30]    369
         (30, 45]    365
         (45, 60]    128
         (60, 75]     38
         Name: cat_age, dtype: int64

In [42]: num_nasabah.info()

<class 'pandas.core.frame.DataFrame'>
RangeIndex: 900 entries, 0 to 899
Data columns (total 5 columns):
percent_of_income     900 non-null int64
years_at_residence    900 non-null int64
age                   900 non-null int64
dependents            900 non-null int64
cat_age               900 non-null category
dtypes: category(1), int64(4)
memory usage: 29.1 KB


In [43]: num_nasabah.head()

Out[43]:    percent_of_income  years_at_residence  age  dependents   cat_age
         0                  1                   2   34           2  (30, 45]
         1                    2                    4   24             1  (15, 30]
         2                    4                    2   29             1  (15, 30]
         3                    3                    2   25             1  (15, 30]
         4                    3                    4   52             1  (45, 60]
```

Change categorical age into numerical value

```
In [44]: # change into string 'cat_age'
         num_nasabah['cat_age'] = num_nasabah['cat_age'].astype(str)
```

```
In [45]: # change '(15, 30]' = 0, '(30, 45]' = 1, '(45, 60]' = 2, '(60, 75]' = 3
         num_nasabah['cat_age_num'] = num_nasabah['cat_age'].map({'(15, 30]': 0, '(30, 45]': 1
                                                                  '(45, 60]': 2, '(60, 75]': 3
         num_nasabah.head()
```

```
Out[45]:    percent_of_income  years_at_residence  age  dependents   cat_age  \
         0                  1                   2   34           2  (30, 45]
         1                  2                   4   24           1  (15, 30]
         2                  4                   2   29           1  (15, 30]
         3                  3                   2   25           1  (15, 30]
         4                  3                   4   52           1  (45, 60]

            cat_age_num
         0            1
         1            0
         2            0
         3            0
         4            2
```

```
In [46]: num_nasabah_train = num_nasabah.drop(['age', 'cat_age'], axis=1)
         num_nasabah_train.head()
```

```
Out[46]:    percent_of_income  years_at_residence  dependents  cat_age_num
         0                  1                   2           2            1
         1                  2                   4           1            0
         2                  4                   2           1            0
         3                  3                   2           1            0
         4                  3                   4           1            2
```

2.3 Merge categorical and numerical data

```
In [47]: nasabah_merge = pd.concat([cat_nasabah_train, num_nasabah_train], axis=1)
         nasabah_merge.head()
```

```
Out[47]:    checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    2                   3
         1                     0                    0                   2
         2                     0                    1                   0
         3                     2                    2                   2
```

```
4                     1                    1                   2

   employment_duration_num  purpose_business  purpose_car  purpose_car0  \
0                        0                 0            1             0
1                        3                 0            1             0
2                        4                 0            0             0
3                        2                 0            0             0
4                        4                 0            0             0

   purpose_education  purpose_furniture/appliances  purpose_renovations  \
0                  0                             0                    0
1                  0                             0                    0
2                  0                             1                    0
3                  0                             0                    1
4                  0                             1                    0

      ...       job_management  job_skilled  job_unemployed  job_unskilled  \
0     ...                    1            0               0              0
1     ...                    0            0               0              1
2     ...                    0            1               0              0
3     ...                    0            0               0              1
4     ...                    0            0               0              1

   phone_num  default_num  percent_of_income  years_at_residence  dependents  \
0          1            1                  1                   2           2
1          0            0                  2                   4           1
2          0            0                  4                   2           1
3          0            0                  3                   2           1
4          0            0                  3                   4           1

   cat_age_num
0            1
1            0
2            0
3            0
4            2

[5 rows x 26 columns]
```

```
In [48]: nasabah_prepared = nasabah_merge.drop('default_num', axis=1)
         nasabah_prepared.head()
```

```
Out[48]:    checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    2                   3
         1                     0                    0                   2
         2                     0                    1                   0
         3                     2                    2                   2
         4                     1                    1                   2
```

```
   employment_duration_num  purpose_business  purpose_car  purpose_car0  \
0                        0                 0            1             0
1                        3                 0            1             0
2                        4                 0            0             0
3                        2                 0            0             0
4                        4                 0            0             0

   purpose_education  purpose_furniture/appliances  purpose_renovations  \
0                  0                             0                    0
1                  0                             0                    0
2                  0                             1                    0
3                  0                             0                    1
4                  0                             1                    0

