ML_Mini_Project

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Exploratory Data Analysis

First we must download our data into our R session

```
#save the input data file into project directory and save pathname
fn.data<-"/Users/gregoryjordan/Downloads/WisconsinCancer.csv"

#read the csv file in, assign row names to first column, and save in data frame variable

wisc.df <- read.csv(fn.data,row.names = 1)
```

examine the data

```
head(wisc.df)
```

```
         diagnosis radius_mean texture_mean perimeter_mean area_mean
842302           M       17.99        10.38         122.80    1001.0
842517           M       20.57        17.77         132.90    1326.0
84300903         M       19.69        21.25         130.00    1203.0
84348301         M       11.42        20.38          77.58     386.1
84358402         M       20.29        14.34         135.10    1297.0
843786           M       12.45        15.70          82.57     477.1
         smoothness_mean compactness_mean concavity_mean concave.points_mean
842302           0.11840          0.27760         0.3001             0.14710
842517           0.08474          0.07864         0.0869             0.07017
84300903         0.10960          0.15990         0.1974             0.12790
84348301         0.14250          0.28390         0.2414             0.10520
84358402         0.10030          0.13280         0.1980             0.10430
843786           0.12780          0.17000         0.1578             0.08089
         symmetry_mean fractal_dimension_mean radius_se texture_se perimeter_se
842302          0.2419                0.07871    1.0950     0.9053        8.589
```

```
842517          0.1812                0.05667    0.5435     0.7339        3.398
84300903        0.2069                0.05999    0.7456     0.7869        4.585
84348301        0.2597                0.09744    0.4956     1.1560        3.445
84358402        0.1809                0.05883    0.7572     0.7813        5.438
843786          0.2087                0.07613    0.3345     0.8902        2.217
         area_se smoothness_se compactness_se concavity_se concave.points_se
842302    153.40      0.006399        0.04904      0.05373           0.01587
842517     74.08      0.005225        0.01308      0.01860           0.01340
84300903   94.03      0.006150        0.04006      0.03832           0.02058
84348301   27.23      0.009110        0.07458      0.05661           0.01867
84358402   94.44      0.011490        0.02461      0.05688           0.01885
843786     27.19      0.007510        0.03345      0.03672           0.01137
         symmetry_se fractal_dimension_se radius_worst texture_worst
842302       0.03003             0.006193        25.38         17.33
842517       0.01389             0.003532        24.99         23.41
84300903     0.02250             0.004571        23.57         25.53
84348301     0.05963             0.009208        14.91         26.50
84358402     0.01756             0.005115        22.54         16.67
843786       0.02165             0.005082        15.47         23.75
         perimeter_worst area_worst smoothness_worst compactness_worst
842302            184.60     2019.0           0.1622            0.6656
842517            158.80     1956.0           0.1238            0.1866
84300903          152.50     1709.0           0.1444            0.4245
84348301           98.87      567.7           0.2098            0.8663
84358402          152.20     1575.0           0.1374            0.2050
843786            103.40      741.6           0.1791            0.5249
         concavity_worst concave.points_worst symmetry_worst
842302            0.7119               0.2654         0.4601
842517            0.2416               0.1860         0.2750
84300903          0.4504               0.2430         0.3613
84348301          0.6869               0.2575         0.6638
84358402          0.4000               0.1625         0.2364
843786            0.5355               0.1741         0.3985
         fractal_dimension_worst  X
842302                   0.11890 NA
842517                   0.08902 NA
84300903                 0.08758 NA
84348301                 0.17300 NA
84358402                 0.07678 NA
843786                   0.12440 NA
```

remove the first column (diagnosis) from wisc.df because that is the answer and we do not need it

```
#use -1 to remove the first column
wisc.data<-wisc.df[,-1]
```

create a diagnosis vector

```
#save the diagnosis column in a new vector
#save as a factor
diagnosis <- as.factor(wisc.df[,1])
```

Explore the Data

Q1. How many observations are in this dataset?

```
#number of rows = number of observations
nrow(wisc.data)
```

```
[1] 569
```

Q2. How many of the observations have a malignant diagnosis?

```
#filter where diagnosis == malignant
#then count number of observations (# of rows)
nrow(wisc.df[wisc.df$diagnosis=="M",])
```

```
[1] 212
```

