FML_Assignment2

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#loading the libraries

```
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(tidyverse)
```

```
## -- Attaching core tidyverse packages ------------------------ tidyverse 2.0.0 --
## v forcats   1.0.0     v stringr   1.5.1
## v lubridate 1.9.3     v tibble    3.2.1
## v purrr     1.0.2     v tidyr     1.3.1
## v readr     2.1.5

## -- Conflicts ------------------------------------------ tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## x purrr::lift()   masks caret::lift()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
library(gmodels)
```

#loading dataset

```
dataset_ub <-  read.csv("C:/Users/santo/OneDrive/Desktop/Fundamental of machinelearning/Assignment_2/Uni
head(dataset_ub)
```

```
##   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_ub1<-dataset_ub[,-1]
head(dataset_ub1)
```

```
##   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_ub1<-dataset_ub1[,-4]
head(dataset_ub1)
```

```
##   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_ub1$Personal.Loan=as.factor(dataset_ub1$Personal.Loan)

#running is.na to check if there are any NA values
head(is.na(dataset_ub1))
```

```
##        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_ub1))
```

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

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

#converting education into character
education<-as.character(dataset_ub1$Education)

dataset_ub2<-cbind(dataset_ub1[,-6],education)
head(dataset_ub2)
```

```
##   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_ub2)
educationdummy<-data.frame(predict(dummymodel,dataset_ub2))
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_ub_dummy<-cbind(dataset_ub2[,-12],educationdummy)
head(dataset_ub_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_ub_dummy$Personal.Loan,p=0.60,list = FALSE)
trainset<-dataset_ub_dummy[train,]
nrow(trainset)
```

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

```
validationset<-dataset_ub_dummy[-train,]
nrow(validationset)
```

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

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


summary(trainset)
```

```
##       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(validationset)
```

```
##       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(testset)
```

```
##       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","O
normalization_values<-preProcess(trainset[,normvar],method = c('center','scale'))

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

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

```
testset.norm<-predict(normalization_values,testset)
summary(testset.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: #Age = 40, Experience = 10, Income = 84, Family = 2, CCAvg = 2, Education_1 = 0, Education_2 = 1, Education_3 = 0, Mortgage = 0, Securities Account = 0, CD Account = 0, Online = 1, and Credit Card= 1. Perform a k-NN classification with all predictors except ID and ZIP code using k = 1. Remember to transform categorical predictors with more than two categories into dummy variables first. Specify the success class as 1 (loan acceptance), and use thedefault cutoff value of 0.5. How would this customer be classified?

```
set.seed(555)
new_grid<-expand.grid(k=c(1))
new_model<-train(Personal.Loan~.,data=trainset.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,testset.norm)
predict_test
```

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

##Explanation #All 5 nearest neighbors will classified as a 0, in turn the customer will be classified as a 0.

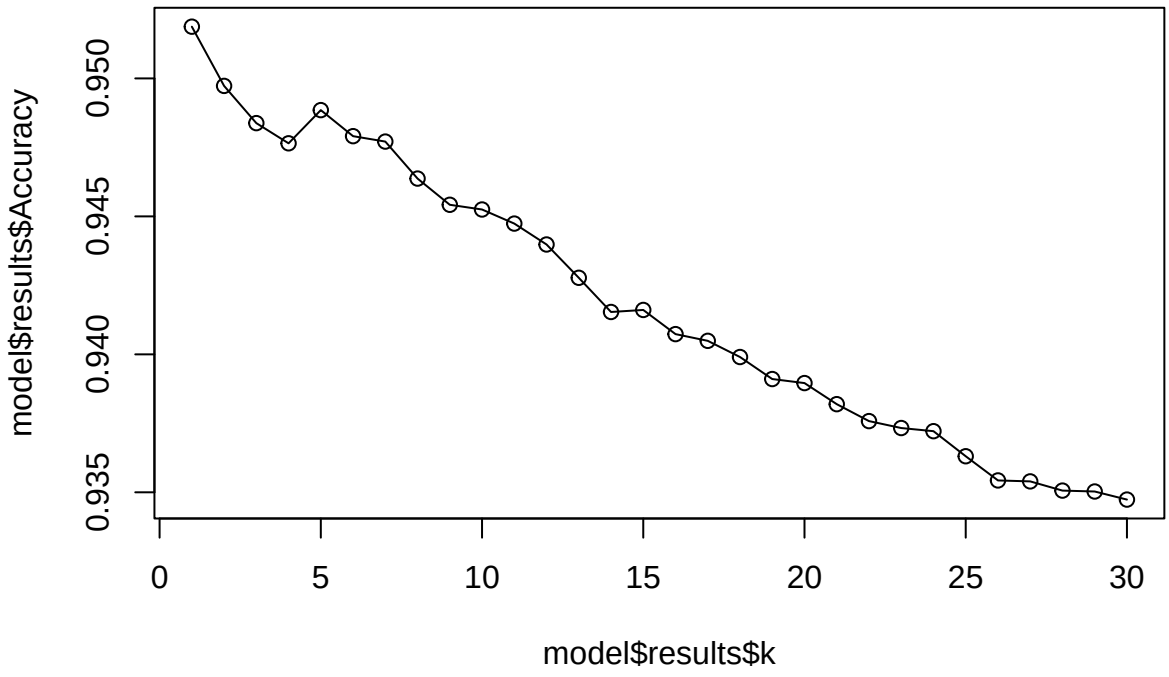
##Question 2: #What is a choice of k that balances between overfitting and ignoring the predictor information

```
set.seed(555)
searchGrid <- expand.grid(k=seq(1:30))
model<-train(Personal.Loan~.,data=trainset.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
```