      ...       housing_rent  job_management  job_skilled  job_unemployed  \
0     ...                  0               1            0               0
1     ...                  1               0            0               0
2     ...                  0               0            1               0
3     ...                  0               0            0               0
4     ...                  0               0            0               0

   job_unskilled  phone_num  percent_of_income  years_at_residence  \
0              0          1                  1                   2
1              1          0                  2                   4
2              0          0                  4                   2
3              1          0                  3                   2
4              1          0                  3                   4

   dependents  cat_age_num
0           2            1
1           1            0
2           1            0
3           1            0
4           1            2

[5 rows x 25 columns]
```

```
In [49]: nasabah_labels = nasabah_merge['default_num']
         nasabah_labels.head()

Out[49]: 0    1
         1    0
         2    0
         3    0
         4    0
         Name: default_num, dtype: int32
```

3 Decision Tree

```
In [50]: from sklearn.tree import DecisionTreeClassifier
```

```
In [51]: tree_reg = DecisionTreeClassifier(random_state=42)
         tree_reg.fit(nasabah_prepared, nasabah_labels)
```

```
Out[51]: DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=None,
                     max_features=None, max_leaf_nodes=None,
                     min_impurity_decrease=0.0, min_impurity_split=None,
                     min_samples_leaf=1, min_samples_split=2,
                     min_weight_fraction_leaf=0.0, presort=False, random_state=42,
                     splitter='best')
```

4 Fine-tune model

```
In [52]: from  sklearn.model_selection import cross_val_score

         scores = cross_val_score(tree_reg, nasabah_prepared, nasabah_labels,
                                  scoring="neg_mean_squared_error", cv=10)
         tree_rmse_scores = np.sqrt(-scores)
```

```
In [53]: tree_rmse_scores
```

```
Out[53]: array([0.61124985, 0.5836603 , 0.62017367, 0.64978629, 0.54772256,
                0.64978629, 0.51639778, 0.58058475, 0.60892242, 0.59962535])
```

```
In [54]: from sklearn.model_selection import GridSearchCV
```

```
In [55]: param_grid = [
                       {'max_depth': [1, 2, 3, 4, 5], 'max_features': [2, 4, 6, 8]},
                       {'criterion': ['entropy'], 'max_depth': [2, 4], 'max_features': [2, 3, 
                      ]

         tree_class = DecisionTreeClassifier(random_state=42)

         grid_search = GridSearchCV(tree_class, param_grid, cv=5,
                                    scoring='neg_mean_squared_error', return_train_score=True)
         grid_search.fit(nasabah_prepared, nasabah_labels)
```

```
Out[55]: GridSearchCV(cv=5, error_score='raise',
                estimator=DecisionTreeClassifier(class_weight=None, criterion='gini', max_dept
                     max_features=None, max_leaf_nodes=None,
                     min_impurity_decrease=0.0, min_impurity_split=None,
                     min_samples_leaf=1, min_samples_split=2,
                     min_weight_fraction_leaf=0.0, presort=False, random_state=42,
                     splitter='best'),
                fit_params=None, iid=True, n_jobs=1,
                param_grid=[{'max_depth': [1, 2, 3, 4, 5], 'max_features': [2, 4, 6, 8]}, {'cr
                pre_dispatch='2*n_jobs', refit=True, return_train_score=True,
                scoring='neg_mean_squared_error', verbose=0)
```

```
In [56]: grid_search.best_params_
```

```
Out[56]: {'max_depth': 3, 'max_features': 6}
```

```
In [57]: grid_search.best_estimator_
```

```
Out[57]: DecisionTreeClassifier(class_weight=None, criterion='gini', max_depth=3,
                     max_features=6, max_leaf_nodes=None, min_impurity_decrease=0.0,
                     min_impurity_split=None, min_samples_leaf=1,
                     min_samples_split=2, min_weight_fraction_leaf=0.0,
                     presort=False, random_state=42, splitter='best')
```

```
In [58]: cvres = grid_search.cv_results_
         for mean_score, params in zip(cvres["mean_test_score"], cvres["params"]):
             print(np.sqrt(-mean_score), params)
```

