

# FML\_Assignment\_2

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```
library(class)
library(dplyr)
```

```
##
## Attaching package: 'dplyr'

## The following objects are masked from 'package:stats':
##
##   filter, lag

## The following objects are masked from 'package:base':
##
##   intersect, setdiff, setequal, union
```

```
library(caret)
```

```
## Loading required package: ggplot2
```

```
## Loading required package: lattice
```

```
library(gmodels)
#loading data set
dataset_univ_bank<-read.csv("C:/Users/pc/Downloads/UniversalBank.csv")
head(dataset_univ_bank)
```

```
##   ID Age Experience Income ZIP.Code Family CCAvg Education Mortgage
## 1  1  25         1     49   91107      4   1.6         1         0
## 2  2  45        19     34   90089      3   1.5         1         0
## 3  3  39        15     11   94720      1   1.0         1         0
## 4  4  35         9    100   94112      1   2.7         2         0
## 5  5  35         8     45   91330      4   1.0         2         0
## 6  6  37        13     29   92121      4   0.4         2        155
##   Personal.Loan Securities.Account CD.Account Online CreditCard
## 1             0                 1           0         0         0
## 2             0                 1           0         0         0
## 3             0                 0           0         0         0
## 4             0                 0           0         0         0
## 5             0                 0           0         0         1
## 6             0                 0           0         1         0
```

```
#removing unwanted columns i.e ID and Zip code
```

```
dataset_univ_bank_1<-dataset_univ_bank[,-1]
```

```
head(dataset_univ_bank_1)
```

```
##      Age Experience Income ZIP.Code Family CCAvg Education Mortgage Personal.Loan
## 1   25           1     49   91107      4   1.6           1         0           0
## 2   45          19     34   90089      3   1.5           1         0           0
## 3   39          15     11   94720      1   1.0           1         0           0
## 4   35           9    100   94112      1   2.7           2         0           0
## 5   35           8     45   91330      4   1.0           2         0           0
## 6   37          13     29   92121      4   0.4           2        155          0
##      Securities.Account CD.Account Online CreditCard
## 1                      1           0      0           0
## 2                      1           0      0           0
## 3                      0           0      0           0
## 4                      0           0      0           0
## 5                      0           0      0           1
## 6                      0           0      1           0
```

```
dataset_univ_bank_1<-dataset_univ_bank_1[,-4]
```

```
head(dataset_univ_bank_1)
```

```
##      Age Experience Income Family CCAvg Education Mortgage Personal.Loan
## 1   25           1     49      4   1.6           1         0           0
## 2   45          19     34      3   1.5           1         0           0
## 3   39          15     11      1   1.0           1         0           0
## 4   35           9    100      1   2.7           2         0           0
## 5   35           8     45      4   1.0           2         0           0
## 6   37          13     29      4   0.4           2        155          0
##      Securities.Account CD.Account Online CreditCard
## 1                      1           0      0           0
## 2                      1           0      0           0
## 3                      0           0      0           0
## 4                      0           0      0           0
## 5                      0           0      0           1
## 6                      0           0      1           0
```

```
#converting personal loan as factor
```

```
dataset_univ_bank_1$Personal.Loan=as.factor(dataset_univ_bank_1$Personal.Loan)
```

```
#running is.na to check if there are any NA values
```

```
head(is.na(dataset_univ_bank_1))
```

```
##      Age Experience Income Family CCAvg Education Mortgage Personal.Loan
## [1,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
## [2,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
## [3,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
## [4,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
## [5,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
## [6,] FALSE      FALSE FALSE  FALSE FALSE      FALSE      FALSE      FALSE
##      Securities.Account CD.Account Online CreditCard
## [1,]                FALSE      FALSE FALSE      FALSE
```

```
## [2,] FALSE FALSE FALSE FALSE
## [3,] FALSE FALSE FALSE FALSE
## [4,] FALSE FALSE FALSE FALSE
## [5,] FALSE FALSE FALSE FALSE
## [6,] FALSE FALSE FALSE FALSE
```

```
any(is.na(dataset_univ_bank_1))
```

```
## [1] FALSE
```

```
# Converting categorical variable into i.e education into dummy variables
```

```
#converting education into character
```

```
education<-as.character(dataset_univ_bank_1$Education)
```

```
dataset_univ_bank_2<-cbind(dataset_univ_bank_1[, -6], education)
```

```
head(dataset_univ_bank_2)
```

```
##   Age Experience Income Family CCAvg Mortgage Personal.Loan Securities.Account
## 1  25          1     49      4   1.6         0           0                1
## 2  45         19     34      3   1.5         0           0                1
## 3  39         15     11      1   1.0         0           0                0
## 4  35          9    100      1   2.7         0           0                0
## 5  35          8     45      4   1.0         0           0                0
## 6  37         13     29      4   0.4        155         0                0
##   CD.Account Online CreditCard education
## 1          0      0           0         1
## 2          0      0           0         1
## 3          0      0           0         1
## 4          0      0           0         2
## 5          0      0           1         2
## 6          0      1           0         2
```

```
dummymodel<-dummyVars("~education", data = dataset_univ_bank_2)
```

```
educationdummy<-data.frame(predict(dummymodel, dataset_univ_bank_2))
```

```
head(educationdummy)
```

```
##   education1 education2 education3
## 1          1          0          0
## 2          1          0          0
## 3          1          0          0
## 4          0          1          0
## 5          0          1          0
## 6          0          1          0
```

