

Assignment3

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```
rm(list = setdiff(ls(), lsf.str()))
```

```
# install.packages('readxl')
library(readxl)
```

```
# install.packages('ggplot2')
library(ggplot2)
```

```
# install.packages('reshape2')
library(reshape2)
```

```
## Warning: package 'reshape2' was built under R version 4.3.3
```

```
# install.packages('stats')
library(stats)
```

```
# install.packages('psych')
library(psych)
```

```
## Warning: package 'psych' was built under R version 4.3.3
```

```
##
## Attaching package: 'psych'
```

```
## The following objects are masked from 'package:ggplot2':
##
##     %+%, alpha
```

Question 1

```
excel_path <- 'C:\\SSDFiles\\GitStuff\\iiith\\Sem 4-2 spring24\\Behavioural Research - Statistical Methods\\Assgn3\\wine.xlsx'
with_target_data <- read_excel(excel_path)
with_target_data
```

T...	Alcohol	Malic	A...	Alcalinity	Magnesi...	Phen...	Flavanoids	Nonflavanoids	Proanthoc...
	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
1	14.23	1.71	2.43	15.6	127	2.80	3.06	0.28	
1	13.20	1.78	2.14	11.2	100	2.65	2.76	0.26	
1	13.16	2.36	2.67	18.6	101	2.80	3.24	0.30	
1	14.37	1.95	2.50	16.8	113	3.85	3.49	0.24	
1	13.24	2.59	2.87	21.0	118	2.80	2.69	0.39	
1	14.20	1.76	2.45	15.2	112	3.27	3.39	0.34	
1	14.39	1.87	2.45	14.6	96	2.50	2.52	0.30	
1	14.06	2.15	2.61	17.6	121	2.60	2.51	0.31	
1	14.83	1.64	2.17	14.0	97	2.80	2.98	0.29	
1	13.86	1.35	2.27	16.0	98	2.98	3.15	0.22	

1-10 of 178 rows | 1-10 of 14 columns

Previous 1 2 3 4 5 6 ... 18 Next