```
0.5507570547286103 {'max_depth': 1, 'max_features': 2}
0.5507570547286103 {'max_depth': 1, 'max_features': 4}
0.5507570547286103 {'max_depth': 1, 'max_features': 6}
0.5507570547286103 {'max_depth': 1, 'max_features': 8}
0.5507570547286103 {'max_depth': 2, 'max_features': 2}
0.5507570547286103 {'max_depth': 2, 'max_features': 4}
0.5507570547286103 {'max_depth': 2, 'max_features': 6}
0.5426273532033236 {'max_depth': 2, 'max_features': 8}
0.5507570547286103 {'max_depth': 3, 'max_features': 2}
0.5557777333511023 {'max_depth': 3, 'max_features': 4}
0.5416025603090641 {'max_depth': 3, 'max_features': 6}
0.5666666666666667 {'max_depth': 3, 'max_features': 8}
0.5686240703077327 {'max_depth': 4, 'max_features': 2}
0.5487359211051442 {'max_depth': 4, 'max_features': 4}
0.5497474167490214 {'max_depth': 4, 'max_features': 6}
0.5763872155263527 {'max_depth': 4, 'max_features': 8}
0.5830951894845301 {'max_depth': 5, 'max_features': 2}
0.5666666666666667 {'max_depth': 5, 'max_features': 4}
0.563717817509592 {'max_depth': 5, 'max_features': 6}
0.5617433182117573 {'max_depth': 5, 'max_features': 8}
0.5507570547286103 {'criterion': 'entropy', 'max_depth': 2, 'max_features': 2}
0.5577733510227171 {'criterion': 'entropy', 'max_depth': 2, 'max_features': 3}
0.5507570547286103 {'criterion': 'entropy', 'max_depth': 2, 'max_features': 4}
0.5647024782032473 {'criterion': 'entropy', 'max_depth': 4, 'max_features': 2}
0.5557777333511023 {'criterion': 'entropy', 'max_depth': 4, 'max_features': 3}
0.5487359211051442 {'criterion': 'entropy', 'max_depth': 4, 'max_features': 4}
```

5 Test

```
In [59]: df_test = pd.read_csv('dataset2/test2.csv')
```

```
In [60]: df_test.head()
```

```
Out[60]:    Unnamed: 0 checking_balance  months_loan_duration credit_history  \
         0           2       1 - 200 DM                    48           good
         1          13       1 - 200 DM                    12           good
         2          16           < 0 DM                    24           good
         3          24       1 - 200 DM                    12       critical
         4          25          unknown                    10       critical

                          purpose  amount savings_balance employment_duration  \
         0  furniture/appliances    5951        < 100 DM         1 - 4 years
         1  furniture/appliances    1567        < 100 DM         1 - 4 years
         2  furniture/appliances    1282    100 - 500 DM         1 - 4 years
         3                   car    1804    100 - 500 DM            < 1 year
         4  furniture/appliances    2069         unknown         1 - 4 years

            percent_of_income  years_at_residence  age other_credit housing  \
         0                  2                   2   22         none     own
         1                  1                   1   22         none     own
         2                  4                   2   32         none     own
         3                  3                   4   44         none     own
         4                  2                   1   26         none     own

            existing_loans_count        job  dependents phone default
         0                     1    skilled           1    no     yes
         1                     1    skilled           1   yes      no
         2                     1  unskilled           1    no     yes
         3                     1    skilled           1    no      no
         4                     2    skilled           1    no      no
```

```
In [61]: nasabah_test = df_test[used_variables]
         nasabah_test.head()
```

```
Out[61]:   checking_balance savings_balance credit_history                 purpose  \
         0       1 - 200 DM        < 100 DM           good  furniture/appliances
         1       1 - 200 DM        < 100 DM           good  furniture/appliances
         2           < 0 DM    100 - 500 DM           good  furniture/appliances
         3       1 - 200 DM    100 - 500 DM       critical                   car
         4          unknown         unknown       critical  furniture/appliances

           employment_duration  percent_of_income  years_at_residence  age  \
         0         1 - 4 years                  2                   2   22
         1         1 - 4 years                  1                   1   22
         2         1 - 4 years                  4                   2   32
         3            < 1 year                  3                   4   44
         4         1 - 4 years                  2                   1   26

           other_credit housing        job  dependents phone default
         0         none     own    skilled           1    no     yes
         1         none     own    skilled           1   yes      no
         2         none     own  unskilled            1    no     yes
         3         none     own    skilled            1    no      no
         4         none     own    skilled            1    no      no
```