```
dataset_univ_bank_dummy<-cbind(dataset_univ_bank_2[, -12], educationdummy)
```

```
head(dataset_univ_bank_dummy)
```

```
##   Age Experience Income Family CCAvg Mortgage Personal.Loan Securities.Account
## 1  25          1     49      4   1.6         0           0                1
## 2  45         19     34      3   1.5         0           0                1
```

```
## 3 39      15      11      1 1.0      0      0      0
## 4 35      9      100     1 2.7      0      0      0
## 5 35      8      45      4 1.0      0      0      0
## 6 37     13      29      4 0.4     155      0      0
##   CD.Account Online CreditCard education1 education2 education3
## 1      0      0      0      1      0      0
## 2      0      0      0      1      0      0
## 3      0      0      0      1      0      0
## 4      0      0      0      0      1      0
## 5      0      0      1      0      1      0
## 6      0      1      0      0      1      0
```

```
#dividing data into training and testing set
set.seed(555)
train<-createDataPartition(dataset_univ_bank_dummy$Personal.Loan,p=0.60,list = FALSE)
train_set<-dataset_univ_bank_dummy[train,]
nrow(train_set)
```

```
## [1] 3000
```

```
validation_set<-dataset_univ_bank_dummy[-train,]
nrow(validation_set)
```

```
## [1] 2000
```

```
test_set<-data.frame(Age = 40, Experience = 10, Income = 84, Family = 2, CCAvg = 2, Mortgage = 0, Securities.Account = 1,
  CreditCard = 1,education1 = 0, education2 = 1, education3 = 0)

summary(train_set)
```

```
##      Age      Experience      Income      Family
## Min.   :23.00  Min.   : -3.00  Min.    :  8.00  Min.    :1.000
## 1st Qu.:35.00  1st Qu.:10.00  1st Qu.: 40.00  1st Qu.:1.000
## Median :45.00  Median :20.00  Median : 65.00  Median :2.000
## Mean   :45.31  Mean   :20.08  Mean    :74.81  Mean    :2.382
## 3rd Qu.:55.00  3rd Qu.:30.00  3rd Qu.:100.00  3rd Qu.:3.000
## Max.   :67.00  Max.   :43.00  Max.    :224.00  Max.    :4.000
##      CCAvg      Mortgage      Personal.Loan      Securities.Account
## Min.   : 0.000  Min.    :  0.00  0:2712      Min.    :0.0000
## 1st Qu.: 0.700  1st Qu.:  0.00  1: 288      1st Qu.:0.0000
## Median : 1.500  Median :  0.00              Median :0.0000
## Mean    : 1.946  Mean     :56.32              Mean    :0.1067
## 3rd Qu.: 2.600  3rd Qu.:101.00              3rd Qu.:0.0000
## Max.    :10.000  Max.     :635.00              Max.    :1.0000
##      CD.Account      Online      CreditCard      education1
## Min.   :0.00000  Min.   :0.0000  Min.    :0.000  Min.    :0.0000
## 1st Qu.:0.00000  1st Qu.:0.0000  1st Qu.:0.000  1st Qu.:0.0000
## Median :0.00000  Median :1.0000  Median :0.000  Median :0.0000
## Mean    :0.06167  Mean    :0.5963  Mean     :0.297  Mean     :0.4267
## 3rd Qu.:0.00000  3rd Qu.:1.0000  3rd Qu.:1.000  3rd Qu.:1.0000
## Max.    :1.00000  Max.    :1.0000  Max.     :1.000  Max.     :1.0000
```

```
##      education2      education3
## Min.      :0.00      Min.      :0.0000
## 1st Qu.:0.00      1st Qu.:0.0000
## Median :0.00      Median :0.0000
## Mean      :0.28      Mean      :0.2933
## 3rd Qu.:1.00      3rd Qu.:1.0000
## Max.      :1.00      Max.      :1.0000
```

```
summary(validation_set)
```

```
##      Age      Experience      Income      Family
## Min.      :23.00      Min.      : -3.00      Min.      :  8.00      Min.      :1.000
## 1st Qu.:35.00      1st Qu.:10.00      1st Qu.: 38.00      1st Qu.:1.000
## Median :45.50      Median :20.00      Median : 62.00      Median :2.000
## Mean      :45.38      Mean      :20.14      Mean      : 72.22      Mean      :2.418
## 3rd Qu.:55.00      3rd Qu.:30.00      3rd Qu.: 94.00      3rd Qu.:4.000
## Max.      :67.00      Max.      :43.00      Max.      :205.00      Max.      :4.000
##      CCAvg      Mortgage      Personal.Loan      Securities.Account
## Min.      :0.000      Min.      :  0.00      0:1808      Min.      :0.000
## 1st Qu.:0.700      1st Qu.:  0.00      1: 192      1st Qu.:0.000
## Median :1.500      Median :  0.00      Median :0.000
## Mean      :1.925      Mean      : 56.77      Mean      :0.101
## 3rd Qu.:2.500      3rd Qu.:101.00      3rd Qu.:0.000
## Max.      :9.300      Max.      :617.00      Max.      :1.000
##      CD.Account      Online      CreditCard      education1
## Min.      :0.0000      Min.      :0.0000      Min.      :0.0000      Min.      :0.000
## 1st Qu.:0.0000      1st Qu.:0.0000      1st Qu.:0.0000      1st Qu.:0.000
## Median :0.0000      Median :1.0000      Median :0.0000      Median :0.000
## Mean      :0.0585      Mean      :0.5975      Mean      :0.2895      Mean      :0.408
## 3rd Qu.:0.0000      3rd Qu.:1.0000      3rd Qu.:1.0000      3rd Qu.:1.000
## Max.      :1.0000      Max.      :1.0000      Max.      :1.0000      Max.      :1.000
##      education2      education3
## Min.      :0.0000      Min.      :0.0000
## 1st Qu.:0.0000      1st Qu.:0.0000
## Median :0.0000      Median :0.0000
## Mean      :0.2815      Mean      :0.3105
## 3rd Qu.:1.0000      3rd Qu.:1.0000
## Max.      :1.0000      Max.      :1.0000
```