Q3. How many variables/features in the data are suffixed with _mean?

```
head(wisc.data)
```

```
         radius_mean texture_mean perimeter_mean area_mean smoothness_mean
842302         17.99        10.38         122.80    1001.0         0.11840
842517         20.57        17.77         132.90    1326.0         0.08474
84300903       19.69        21.25         130.00    1203.0         0.10960
84348301       11.42        20.38          77.58     386.1         0.14250
84358402       20.29        14.34         135.10    1297.0         0.10030
843786         12.45        15.70          82.57     477.1         0.12780
         compactness_mean concavity_mean concave.points_mean symmetry_mean
```

```
842302           0.27760         0.3001            0.14710        0.2419
842517           0.07864         0.0869            0.07017        0.1812
84300903         0.15990         0.1974            0.12790        0.2069
84348301         0.28390         0.2414            0.10520        0.2597
84358402         0.13280         0.1980            0.10430        0.1809
843786           0.17000         0.1578            0.08089        0.2087
         fractal_dimension_mean radius_se texture_se perimeter_se area_se
842302                  0.07871    1.0950     0.9053        8.589  153.40
842517                  0.05667    0.5435     0.7339        3.398   74.08
84300903                0.05999    0.7456     0.7869        4.585   94.03
84348301                0.09744    0.4956     1.1560        3.445   27.23
84358402                0.05883    0.7572     0.7813        5.438   94.44
843786                  0.07613    0.3345     0.8902        2.217   27.19
         smoothness_se compactness_se concavity_se concave.points_se
842302        0.006399        0.04904      0.05373           0.01587
842517        0.005225        0.01308      0.01860           0.01340
84300903      0.006150        0.04006      0.03832           0.02058
84348301      0.009110        0.07458      0.05661           0.01867
84358402      0.011490        0.02461      0.05688           0.01885
843786        0.007510        0.03345      0.03672           0.01137
         symmetry_se fractal_dimension_se radius_worst texture_worst
842302       0.03003             0.006193        25.38         17.33
842517       0.01389             0.003532        24.99         23.41
84300903     0.02250             0.004571        23.57         25.53
84348301     0.05963             0.009208        14.91         26.50
84358402     0.01756             0.005115        22.54         16.67
843786       0.02165             0.005082        15.47         23.75
         perimeter_worst area_worst smoothness_worst compactness_worst
842302            184.60     2019.0           0.1622            0.6656
842517            158.80     1956.0           0.1238            0.1866
84300903          152.50     1709.0           0.1444            0.4245
84348301           98.87      567.7           0.2098            0.8663
84358402          152.20     1575.0           0.1374            0.2050
843786            103.40      741.6           0.1791            0.5249
         concavity_worst concave.points_worst symmetry_worst
842302            0.7119               0.2654         0.4601
842517            0.2416               0.1860         0.2750
84300903          0.4504               0.2430         0.3613
84348301          0.6869               0.2575         0.6638
84358402          0.4000               0.1625         0.2364
843786            0.5355               0.1741         0.3985
         fractal_dimension_worst  X
842302                   0.11890 NA
```

```
842517                  0.08902 NA
84300903                0.08758 NA
84348301                0.17300 NA
84358402                0.07678 NA
843786                  0.12440 NA
```

```
#get indices of wisc.data column names that end in _mean
#get length of resultant vector to determine # of variables suffixed with _mean
length(grep(x=colnames(wisc.data),pattern="*_mean$"))
```

```
[1] 10
```