```
In [62]: nasabah_test.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 100 entries, 0 to 99
Data columns (total 14 columns):
checking_balance       100 non-null object
savings_balance        100 non-null object
credit_history         100 non-null object
purpose                100 non-null object
employment_duration    100 non-null object
percent_of_income      100 non-null int64
years_at_residence     100 non-null int64
age                    100 non-null int64
other_credit           100 non-null object
housing                100 non-null object
job                    100 non-null object
dependents             100 non-null int64
phone                  100 non-null object
default                100 non-null object
dtypes: int64(4), object(10)
memory usage: 11.0+ KB
```

6 Preprocessing Data Test

6.1 Categorical Data

```
In [63]: cat_nasabah_test = nasabah_test.select_dtypes(include=['object']).copy()
         cat_nasabah_test.head()
```

```
Out[63]:   checking_balance savings_balance credit_history                purpose  \
         0       1 - 200 DM        < 100 DM           good  furniture/appliances
         1       1 - 200 DM        < 100 DM           good  furniture/appliances
         2           < 0 DM    100 - 500 DM           good  furniture/appliances
         3       1 - 200 DM    100 - 500 DM       critical                    car
         4          unknown         unknown       critical  furniture/appliances

           employment_duration other_credit housing         job phone default
         0         1 - 4 years         none     own     skilled    no     yes
         1         1 - 4 years         none     own     skilled   yes      no
         2         1 - 4 years         none     own   unskilled    no     yes
         3            < 1 year         none     own     skilled    no      no
         4         1 - 4 years         none     own     skilled    no      no
```

```
In [64]: list_cat_nasabah_test = list(cat_nasabah_test)
         list_cat_nasabah_test.remove('purpose')
         list_cat_nasabah_test.remove('other_credit')
         list_cat_nasabah_test.remove('housing')
         list_cat_nasabah_test.remove('job')
         list_cat_nasabah_test
```

```
Out[64]: ['checking_balance',
          'savings_balance',
          'credit_history',
          'employment_duration',
          'phone',
          'default']
```

6.1.1 Data interval

Change data into numerical using Label Encoding

```
In [65]: # change 'unknown' = 0, '< 0 DM' = 1, '1 - 200 DM' = 2, '> 200 DM' = 3
         cat_nasabah_test['checking_balance_num'] = cat_nasabah_test['checking_balance'].map({

         # change 'unknown' = 0, '< 100 DM' = 1, '100 - 500 DM' = 2, '500 - 1000 DM' = 3, '> 1(
         cat_nasabah_test['savings_balance_num'] = cat_nasabah_test['savings_balance'].map({'un
                                                                                  '100 - 500 DI
                                                                                  '> 1000 DM':

         # change 'critical' = 0, 'poor' = 1, 'good' = 2, 'very good' = 3, 'perfect' =  4
         cat_nasabah_test['credit_history_num'] = cat_nasabah_test['credit_history'].map({'cri
                                                                                  'good': 2, ''
                                                                                  'perfect': 4]

         # change 'unemployed' = 0, '< 1 year' = 1, '1 - 4 years' = 2, '4 - 7 years' = 3, '> 7
         cat_nasabah_test['employment_duration_num'] = cat_nasabah_test['employment_duration']
                                                                                  '1 - 4 years
                                                                                  '> 7 years':

         # cat_nasabah_test.head()
```

6.1.2 Data Categorical

Change data into numerical using One Hot Encoding

```
In [66]: cat_nasabah_test = pd.get_dummies(cat_nasabah_test, columns=['purpose'], prefix=['purp
         cat_nasabah_test = pd.get_dummies(cat_nasabah_test, columns=['other_credit'], prefix=
         cat_nasabah_test = pd.get_dummies(cat_nasabah_test, columns=['housing'], prefix=['hous
         cat_nasabah_test = pd.get_dummies(cat_nasabah_test, columns=['job'], prefix=['job'])
         # cat_nasabah_test.head()
```

6.1.3 Data Boolean

Change 'yes' into 1 and 'no' into 0