```
summary(test_set)
```

```
##      Age      Experience      Income      Family      CCAvg      Mortgage
## Min.      :40      Min.      :10      Min.      :84      Min.      :2      Min.      :2      Min.      :0
## 1st Qu.:40      1st Qu.:10      1st Qu.:84      1st Qu.:2      1st Qu.:2      1st Qu.:0
## Median :40      Median :10      Median :84      Median :2      Median :2      Median :0
## Mean      :40      Mean      :10      Mean      :84      Mean      :2      Mean      :2      Mean      :0
## 3rd Qu.:40      3rd Qu.:10      3rd Qu.:84      3rd Qu.:2      3rd Qu.:2      3rd Qu.:0
## Max.      :40      Max.      :10      Max.      :84      Max.      :2      Max.      :2      Max.      :0
##      Securities.Account      CD.Account      Online      CreditCard      education1
## Min.      :0      Min.      :0      Min.      :1      Min.      :1      Min.      :0
## 1st Qu.:0      1st Qu.:0      1st Qu.:1      1st Qu.:1      1st Qu.:0
## Median :0      Median :0      Median :1      Median :1      Median :0
## Mean      :0      Mean      :0      Mean      :1      Mean      :1      Mean      :0
```

```
## 3rd Qu.:0          3rd Qu.:0      3rd Qu.:1      3rd Qu.:1      3rd Qu.:0
## Max. :0           Max. :0       Max. :1       Max. :1       Max. :0
## education2 education3
## Min. :1          Min. :0
## 1st Qu.:1        1st Qu.:0
## Median :1         Median :0
## Mean :1           Mean :0
## 3rd Qu.:1         3rd Qu.:0
## Max. :1           Max. :0
```

*#normalizing*

```
normvar<-c('Age','Experience','Income','Family','CCAvg','Mortgage','Securities.Account','CD.Account','Online.Loan','CreditCard','education1','education2','education3')
normalization_values<-preProcess(train_set[,normvar],method = c('center','scale'))

train_set.norm<-predict(normalization_values,train_set)
summary(train_set.norm)
```

```
##      Age      Experience      Income      Family
## Min. :-1.95104 Min. :-2.0186 Min. :-1.4431 Min. :-1.2107
## 1st Qu.: -0.90159 1st Qu.: -0.8817 1st Qu.: -0.7519 1st Qu.: -1.2107
## Median : -0.02705 Median : -0.0072 Median : -0.2119 Median : -0.3344
## Mean : 0.00000 Mean : 0.0000 Mean : 0.0000 Mean : 0.0000
## 3rd Qu.: 0.84749 3rd Qu.: 0.8673 3rd Qu.: 0.5441 3rd Qu.: 0.5418
## Max. : 1.89694 Max. : 2.0042 Max. : 3.2226 Max. : 1.4180
##      CCAvg      Mortgage      Personal.Loan      Securities.Account
## Min. :-1.0976 Min. :-0.5527 0:2712 Min. :-0.3455
## 1st Qu.: -0.7028 1st Qu.: -0.5527 1: 288 1st Qu.: -0.3455
## Median : -0.2517 Median : -0.5527 Median : -0.3455
## Mean : 0.0000 Mean : 0.0000 Mean : 0.0000
## 3rd Qu.: 0.3687 3rd Qu.: 0.4385 3rd Qu.: -0.3455
## Max. : 4.5418 Max. : 5.6790 Max. : 2.8935
##      CD.Account      Online      CreditCard      education1
## Min. :-0.2563 Min. :-1.2152 Min. :-0.6499 Min. :-0.8625
## 1st Qu.: -0.2563 1st Qu.: -1.2152 1st Qu.: -0.6499 1st Qu.: -0.8625
## Median : -0.2563 Median : 0.8226 Median : -0.6499 Median : -0.8625
## Mean : 0.0000 Mean : 0.0000 Mean : 0.0000 Mean : 0.0000
## 3rd Qu.: -0.2563 3rd Qu.: 0.8226 3rd Qu.: 1.5383 3rd Qu.: 1.1590
## Max. : 3.9001 Max. : 0.8226 Max. : 1.5383 Max. : 1.1590
##      education2      education3
## Min. :-0.6235 Min. :-0.6442
## 1st Qu.: -0.6235 1st Qu.: -0.6442
## Median : -0.6235 Median : -0.6442
## Mean : 0.0000 Mean : 0.0000
## 3rd Qu.: 1.6033 3rd Qu.: 1.5519
## Max. : 1.6033 Max. : 1.5519
```