Principal Component Analysis

determine if the data needs to be scaled (i.e. different units or significantly different variances)

```
#check column means and standard deviations
#colMeans function to get mean of columns
colMeans(wisc.data)
```

```
          radius_mean           texture_mean         perimeter_mean
         1.412729e+01           1.928965e+01           9.196903e+01
            area_mean        smoothness_mean       compactness_mean
         6.548891e+02           9.636028e-02           1.043410e-01
       concavity_mean     concave.points_mean          symmetry_mean
         8.879932e-02           4.891915e-02           1.811619e-01
fractal_dimension_mean              radius_se             texture_se
         6.279761e-02           4.051721e-01           1.216853e+00
       perimeter_se                 area_se          smoothness_se
         2.866059e+00           4.033708e+01           7.040979e-03
      compactness_se           concavity_se      concave.points_se
         2.547814e-02           3.189372e-02           1.179614e-02
         symmetry_se    fractal_dimension_se            radius_worst
         2.054230e-02           3.794904e-03           1.626919e+01
       texture_worst         perimeter_worst              area_worst
         2.567722e+01           1.072612e+02           8.805831e+02
     smoothness_worst       compactness_worst         concavity_worst
         1.323686e-01           2.542650e-01           2.721885e-01
```

```
  concave.points_worst          symmetry_worst fractal_dimension_worst
          1.146062e-01            2.900756e-01            8.394582e-02
                     X
                    NA
```

```
#remember apply function to apply a function over a vector
apply(wisc.data,2,sd)
```

```
           radius_mean            texture_mean          perimeter_mean
          3.524049e+00            4.301036e+00            2.429898e+01
             area_mean         smoothness_mean        compactness_mean
          3.519141e+02            1.406413e-02            5.281276e-02
        concavity_mean     concave.points_mean           symmetry_mean
          7.971981e-02            3.880284e-02            2.741428e-02
 fractal_dimension_mean               radius_se              texture_se
          7.060363e-03            2.773127e-01            5.516484e-01
          perimeter_se                 area_se           smoothness_se
          2.021855e+00            4.549101e+01            3.002518e-03
        compactness_se            concavity_se       concave.points_se
          1.790818e-02            3.018606e-02            6.170285e-03
           symmetry_se    fractal_dimension_se            radius_worst
          8.266372e-03            2.646071e-03            4.833242e+00
         texture_worst         perimeter_worst              area_worst
          6.146258e+00            3.360254e+01            5.693570e+02
      smoothness_worst       compactness_worst         concavity_worst
          2.283243e-02            1.573365e-01            2.086243e-01
  concave.points_worst          symmetry_worst fractal_dimension_worst
          6.573234e-02            6.186747e-02            1.806127e-02
                     X
                    NA
```

use `prcomp()` for PCA function

```
#perform pca on wisc.data
#the data$X column is full of nulls so let's remove it
#scale the units

wisc.pr <- prcomp(wisc.data[-31],scale. = TRUE)
```

```
#look at the summary of the results
summary(wisc.pr)
```

```
Importance of components:
                          PC1    PC2     PC3     PC4     PC5     PC6     PC7
Standard deviation     3.6444 2.3857 1.67867 1.40735 1.28403 1.09880 0.82172
Proportion of Variance 0.4427 0.1897 0.09393 0.06602 0.05496 0.04025 0.02251
Cumulative Proportion  0.4427 0.6324 0.72636 0.79239 0.84734 0.88759 0.91010
                           PC8    PC9    PC10   PC11    PC12    PC13    PC14
Standard deviation     0.69037 0.6457 0.59219 0.5421 0.51104 0.49128 0.39624
Proportion of Variance 0.01589 0.0139 0.01169 0.0098 0.00871 0.00805 0.00523
Cumulative Proportion  0.92598 0.9399 0.95157 0.9614 0.97007 0.97812 0.98335
                          PC15    PC16    PC17    PC18    PC19    PC20   PC21
Standard deviation     0.30681 0.28260 0.24372 0.22939 0.22244 0.17652 0.1731
Proportion of Variance 0.00314 0.00266 0.00198 0.00175 0.00165 0.00104 0.0010
Cumulative Proportion  0.98649 0.98915 0.99113 0.99288 0.99453 0.99557 0.9966
                          PC22    PC23   PC24    PC25    PC26    PC27    PC28
Standard deviation     0.16565 0.15602 0.1344 0.12442 0.09043 0.08307 0.03987
Proportion of Variance 0.00091 0.00081 0.0006 0.00052 0.00027 0.00023 0.00005
Cumulative Proportion  0.99749 0.99830 0.9989 0.99942 0.99969 0.99992 0.99997
                          PC29    PC30
Standard deviation     0.02736 0.01153
Proportion of Variance 0.00002 0.00000
Cumulative Proportion  1.00000 1.00000
```

Q4. From your results, what proportion of the original variance is captured by the first principal components (PC1)?

about 44% of the data

Q5. How many principal components (PCs) are required to describe at least 70% of the original variance in the data?