```
In [67]: # change 'yes' = 1, 'no' = 0
         cat_nasabah_test['phone_num'] = cat_nasabah_test['phone'].map({'yes': 1, 'no': 0}).as
         cat_nasabah_test['default_num'] = cat_nasabah_test['default'].map({'yes': 1, 'no': 0}
         # cat_nasabah_test.head()
```

```
In [68]: cat_nasabah_test = cat_nasabah_test.drop(list_cat_nasabah_test, axis=1)
         cat_nasabah_test.head()
```

```
Out[68]:    checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    1                   2
         1                     2                    1                   2
         2                     1                    2                   2
         3                     2                    2                   0
         4                     0                    0                   0

            employment_duration_num  purpose_business  purpose_car  purpose_car0  \
         0                        2                 0            0             0
         1                        2                 0            0             0
         2                        2                 0            0             0
         3                        1                 0            1             0
         4                        2                 0            0             0

            purpose_education  purpose_furniture/appliances  purpose_renovations  \
         0                  0                             1                    0
         1                  0                             1                    0
         2                  0                             1                    0
         3                  0                             0                    0
         4                  0                             1                    0

               ...       other_credit_store  housing_other  housing_own  housing_rent  \
         0     ...                        0              0            1             0
         1     ...                        0              0            1             0
         2     ...                        0              0            1             0
         3     ...                        0              0            1             0
         4     ...                        0              0            1             0

            job_management  job_skilled  job_unemployed  job_unskilled  phone_num  \
         0               0            1               0              0          0
         1               0            1               0              0          1
         2               0            0               0              1          0
         3               0            1               0              0          0
         4               0            1               0              0          0

            default_num
         0            1
```

```
1            0
2            1
3            0
4            0

[5 rows x 22 columns]
```

6.2 Numerical Data

```
In [69]: num_nasabah_test = nasabah_test.select_dtypes(include=['int64']).copy()
         num_nasabah_test.head()
```

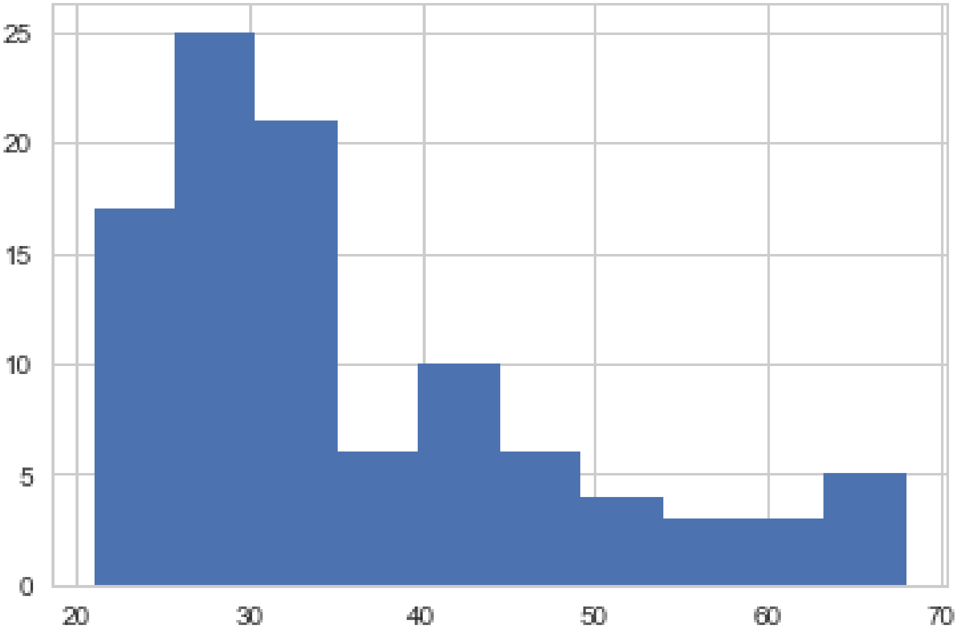
```
Out[69]:    percent_of_income  years_at_residence  age  dependents
         0                  2                   2   22           1
         1                  1                   1   22           1
         2                  4                   2   32           1
         3                  3                   4   44           1
         4                  2                   1   26           1
```

6.2.1 Age

Change into categorical data