```
validation_set.norm<-predict(normalization_values,validation_set)
summary(validation_set.norm)
```

```
##      Age      Experience      Income      Family
## Min. :-1.951044 Min. :-2.018590 Min. :-1.44310 Min. :-1.21067
## 1st Qu.: -0.901594 1st Qu.: -0.881718 1st Qu.: -0.79509 1st Qu.: -1.21067
```

```
## Median : 0.016675 Median :-0.007200 Median :-0.27668 Median :-0.33443
## Mean : 0.006355 Mean : 0.004868 Mean :-0.05588 Mean : 0.03227
## 3rd Qu.: 0.847489 3rd Qu.: 0.867317 3rd Qu.: 0.41453 3rd Qu.: 1.41805
## Max. : 1.896939 Max. : 2.004190 Max. : 2.81218 Max. : 1.41805
## CCAvg Mortgage Personal.Loan Securities.Account
## Min. :-1.09759 Min. :-0.552664 0:1808 Min. :-0.34549
## 1st Qu.: -0.70283 1st Qu.: -0.552664 1: 192 1st Qu.: -0.34549
## Median : -0.25168 Median : -0.552664 Median : -0.34549
## Mean : -0.01177 Mean : 0.004477 Mean : -0.01835
## 3rd Qu.: 0.31226 3rd Qu.: 0.438506 3rd Qu.: -0.34549
## Max. : 4.14705 Max. : 5.502307 Max. : 2.89348
## CD.Account Online CreditCard education1
## Min. :-0.25632 Min. :-1.215236 Min. :-0.64987 Min. :-0.86252
## 1st Qu.: -0.25632 1st Qu.: -1.215236 1st Qu.: -0.64987 1st Qu.: -0.86252
## Median : -0.25632 Median : 0.822611 Median : -0.64987 Median : -0.86252
## Mean : -0.01316 Mean : 0.002377 Mean : -0.01641 Mean : -0.03774
## 3rd Qu.: -0.25632 3rd Qu.: 0.822611 3rd Qu.: 1.53825 3rd Qu.: 1.15901
## Max. : 3.90015 Max. : 0.822611 Max. : 1.53825 Max. : 1.15901
## education2 education3
## Min. :-0.62351 Min. :-0.6442
## 1st Qu.: -0.62351 1st Qu.: -0.6442
## Median : -0.62351 Median : -0.6442
## Mean : 0.00334 Mean : 0.0377
## 3rd Qu.: 1.60330 3rd Qu.: 1.5519
## Max. : 1.60330 Max. : 1.5519
```

```
test_set.norm<-predict(normalization_values,test_set)
summary(test_set.norm)
```

```
## Age Experience Income Family
## Min. :-0.4643 Min. :-0.8817 Min. :0.1985 Min. :-0.3344
## 1st Qu.: -0.4643 1st Qu.: -0.8817 1st Qu.:0.1985 1st Qu.: -0.3344
## Median : -0.4643 Median : -0.8817 Median :0.1985 Median : -0.3344
## Mean : -0.4643 Mean : -0.8817 Mean :0.1985 Mean : -0.3344
## 3rd Qu.: -0.4643 3rd Qu.: -0.8817 3rd Qu.:0.1985 3rd Qu.: -0.3344
## Max. : -0.4643 Max. : -0.8817 Max. :0.1985 Max. : -0.3344
## CCAvg Mortgage Securities.Account CD.Account
## Min. :0.03029 Min. :-0.5527 Min. :-0.3455 Min. :-0.2563
## 1st Qu.:0.03029 1st Qu.: -0.5527 1st Qu.: -0.3455 1st Qu.: -0.2563
## Median :0.03029 Median : -0.5527 Median : -0.3455 Median : -0.2563
## Mean :0.03029 Mean : -0.5527 Mean : -0.3455 Mean : -0.2563
## 3rd Qu.:0.03029 3rd Qu.: -0.5527 3rd Qu.: -0.3455 3rd Qu.: -0.2563
## Max. :0.03029 Max. : -0.5527 Max. : -0.3455 Max. : -0.2563
## Online CreditCard education1 education2
## Min. :0.8226 Min. :1.538 Min. :-0.8625 Min. :1.603
## 1st Qu.:0.8226 1st Qu.:1.538 1st Qu.: -0.8625 1st Qu.:1.603
## Median :0.8226 Median :1.538 Median : -0.8625 Median :1.603
## Mean :0.8226 Mean :1.538 Mean : -0.8625 Mean :1.603
## 3rd Qu.:0.8226 3rd Qu.:1.538 3rd Qu.: -0.8625 3rd Qu.:1.603
## Max. :0.8226 Max. :1.538 Max. : -0.8625 Max. :1.603
## education3
## Min. :-0.6442
## 1st Qu.: -0.6442
## Median : -0.6442
```