3 principal components (PC1:PC3)

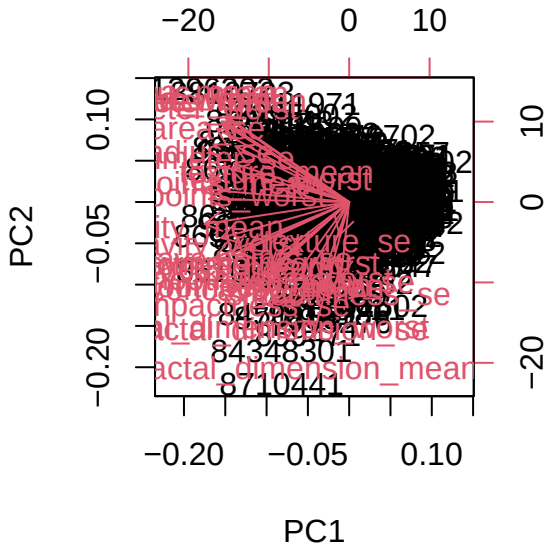
Q6. How many principal components (PCs) are required to describe at least 90% of the original variance in the data?

7 principal components (PC1:PC7)

Interpreting PCA Results

creat a biplot using the `biplot()` function

```
biplot(wisc.pr)
```

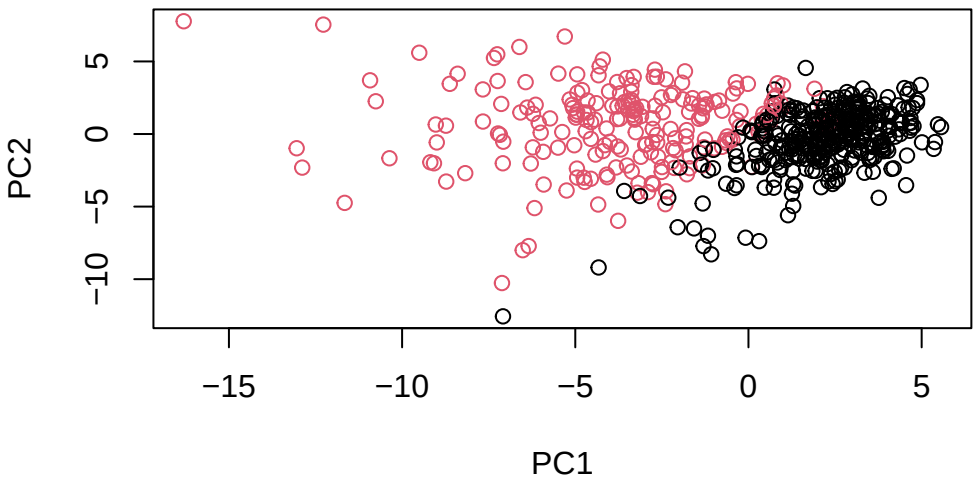


Q7. What stands out to you about this plot? Is it easy or difficult to understand? Why?

What stands out is that it is a hot mess. It is hard to understand. Data is all over the place and hard to visually interpret. We need a cleaner plot