```
In [70]: num_nasabah_test['age'].hist()
```

```
Out[70]: <matplotlib.axes._subplots.AxesSubplot at 0x127989b5b38>
```



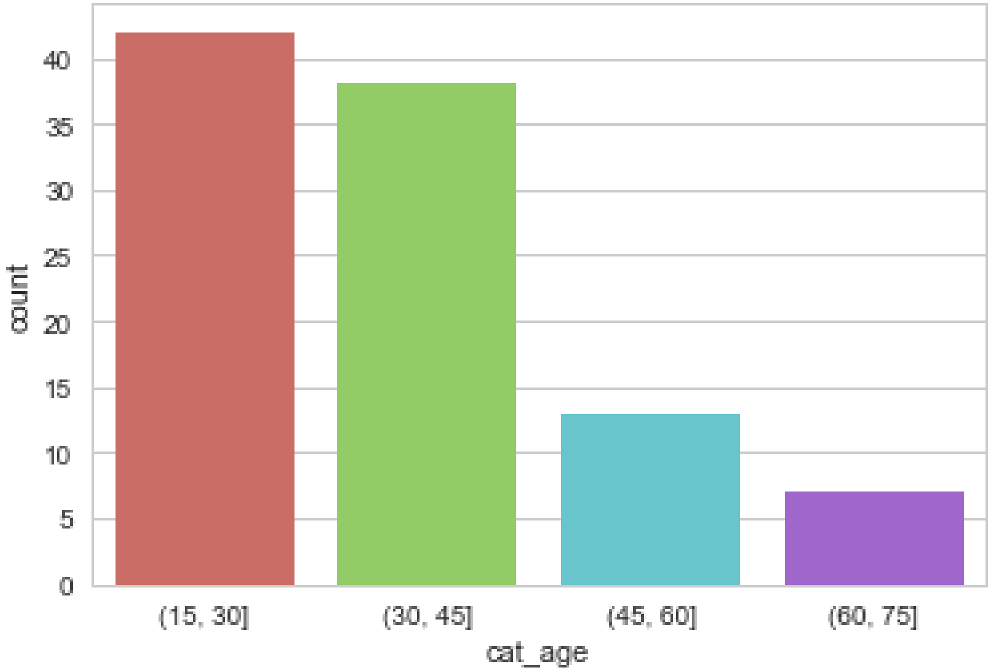
In [71]:
```
# set up bins
bin = [15, 30, 45, 60, 75]

# use pd.cut
cat_age = pd.cut(num_nasabah_test['age'], bin)
cat_age = cat_age.to_frame()
cat_age.columns = ['cat_age']

# concatenate age and its bin
num_nasabah_test = pd.concat([num_nasabah_test, cat_age], axis=1)
```

In [72]:
```
# draw histogram plot
sns.countplot(x ='cat_age', data=num_nasabah_test, palette='hls')
plt.show()
```

```
c:\users\yasir\anaconda3\lib\site-packages\seaborn\categorical.py:1428: FutureWarning: remove_
  stat_data = remove_na(group_data)
```



Change categorical age into numerical value

In [73]:
```
# change into string 'cat_age'
num_nasabah_test['cat_age'] = num_nasabah_test['cat_age'].astype(str)

# change '(15, 30]' = 0, '(30, 45]' = 1, '(45, 60]' = 2, '(60, 75]' = 3
num_nasabah_test['cat_age_num'] = num_nasabah_test['cat_age'].map({'(15, 30]': 0, '(3
                                                         '(45, 60]': 2, '(60, 75]': 3

# num_nasabah_test.head()
```

```
In [74]: num_nasabah_test = num_nasabah_test.drop(['age', 'cat_age'], axis=1)
         num_nasabah_test.head()
```

```
Out[74]:    percent_of_income  years_at_residence  dependents  cat_age_num
         0                  2                   2           1            0
         1                  1                   1           1            0
         2                  4                   2           1            1
         3                  3                   4           1            1
         4                  2                   1           1            0
```

6.3 Merge categorical and numerical data

```
In [75]: nasabah_test_merge = pd.concat([cat_nasabah_test, num_nasabah_test], axis=1)
         nasabah_test_merge.head()
```