```
## Mean    :-0.6442
## 3rd Qu. :-0.6442
## Max.    :-0.6442
```

```
#question 1: Classifying the given customer
```

```
set.seed(555)
new_grid<-expand.grid(k=c(1))
new_model<-train(Personal.Loan~.,data=train_set.norm,method="knn",tuneGrid=new_grid)

new_model
```

```
## k-Nearest Neighbors
##
## 3000 samples
## 13 predictor
## 2 classes: '0', '1'
##
## No pre-processing
## Resampling: Bootstrapped (25 reps)
## Summary of sample sizes: 3000, 3000, 3000, 3000, 3000, 3000, ...
## Resampling results:
##
## Accuracy Kappa
## 0.9518741 0.6936177
##
## Tuning parameter 'k' was held constant at a value of 1
```

```
predict_test<-predict(new_model,test_set.norm)
predict_test
```

```
## [1] 0
## Levels: 0 1
```

```
#question 2: identifying the best k
```

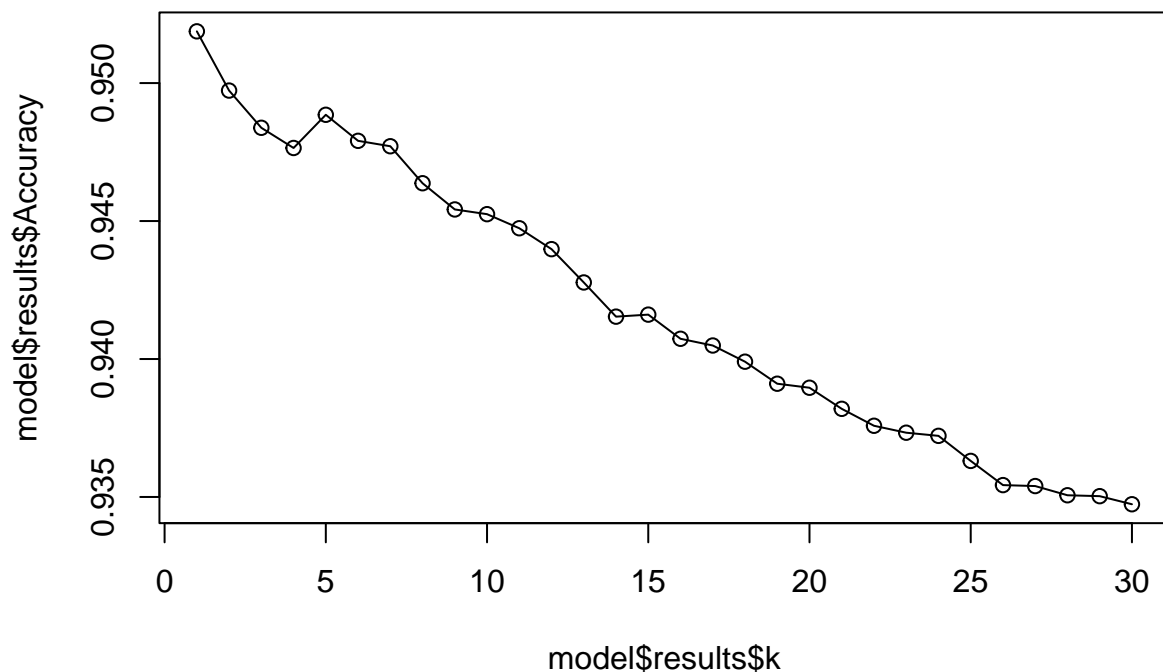
```
set.seed(555)
searchGrid <- expand.grid(k=seq(1:30))
model<-train(Personal.Loan~.,data=train_set.norm,method="knn",tuneGrid=searchGrid)
model
```

```
## k-Nearest Neighbors
##
## 3000 samples
## 13 predictor
## 2 classes: '0', '1'
##
## No pre-processing
## Resampling: Bootstrapped (25 reps)
## Summary of sample sizes: 3000, 3000, 3000, 3000, 3000, 3000, ...
## Resampling results across tuning parameters:
##
## k Accuracy Kappa
## 1 0.9518741 0.6936177
```



```
##      2  0.9497284  0.6783892
##      3  0.9483786  0.6611715
##      4  0.9476472  0.6493192
##      5  0.9488503  0.6502041
##      6  0.9479069  0.6389555
##      7  0.9477101  0.6312418
##      8  0.9463695  0.6188154
##      9  0.9454200  0.6064940
##     10  0.9452489  0.6023107
##     11  0.9447388  0.5956424
##     12  0.9439812  0.5885615
##     13  0.9427742  0.5771545
##     14  0.9415347  0.5630486
##     15  0.9416088  0.5628185
##     16  0.9407328  0.5548557
##     17  0.9404893  0.5516391
##     18  0.9399027  0.5455684
##     19  0.9391046  0.5359012
##     20  0.9389587  0.5339743
##     21  0.9381946  0.5253688
##     22  0.9375805  0.5184377
##     23  0.9373295  0.5160644
##     24  0.9372150  0.5151960
##     25  0.9363069  0.5052569
##     26  0.9354303  0.4956116
##     27  0.9353960  0.4944564
##     28  0.9350620  0.4895966
##     29  0.9350298  0.4882462
##     30  0.9347369  0.4839273
##
## Accuracy was used to select the optimal model using the largest value.
## The final value used for the model was k = 1.
```