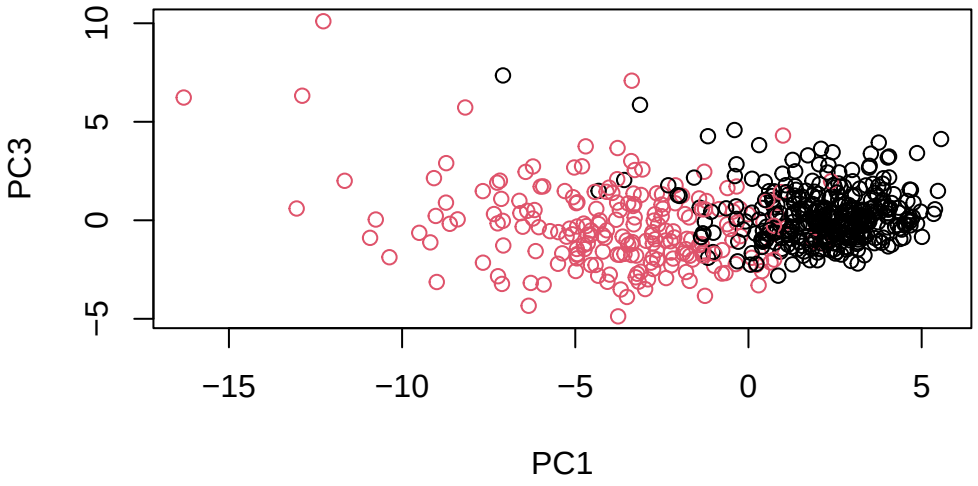
make a scatter plot of PC1 vs PC2 to make the trend clearer

```
#scatterplot of PC1 vs PC2
plot(wisc.pr$x[,1],wisc.pr$x[,2],col=diagnosis,xlab="PC1",ylab="PC2")
```



Q8. Generate a similar plot for principal components 1 and 3. What do you notice about these plots?

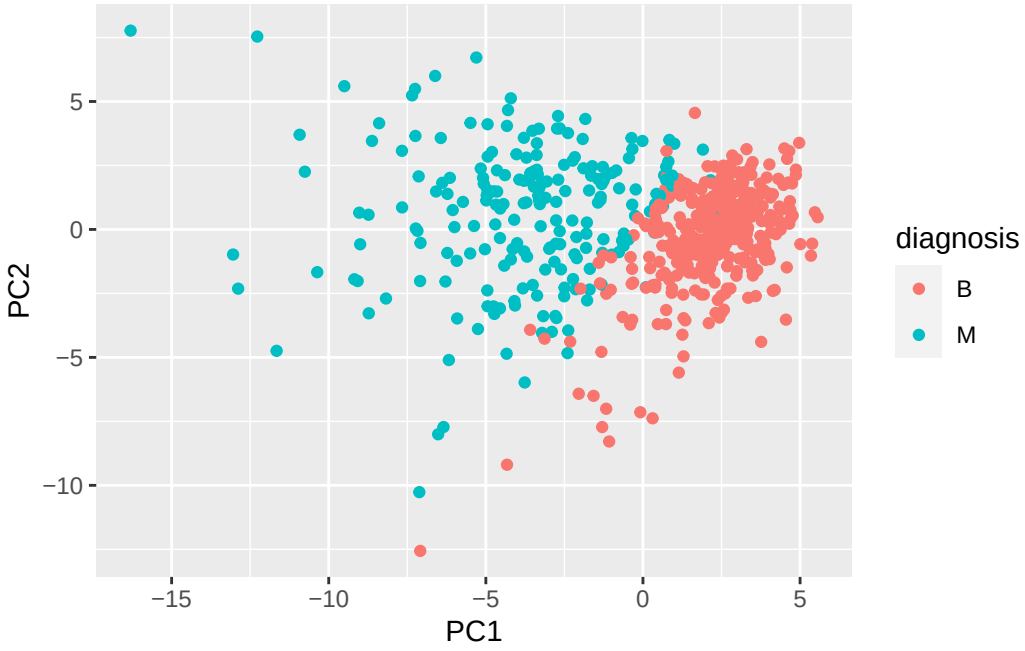
```
#scatterplot of PC1 vs PC3
plot(wisc.pr$x[,1],wisc.pr$x[,3],col=diagnosis,xlab="PC1",ylab="PC3")
```



the plots look very similar, but the one with PC2 has a little more separation between the two populations because PC2 captures more of the variance