```
data <- with_target_data[, c("Alcohol","Malic","Ash","Alcalinity","Magnesium","Phenols","Flavano
ids","Nonflavanoids","Proanthocyanins","Color","Hue","Dilution","Proline")]
data
```

Alcohol	Malic	A...	Alcalinity	Magnesi...	Phen...	Flavanoids	Nonflavanoids	Proanthocyanin...
<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>	<dbl>
14.23	1.71	2.43	15.6	127	2.80	3.06	0.28	2.1
13.20	1.78	2.14	11.2	100	2.65	2.76	0.26	1.2
13.16	2.36	2.67	18.6	101	2.80	3.24	0.30	2.8
14.37	1.95	2.50	16.8	113	3.85	3.49	0.24	2.1
13.24	2.59	2.87	21.0	118	2.80	2.69	0.39	1.8
14.20	1.76	2.45	15.2	112	3.27	3.39	0.34	1.9
14.39	1.87	2.45	14.6	96	2.50	2.52	0.30	1.9
14.06	2.15	2.61	17.6	121	2.60	2.51	0.31	1.2
14.83	1.64	2.17	14.0	97	2.80	2.98	0.29	1.9
13.86	1.35	2.27	16.0	98	2.98	3.15	0.22	1.8

1-10 of 178 rows | 1-10 of 13 columns

Previous 1 2 3 4 5 6 ... 18 Next

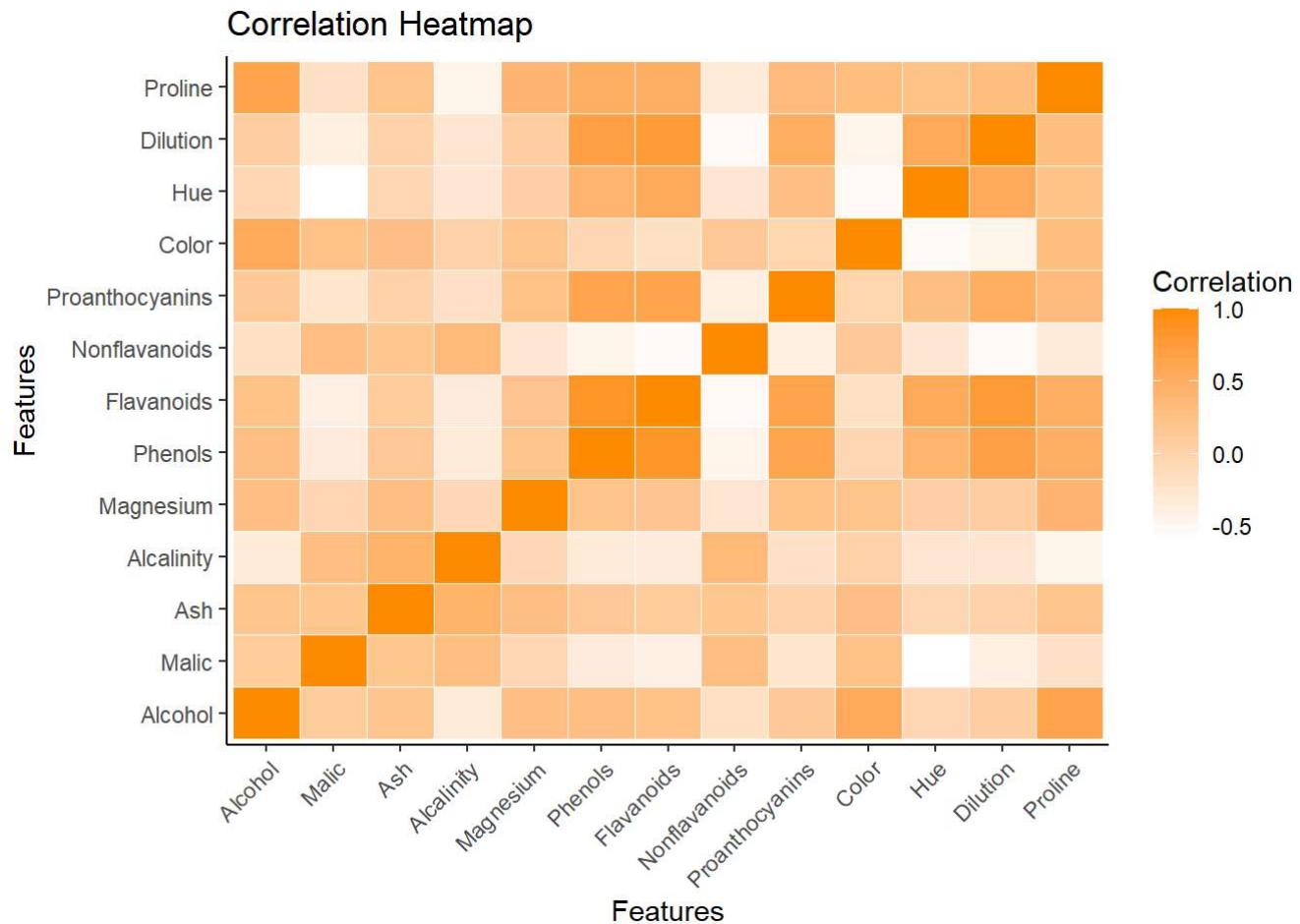
Question 2

Question 2.1