```
plot(model$results$k,model$results$Accuracy, type = 'o')
```



```
#finding the best k
best_k <- model$bestTune[[1]]
best_k
```

```
## [1] 1
```

```
#question3:confusion matrix
library(gmodels)

train_label<-train_set.norm[,7]
validation_label<-validation_set.norm[,7]
test_label<-test_set.norm[,7]

predicted_validation_label<-knn(train_set.norm,validation_set.norm,cl=train_label,k=5)

CrossTable(x=validation_label,y=predicted_validation_label,prop.chisq = FALSE)
```

```
##
##
##      Cell Contents
## |-----|
## |                      N |
## |      N / Row Total |
## |      N / Col Total |
## |      N / Table Total |
```

```
## |-----|
##
##
## Total Observations in Table:  2000
##
##
##      | predicted_validation_label
## validation_label |          0 |          1 | Row Total |
## -----|-----|-----|-----|
##           0 |      1803 |          5 |      1808 |
##           |      0.997 |      0.003 |      0.904 |
##           |      0.971 |      0.035 |           |
##           |      0.901 |      0.002 |           |
## -----|-----|-----|-----|
##           1 |         54 |        138 |         192 |
##           |      0.281 |      0.719 |      0.096 |
##           |      0.029 |      0.965 |           |
##           |      0.027 |      0.069 |           |
## -----|-----|-----|-----|
##      Column Total |      1857 |         143 |      2000 |
##           |      0.928 |      0.071 |           |
## -----|-----|-----|-----|
##
##
```

```
#question4:Classifying the given customer with best k
set.seed(555)
bestk_grid<-expand.grid(k=c(best_k))
bestk_model<-train(Personal.Loan~.,data=train_set.norm,method="knn",tuneGrid=bestk_grid)
bestk_model
```

```
## k-Nearest Neighbors
##
## 3000 samples
## 13 predictor
## 2 classes: '0', '1'
##
## No pre-processing
## Resampling: Bootstrapped (25 reps)
## Summary of sample sizes: 3000, 3000, 3000, 3000, 3000, 3000, ...
## Resampling results:
##
## Accuracy   Kappa
## 0.9518741  0.6936177
##
## Tuning parameter 'k' was held constant at a value of 1
```

```
bestk_test<-predict(bestk_model,test_set.norm)
bestk_test
```

```
## [1] 0
## Levels: 0 1
```

```
#question5:confusion matrix for validation and training sets
#dividing dataset into training, validation and testing set
set.seed(555)
train1<-createDataPartition(dataset_univ_bank_dummy$Personal.Loan,p=0.50,list = FALSE)
train_set_2<-dataset_univ_bank_dummy[train1,]
middle_set<-dataset_univ_bank_dummy[-train1,]
nrow(middle_set)
```

```
## [1] 2500
```

```
train2<-createDataPartition(middle_set$Personal.Loan,p=0.6,list = FALSE)
validation_set_2<-middle_set[train2,]
test_set_2<-middle_set[-train2,]
nrow(train_set_2)
```

```
## [1] 2500
```

```
nrow(validation_set_2)
```

```
## [1] 1500
```

```
nrow(test_set_2)
```

```
## [1] 1000
```

```
#normalizing trainset_2, validationset_2, testset_2
```

```
normvar<-c('Age','Experience','Income','Family','CCAvg','Mortgage','Securities.Account','CD.Account','Online','CreditCard','education1')
normalization_values_2<-preProcess(train_set_2[,normvar],method = c('center','scale'))
train_set.norm_2<-predict(normalization_values_2,train_set_2)
summary(train_set.norm_2)
```

```
##      Age      Experience      Income      Family
##  Min.   :-1.93768    Min.   :-2.009123   Min.   :-1.4553    Min.   :-1.2004
##  1st Qu.: -0.89130    1st Qu.: -0.873828   1st Qu.: -0.7568    1st Qu.: -1.2004
##  Median : -0.01932    Median : -0.000524   Median : -0.2111    Median : -0.3216
##  Mean    :  0.00000    Mean    :  0.000000   Mean    :  0.0000    Mean    :  0.0000
##  3rd Qu.:  0.85266    3rd Qu.:  0.872780   3rd Qu.:  0.5747    3rd Qu.:  0.5571
##  Max.     :  1.89903    Max.     :  2.008075   Max.     :  3.1285    Max.     :  1.4359
##      CCAvg      Mortgage      Personal.Loan  Securities.Account
##  Min.   :-1.1142    Min.   :-0.5617     0: 2260        Min.   :-0.3435
##  1st Qu.: -0.7136    1st Qu.: -0.5617     1: 240         1st Qu.: -0.3435
##  Median : -0.1987    Median : -0.5617                     Median : -0.3435
##  Mean    :  0.0000    Mean    :  0.0000                     Mean    :  0.0000
##  3rd Qu.:  0.3735    3rd Qu.:  0.4160                     3rd Qu.: -0.3435
##  Max.     :  4.0353    Max.     :  5.4080                     Max.     :  2.9097
##      CD.Account      Online      CreditCard      education1
##  Min.   :-0.2454    Min.   :-1.2093    Min.   :-0.652    Min.   :-0.8648
```