Trying ggplot2

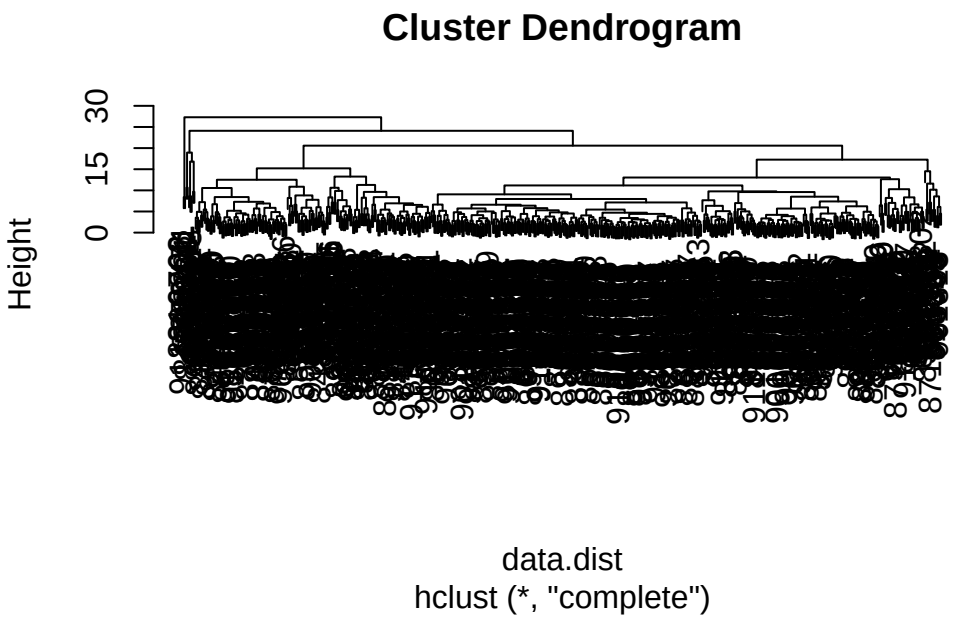
```
#load in ggplot2
library(ggplot2)
#creat a data frame
df<-as.data.frame(wisc.pr$x)
df$diagnosis<-diagnosis
#make a scatter plot
ggplot(df) + aes(PC1,PC2,col=diagnosis) + geom_point()
```



Heirarchial Clustering of Data

```
#scale the data
data.scaled<-scale(wisc.data)
#get distance matrix
data.dist<-dist(data.scaled)
#heirarchial clustering
wisc.hclust<-hclust(data.dist)
```

```
#make a plot
wisc.plot<-plot(wisc.hclust)
```



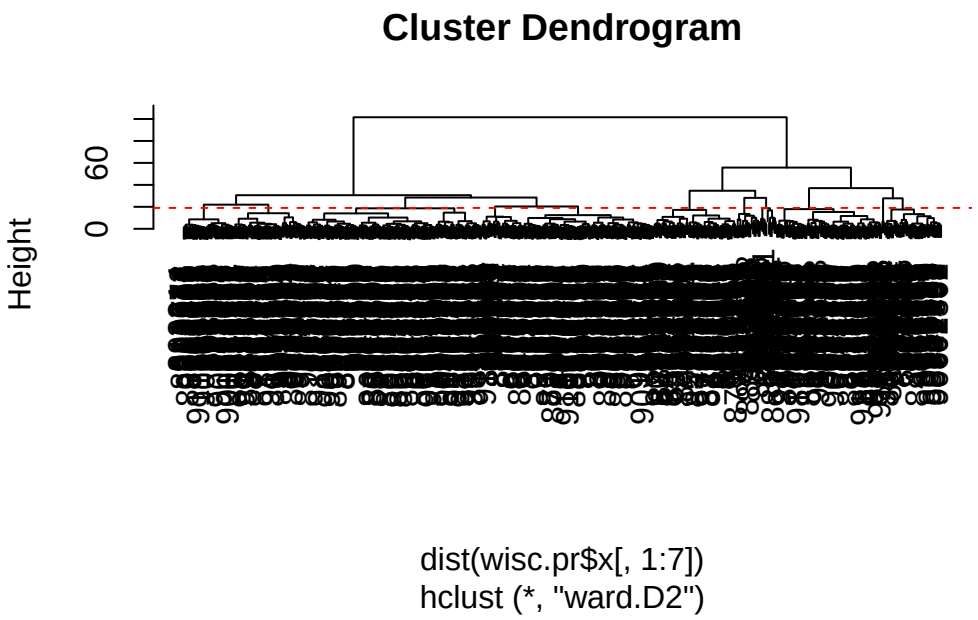
Q10. Using the plot() and abline() functions, what is the height at which the clustering model has 4 clusters?