```
correlation_matrix <- cor(data)
correlation_matrix
```

	Alcohol	Malic	Ash	Alcalinity	Magnesium
## Alcohol	1.0000000	0.09439694	0.211544596	-0.31023514	0.27079823
## Malic	0.09439694	1.00000000	0.164045470	0.28850040	-0.05457510
## Ash	0.21154460	0.16404547	1.000000000	0.44336719	0.28658669
## Alcalinity	-0.31023514	0.28850040	0.443367187	1.00000000	-0.08333309
## Magnesium	0.27079823	-0.05457510	0.286586691	-0.08333309	1.00000000
## Phenols	0.28910112	-0.33516700	0.128979538	-0.32111332	0.21440123
## Flavanoids	0.23681493	-0.41100659	0.115077279	-0.35136986	0.19578377
## Nonflavanoids	-0.15592947	0.29297713	0.186230446	0.36192172	-0.25629405
## Proanthocyanins	0.13669791	-0.22074619	0.009651935	-0.19732684	0.23644061
## Color	0.54636420	0.24898534	0.258887259	0.01873198	0.19995001
## Hue	-0.07174720	-0.56129569	-0.074666889	-0.27395522	0.05539820
## Dilution	0.07234319	-0.36871043	0.003911231	-0.27676855	0.06600394
## Proline	0.64372004	-0.19201056	0.223626264	-0.44059693	0.39335085
	Phenols	Flavanoids	Nonflavanoids	Proanthocyanins	
## Alcohol	0.28910112	0.2368149	-0.1559295	0.136697912	
## Malic	-0.33516700	-0.4110066	0.2929771	-0.220746187	
## Ash	0.12897954	0.1150773	0.1862304	0.009651935	
## Alcalinity	-0.32111332	-0.3513699	0.3619217	-0.197326836	
## Magnesium	0.21440123	0.1957838	-0.2562940	0.236440610	
## Phenols	1.00000000	0.8645635	-0.4499353	0.612413084	
## Flavanoids	0.86456350	1.0000000	-0.5378996	0.652691769	
## Nonflavanoids	-0.44993530	-0.5378996	1.0000000	-0.365845099	
## Proanthocyanins	0.61241308	0.6526918	-0.3658451	1.000000000	
## Color	-0.05513642	-0.1723794	0.1390570	-0.025249931	
## Hue	0.43368134	0.5434786	-0.2626396	0.295544253	
## Dilution	0.69994936	0.7871939	-0.5032696	0.519067096	
## Proline	0.49811488	0.4941931	-0.3113852	0.330416700	
	Color	Hue	Dilution	Proline	
## Alcohol	0.54636420	-0.07174720	0.072343187	0.6437200	
## Malic	0.24898534	-0.56129569	-0.368710428	-0.1920106	
## Ash	0.25888726	-0.07466689	0.003911231	0.2236263	
## Alcalinity	0.01873198	-0.27395522	-0.276768549	-0.4405969	
## Magnesium	0.19995001	0.05539820	0.066003936	0.3933508	
## Phenols	-0.05513642	0.43368134	0.699949365	0.4981149	
## Flavanoids	-0.17237940	0.54347857	0.787193902	0.4941931	
## Nonflavanoids	0.13905701	-0.26263963	-0.503269596	-0.3113852	
## Proanthocyanins	-0.02524993	0.29554425	0.519067096	0.3304167	
## Color	1.00000000	-0.52181319	-0.428814942	0.3161001	
## Hue	-0.52181319	1.00000000	0.565468293	0.2361834	
## Dilution	-0.42881494	0.56546829	1.000000000	0.3127611	
## Proline	0.31610011	0.23618345	0.312761075	1.0000000	

```
melted_data <- melt(correlation_matrix)
ggplot(melted_data, aes(x = Var1, y = Var2, fill = value)) +
  geom_tile(color = "white") +
  scale_fill_gradient(low = "white", high = "darkorange", name = "Correlation") +
  labs(title = "Correlation Heatmap", x = "Features", y = "Features") +
  theme_classic() +
  theme(axis.text.x = element_text(angle = 45, hjust = 1))
```