```
## 1st Qu.: -0.2454 1st Qu.: -1.2093 1st Qu.: -0.652 1st Qu.: -0.8648
## Median : -0.2454 Median : 0.8266 Median : -0.652 Median : -0.8648
## Mean : 0.0000 Mean : 0.0000 Mean : 0.000 Mean : 0.0000
## 3rd Qu.: -0.2454 3rd Qu.: 0.8266 3rd Qu.: 1.533 3rd Qu.: 1.1558
## Max. : 4.0742 Max. : 0.8266 Max. : 1.533 Max. : 1.1558
## education2 education3
## Min. : -0.6315 Min. : -0.634
## 1st Qu.: -0.6315 1st Qu.: -0.634
## Median : -0.6315 Median : -0.634
## Mean : 0.0000 Mean : 0.000
## 3rd Qu.: 1.5828 3rd Qu.: 1.577
## Max. : 1.5828 Max. : 1.577
```

```
validation_set.norm_2 <- predict(normalization_values_2, validation_set_2)
summary(validation_set.norm_2)
```

```
## Age Experience Income Family
## Min. : -1.93768 Min. : -2.009123 Min. : -1.4553 Min. : -1.20039
## 1st Qu.: -0.80410 1st Qu.: -0.786498 1st Qu.: -0.7841 1st Qu.: -1.20039
## Median : -0.01932 Median : -0.000524 Median : -0.2766 Median : -0.32163
## Mean : 0.02532 Mean : 0.021076 Mean : -0.0367 Mean : 0.02578
## 3rd Qu.: 0.85266 3rd Qu.: 0.872780 3rd Qu.: 0.4601 3rd Qu.: 0.55714
## Max. : 1.89903 Max. : 2.008075 Max. : 3.2595 Max. : 1.43590
## CCAvg Mortgage Personal.Loan Securities.Account
## Min. : -1.11415 Min. : -0.56174 0:1356 Min. : -0.343541
## 1st Qu.: -0.71364 1st Qu.: -0.56174 1: 144 1st Qu.: -0.343541
## Median : -0.25592 Median : -0.56174 Median : -0.343541
## Mean : -0.01726 Mean : -0.05339 Mean : -0.007374
## 3rd Qu.: 0.31624 3rd Qu.: 0.36193 3rd Qu.: -0.343541
## Max. : 4.60742 Max. : 4.97559 Max. : 2.909692
## CD.Account Online CreditCard education1
## Min. : -0.24535 Min. : -1.20933 Min. : -0.6520 Min. : -0.86484
## 1st Qu.: -0.24535 1st Qu.: -1.20933 1st Qu.: -0.6520 1st Qu.: -0.86484
## Median : -0.24535 Median : 0.82658 Median : -0.6520 Median : -0.86484
## Mean : 0.03398 Mean : -0.01086 Mean : -0.0169 Mean : -0.01347
## 3rd Qu.: -0.24535 3rd Qu.: 0.82658 3rd Qu.: 1.5331 3rd Qu.: 1.15582
## Max. : 4.07419 Max. : 0.82658 Max. : 1.5331 Max. : 1.15582
## education2 education3
## Min. : -0.63153 Min. : -0.63401
## 1st Qu.: -0.63153 1st Qu.: -0.63401
## Median : -0.63153 Median : -0.63401
## Mean : -0.03513 Mean : 0.04981
## 3rd Qu.: 1.58282 3rd Qu.: 1.57663
## Max. : 1.58282 Max. : 1.57663
```

```
test_set.norm_2 <- predict(normalization_values_2, test_set_2)
summary(test_set.norm_2)
```

```
## Age Experience Income Family
## Min. : -1.93768 Min. : -2.00912 Min. : -1.45534 Min. : -1.20039
## 1st Qu.: -0.89130 1st Qu.: -0.96116 1st Qu.: -0.80050 1st Qu.: -1.20039
## Median : 0.06787 Median : 0.08681 Median : -0.25480 Median : -0.32163
## Mean : 0.01294 Mean : 0.01144 Mean : -0.04307 Mean : 0.09491
```

```
## 3rd Qu.: 0.93985 3rd Qu.: 0.87278 3rd Qu.: 0.40549 3rd Qu.: 1.43590
## Max. : 1.89903 Max. : 1.83341 Max. : 2.82295 Max. : 1.43590
## CCAvg Mortgage Personal.Loan Securities.Account
## Min. :-1.114153 Min. :-0.56174 0:904 Min. :-0.343541
## 1st Qu.: -0.713643 1st Qu.: -0.56174 1: 96 1st Qu.: -0.343541
## Median : -0.255917 Median : -0.56174 Median : -0.343541
## Mean : -0.000843 Mean : -0.07284 Mean : -0.008458
## 3rd Qu.: 0.316241 3rd Qu.: 0.35958 3rd Qu.: -0.343541
## Max. : 4.607421 Max. : 4.95679 Max. : 2.909692
## CD.Account Online CreditCard education1
## Min. :-0.24535 Min. :-1.20933 Min. :-0.65203 Min. :-0.8648
## 1st Qu.: -0.24535 1st Qu.: -1.20933 1st Qu.: -0.65203 1st Qu.: -0.8648
## Median : -0.24535 Median : 0.82658 Median : -0.65203 Median : -0.8648
## Mean : 0.02678 Mean : 0.04479 Mean : -0.02272 Mean : -0.0687
## 3rd Qu.: -0.24535 3rd Qu.: 0.82658 3rd Qu.: 1.53306 3rd Qu.: 1.1558
## Max. : 4.07419 Max. : 0.82658 Max. : 1.53306 Max. : 1.1558
## education2 education3
## Min. :-0.631532 Min. :-0.63401
## 1st Qu.: -0.631532 1st Qu.: -0.63401
## Median : -0.631532 Median : -0.63401
## Mean : 0.001772 Mean : 0.07339
## 3rd Qu.: 1.582817 3rd Qu.: 1.57663
## Max. : 1.582817 Max. : 1.57663
```