around 20 height

##Combining methods and clustering on PCA results

```
#combine clustering and PCA
wisc.pr.hclust <- hclust(dist(wisc.pr$x[,1:7]),method="ward.D2")

#plot results
plot(wisc.pr.hclust)
abline(h=19, col="red", lty=2)
```



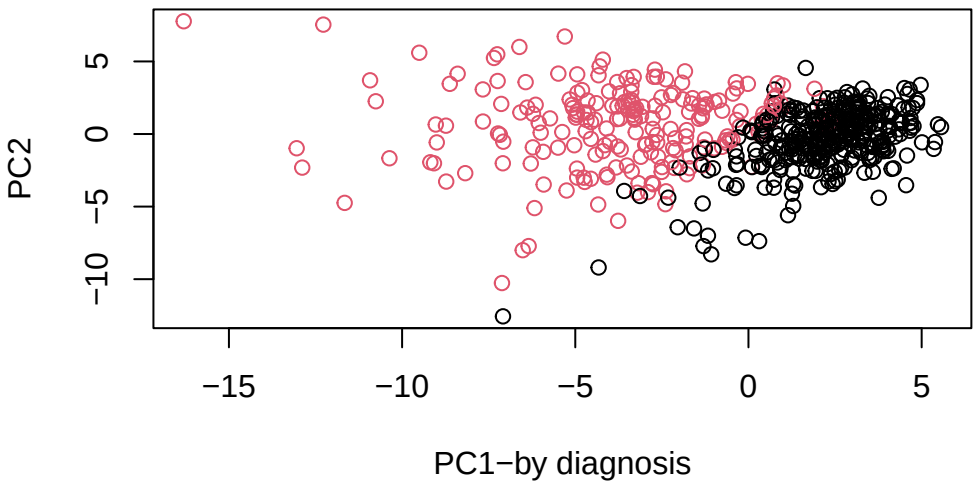
Q12. Which method gives your favorite results for the same data.dist dataset? Explain your reasoning.

I like ward.D2 because it works to minimize the variance within clusters which makes the cluster data more tight.

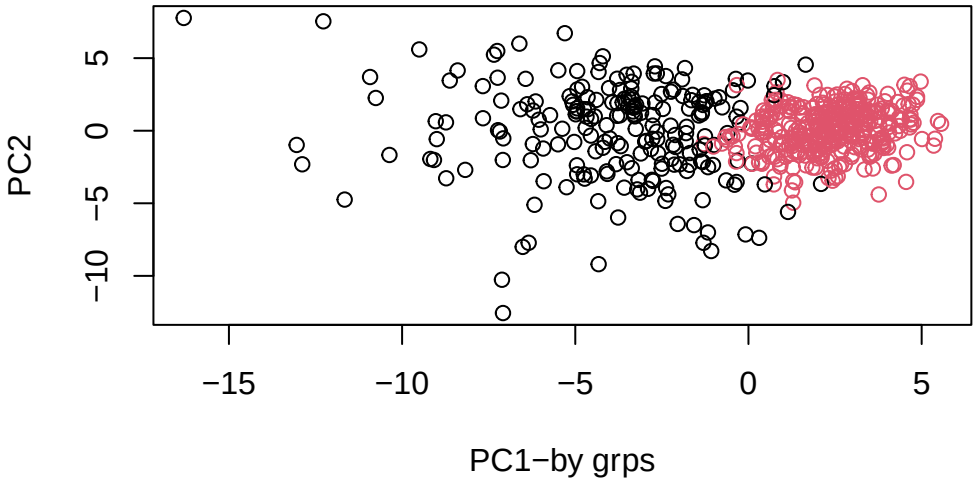
```
#cut it into groups
grps <- cutree(wisc.pr.hclust,k=2)
table(grps)
```

```
grps
  1   2
216 353
```

```
#make plots
plot(wisc.pr$x[,1:2], col=diagnosis, xlab="PC1-by diagnosis")
```




```
plot(wisc.pr$x[,1:2], col=grps, xlab="PC1-by grps")
```



```r
g <- as.factor(grps)
g <- relevel(g,2)
plot(wisc.pr$x[,1:2], col=g)
```