#Explanation #The best choice of k which also balances the model from overfitting is k = 1

##Question3: #Show the confusion matrix for the validation data that results from using the best k

```
train_label<-trainset.norm[,7]
validation_label<-validationset.norm[,7]
test_label<-testset.norm[,7]
```

```
predicted_validationlabel<-knn(trainset.norm,validationset.norm,cl=train_label,k=1)

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

```
##
##
##    Cell Contents
## |-------------------------|
## |                       N |
## |           N / Row Total |
## |           N / Col Total |
## |         N / Table Total |
## |-------------------------|
##
##
## Total Observations in Table:  2000
##
##
##                  | predicted_validationlabel
## validation_label |         0 |         1 | Row Total |
## -----------------|-----------|-----------|-----------|
##                0 |      1805 |         3 |      1808 |
##                  |     0.998 |     0.002 |     0.904 |
##                  |     0.981 |     0.019 |           |
##                  |     0.902 |     0.002 |           |
## -----------------|-----------|-----------|-----------|
##                1 |        35 |       157 |       192 |
##                  |     0.182 |     0.818 |     0.096 |
##                  |     0.019 |     0.981 |           |
##                  |     0.018 |     0.078 |           |
## -----------------|-----------|-----------|-----------|
##     Column Total |      1840 |       160 |      2000 |
##                  |     0.920 |     0.080 |           |
## -----------------|-----------|-----------|-----------|
##
##
```

##Explanation #Confusion matrix as per above

##Question4: #Consider the following customer: Age = 40, Experience = 10, Income = 84, Family = 2, CCAvg = 2, Education_1 = 0, Education_2 = 1, Education_3 = 0, Mortgage = 0, Securities Account = 0, CD Account = 0, Online = 1 and CreditCard = 1. Classify the customer using the best k.

```
set.seed(555)
bestk_grid<-expand.grid(k=c(best_k))
bestk_model<-train(Personal.Loan~.,data=trainset.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,testset.norm)
bestk_test
```

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

##Explanation #Customer is classified as a 1 with 100% probability

##Question5: #Repartition the data, this time into training, validation, and test sets (50% : 30% : 20%). Apply the k-NN method with the k chosen above. Compare the confusion matrix of the test set with that of the training and validation sets. Comment on the differences and their reason.

```
set.seed(555)
train1<-createDataPartition(dataset_ub_dummy$Personal.Loan,p=0.50,list = FALSE)
trainset_2<-dataset_ub_dummy[train1,]
middleset<-dataset_ub_dummy[-train1,]
nrow(middleset)
```

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

```
train2<-createDataPartition(middleset$Personal.Loan,p=0.6,list = FALSE)
validationset_2<-middleset[train2,]
testset_2<-middleset[-train2,]

nrow(trainset_2)
```

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

```
nrow(validationset_2)
```

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

```
nrow(testset_2)
```

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

```
#normalizing trainset_2,validationset_2,testset_2

normvar<-c('Age',"Experience","Income","Family","CCAvg","Mortgage","Securities.Account","CD.Account","O
normalization_values_2<-preProcess(trainset_2[,normvar],method = c('center','scale'))

trainset.norm_2<-predict(normalization_values_2,trainset_2)
summary(trainset.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
```

```
validationset.norm_2<-predict(normalization_values_2,validationset_2)
summary(validationset.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
```

```
testset.norm_2<-predict(normalization_values_2,testset_2)
summary(testset.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<-trainset.norm_2[,7]
validation_label_2<-validationset.norm_2[,7]
test_label_2<-testset.norm_2[,7]

predicted_validationlabel_2<-knn(trainset.norm_2,validationset.norm_2,cl=train_label_2,k=best_k)

predicted_testlabel_2<-knn(trainset.norm_2,testset.norm_2,cl=train_label_2,k=best_k)

confusionmatrix_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 |           |
## -------------------|-----------|-----------|-----------|
##
##
```

```
confusionmatrix_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
##
```

###Explanation #As the model is being fit on the training data it would make intuitive sense that the classifications are most accurate on the training data set and least accurate on the test datasets. "'