```
#confusion matrix
library(gmodels)

train_label_2<-train_set.norm_2[,7]
validation_label_2<-validation_set.norm_2[,7]
test_label_2<-test_set.norm_2[,7]

predicted_validationlabel_2<-knn(train_set.norm_2,validation_set.norm_2,cl=train_label_2,k=best_k)

predicted_testlabel_2<-knn(train_set.norm_2,test_set.norm_2,cl=train_label_2,k=best_k)

confusion_matrix_1<-CrossTable(x=validation_label_2,y=predicted_validationlabel_2,prop.chisq = FALSE)
```

```
##
##
## Cell Contents
## |-----|
## | N |
## | N / Row Total |
## | N / Col Total |
## | N / Table Total |
## |-----|
##
##
## Total Observations in Table: 1500
##
## | predicted_validationlabel_2
## validation_label_2 | 0 | 1 | Row Total |
## -----|-----|-----|-----|
```

```
##           0 |      1354 |      2 |      1356 |
##           |      0.999 |      0.001 |      0.904 |
##           |      0.974 |      0.018 |           |
##           |      0.903 |      0.001 |           |
## -----|-----|-----|-----|
##           1 |       36 |      108 |      144 |
##           |      0.250 |      0.750 |      0.096 |
##           |      0.026 |      0.982 |           |
##           |      0.024 |      0.072 |           |
## -----|-----|-----|-----|
##      Column Total |      1390 |      110 |      1500 |
##           |      0.927 |      0.073 |           |
## -----|-----|-----|-----|
##
##
```

```
confusion_matrix_2<-CrossTable(x=test_label_2,y=predicted_testlabel_2,prop.chisq = FALSE)
```

```
##
##
##      Cell Contents
## |-----|
## |              N |
## |      N / Row Total |
## |      N / Col Total |
## |      N / Table Total |
## |-----|
##
##
## Total Observations in Table:  1000
##
##
##      | predicted_testlabel_2
## test_label_2 |      0 |      1 | Row Total |
## -----|-----|-----|-----|
##           0 |      901 |       3 |      904 |
##           |      0.997 |      0.003 |      0.904 |
##           |      0.979 |      0.037 |           |
##           |      0.901 |      0.003 |           |
## -----|-----|-----|-----|
##           1 |       19 |      77 |       96 |
##           |      0.198 |      0.802 |      0.096 |
##           |      0.021 |      0.963 |           |
##           |      0.019 |      0.077 |           |
## -----|-----|-----|-----|
##      Column Total |      920 |       80 |      1000 |
##           |      0.920 |      0.080 |           |
## -----|-----|-----|-----|
##
##
```

```
validation_table<-table(validation_label_2,predicted_validationlabel_2)
confusionMatrix(validation_table)
```

```
## Confusion Matrix and Statistics
##
##           predicted_validationlabel_2
## validation_label_2    0    1
##           0 1354    2
##           1   36 108
##
##           Accuracy : 0.9747
##           95% CI : (0.9654, 0.982)
##           No Information Rate : 0.9267
##           P-Value [Acc > NIR] : 2.894e-16
##
##           Kappa : 0.8368
##
## Mcnemar's Test P-Value : 8.636e-08
##
##           Sensitivity : 0.9741
##           Specificity : 0.9818
##           Pos Pred Value : 0.9985
##           Neg Pred Value : 0.7500
##           Prevalence : 0.9267
##           Detection Rate : 0.9027
##           Detection Prevalence : 0.9040
##           Balanced Accuracy : 0.9780
##
##           'Positive' Class : 0
##
```

```
test_table<-table(test_label_2,predicted_testlabel_2)
confusionMatrix(test_table)
```

```
## Confusion Matrix and Statistics
##
##           predicted_testlabel_2
## test_label_2    0    1
##           0 901    3
##           1  19  77
##
##           Accuracy : 0.978
##           95% CI : (0.9669, 0.9862)
##           No Information Rate : 0.92
##           P-Value [Acc > NIR] : 2.68e-15
##
##           Kappa : 0.863
##
## Mcnemar's Test P-Value : 0.001384
##
##           Sensitivity : 0.9793
##           Specificity : 0.9625
##           Pos Pred Value : 0.9967
##           Neg Pred Value : 0.8021
##           Prevalence : 0.9200
##           Detection Rate : 0.9010
##           Detection Prevalence : 0.9040
```



```
##      Balanced Accuracy : 0.9709
##
##      'Positive' Class : 0
##
```

*# on comparing the confusion matrix of validation set and testing set it can be seen that accuracy and*