```
# heatmap(correlation_matrix)
```

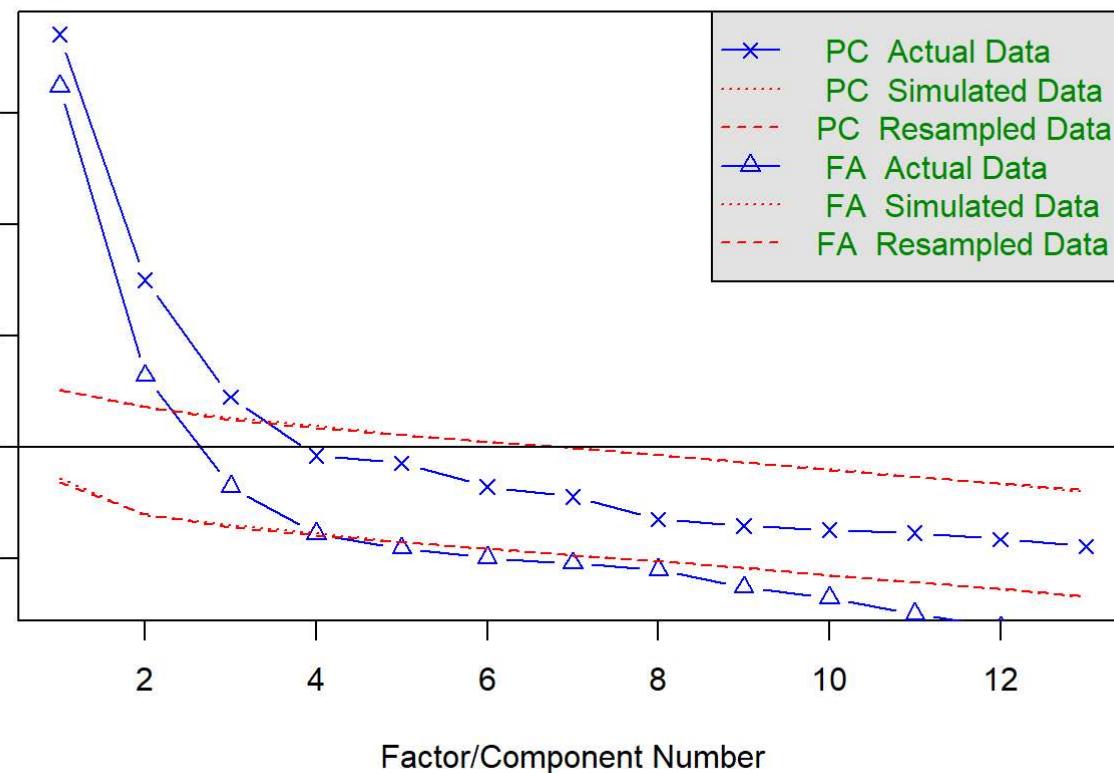
Question 2.2

```
parallel_results <- fa.parallel(data)
```

```
## Warning in fa.stats(r = r, f = f, phi = phi, n.obs = n.obs, np.obs = np.obs, :
## The estimated weights for the factor scores are probably incorrect. Try a
## different factor score estimation method.
```

eigenvalues of principal components and factor analysis

Parallel Analysis Scree Plots



```
## Parallel analysis suggests that the number of factors = 3 and the number of components = 3
```

Parallel analysis suggests that the number of factors = 3 and the number of components = 3

Question 2.3