```
Out[75]:    checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    1                   2
         1                     2                    1                   2
         2                     1                    2                   2
         3                     2                    2                   0
         4                     0                    0                   0

            employment_duration_num  purpose_business  purpose_car  purpose_car0  \
         0                        2                 0            0             0
         1                        2                 0            0             0
         2                        2                 0            0             0
         3                        1                 0            1             0
         4                        2                 0            0             0

            purpose_education  purpose_furniture/appliances  purpose_renovations  \
         0                  0                             1                    0
         1                  0                             1                    0
         2                  0                             1                    0
         3                  0                             0                    0
         4                  0                             1                    0

               ...       job_management  job_skilled  job_unemployed  job_unskilled  \
         0     ...                    0            1               0              0
         1     ...                    0            1               0              0
         2     ...                    0            0               0              1
         3     ...                    0            1               0              0
         4     ...                    0            1               0              0

            phone_num  default_num  percent_of_income  years_at_residence  dependents  \
         0          0            1                  2                   2           1
         1          1            0                  1                   1           1
         2          0            1                  4                   2           1
         3          0            0                  3                   4           1
```

```
4          0            0                  2                   1           1

   cat_age_num
0            0
1            0
2            1
3            1
4            0

[5 rows x 26 columns]
```

```
In [76]: nasabah_test_prepared = nasabah_test_merge.drop('default_num', axis=1)
         nasabah_test_prepared.head()
```

```
Out[76]:    checking_balance_num  savings_balance_num  credit_history_num  \
         0                     2                    1                   2
         1                     2                    1                   2
         2                     1                    2                   2
         3                     2                    2                   0
         4                     0                    0                   0

            employment_duration_num  purpose_business  purpose_car  purpose_car0  \
         0                        2                 0            0             0
         1                        2                 0            0             0
         2                        2                 0            0             0
         3                        1                 0            1             0
         4                        2                 0            0             0

            purpose_education  purpose_furniture/appliances  purpose_renovations  \
         0                  0                             1                    0
         1                  0                             1                    0
         2                  0                             1                    0
         3                  0                             0                    0
         4                  0                             1                    0

               ...       housing_rent  job_management  job_skilled  job_unemployed  \
         0     ...                  0               0            1               0
         1     ...                  0               0            1               0
         2     ...                  0               0            0               0
         3     ...                  0               0            1               0
         4     ...                  0               0            1               0

            job_unskilled  phone_num  percent_of_income  years_at_residence  \
         0              0          0                  2                   2
         1              0          1                  1                   1
         2              1          0                  4                   2
         3              0          0                  3                   4
         4              0          0                  2                   1
```

```
   dependents  cat_age_num
0           1            0
1           1            0
2           1            1
3           1            1
4           1            0

[5 rows x 25 columns]
```

```
In [77]: nasabah_test_labels = nasabah_test_merge['default_num']
         nasabah_test_labels.head()
```

```
Out[77]: 0    1
         1    0
         2    1
         3    0
         4    0
         Name: default_num, dtype: int32
```

7 Predict

```
In [78]: final_model = grid_search.best_estimator_
         predictions = final_model.predict(nasabah_test_prepared)
```

8 Accuracy Score

```
In [79]: from sklearn.metrics import accuracy_score
```

```
In [80]: accuracy_score(nasabah_test_labels, predictions)
```

```
Out[80]: 0.69
```

8.1 Question 8

Diberikan cross tabulasi perbandingan klasifikasi default hasil prediksi dan aktual menggunakan model decision tree sebagai berikut:

		actual	
		no	yes
predicted	no	57	12
	yes	16	15

Berapa banyak observasi yang yang salah diklasifikasikan oleh model decision tree tersebut?
Answer: 28

```
In [81]: # banyak observasi yang salah diklasifikasikan = False positive + False negative
```

```
         result = 12 + 16
         result

Out[81]: 28
```

8.2 Question 9

Berdasarkan tabel cross tabulasi sebelumnya, metrik pengukuran apa yang dapat digunakan sebagai pertimbangan pemilihan model?

Answer: accuracy 72%, recall 55%

```
In [82]: accuracy = (57+15)/(57+12+16+15)
         accuracy

Out[82]: 0.72

In [83]: precision = 15/(15+16)
         precision

Out[83]: 0.4838709677419355

In [84]: recall = 15/(15+12)
         recall

Out[84]: 0.5555555555555556
```

8.3 Question 10

Metode yang tidak tepat untuk mengevaluasi masalah klasifikasi dan membandingkan performa klasifier adalah :

Answer: R-squared