```
scaled_data <- scale(data)
scaled_data
```

```

##          Alcohol        Malic        Ash      Alcalinity      Magnesium
## [1,]  1.51434077 -0.56066822  0.23139979 -1.166303174  1.90852151
## [2,]  0.24559683 -0.49800856 -0.82566722 -2.483840525  0.01809398
## [3,]  0.19632522  0.02117152  1.10621386 -0.267982252  0.08810981
## [4,]  1.68679140 -0.34583508  0.48655389 -0.806974805  0.92829983
## [5,]  0.29486844  0.22705328  1.83522559  0.450674485  1.27837900
## [6,]  1.47738706 -0.51591132  0.30430096 -1.286079296  0.85828399
## [7,]  1.71142720 -0.41744613  0.30430096 -1.465743481 -0.26196936
## [8,]  1.30493643 -0.16680747  0.88751034 -0.567422559  1.48842650
## [9,]  2.25341491 -0.62332789 -0.71631546 -1.645407665 -0.19195352
## [10,] 1.05857838 -0.88291793 -0.35180959 -1.046527051 -0.12193769
## [11,] 1.35420804 -0.15785609 -0.24245783 -0.447646437  0.36817315
## [12,] 1.37884384 -0.76654998 -0.16955666 -0.806974805 -0.33198519
## [13,] 0.92308146 -0.54276546  0.15849862 -1.046527051 -0.75208020
## [14,] 2.15487169 -0.54276546  0.08559744 -2.423952463 -0.61204853
## [15,] 1.69910930 -0.41744613  0.04914686 -2.244288279  0.15812565
## [16,] 0.77526663 -0.47115441  1.21556562 -0.687198682  0.85828399
## [17,] 1.60056608 -0.37268923  1.28846679  0.151234178  1.41841067
## [18,] 1.02162467 -0.68598755  0.92396093  0.151234178  1.06833150
## [19,] 1.46506916 -0.66808479  0.41365272 -0.896806897  0.57822065
## [20,] 0.78758453  0.68357369  0.70525741 -1.286079296  1.13834733
## [21,] 1.30493643 -0.63227927 -0.31535901 -1.046527051  1.83850567
## [22,] -0.08698653  1.31017034  1.03331269 -0.267982252  0.15812565
## [23,] 0.87380985 -0.42639751 -0.02375431 -0.866862867  0.08810981
## [24,] -0.18552975 -0.65913341  0.55945507 -0.507534498 -0.33198519
## [25,] 0.61513390 -0.47115441  0.88751034  0.151234178 -0.26196936
## [26,] 0.06082829 -0.25632128  3.11099611  1.648435713  1.69847400
## [27,] 0.47963697 -0.50695994  0.92396093 -1.016583020 -0.47201686
## [28,] 0.36877585 -0.55171684 -0.82566722 -0.747086744 -0.40200103
## [29,] 1.07089628 -0.39059199  1.58007149 -0.028430007  0.50820482
## [30,] 1.25566482 -0.58752236 -0.57051311 -1.046527051 -0.26196936
## [31,] 0.89844565 -0.74864721  1.21556562  0.899834945  0.08810981
## [32,] 0.71367712 -0.60542512 -0.02375431 -0.118262099  0.43818899
## [33,] 0.83685614 -0.45325165 -0.02375431 -0.687198682  0.29815732
## [34,] 0.93539936 -0.72179307  1.21556562  0.001514024  2.25860068
## [35,] 0.62745180 -0.48010579  1.03331269 -0.148206130  0.71825232
## [36,] 0.59049809 -0.47115441  0.15849862  0.300954331  0.01809398
## [37,] 0.34414005 -0.62332789  1.72587383 -1.196247204  0.71825232
## [38,] 0.06082829 -0.61437650  0.66880683 -0.447646437 -0.12193769
## [39,] 0.08546410 -0.74864721 -0.97146956 -1.196247204 -0.12193769
## [40,] 1.50202286  1.48024658  0.52300448 -1.884959911  1.97853734
## [41,] 0.68904131 -0.56066822 -0.20600725 -0.986638989  1.20836316
## [42,] 0.50427278  1.34597587 -0.89856839 -0.208094191 -0.68206436
## [43,] 1.08321419 -0.39954337  0.81460917 -1.345967358  0.08810981
## [44,] 0.29486844  1.47129519 -0.27890842 -0.597366590  0.22814148
## [45,] 0.06082829 -0.50695994 -0.97146956 -0.747086744  0.50820482
## [46,] 1.48970496  1.52500348  0.26785038 -0.178150160  0.78826816
## [47,] 1.69910930  1.12219135 -0.31535901 -1.046527051  0.15812565
## [48,] 1.10784999 -0.58752236 -0.89856839 -1.046527051  0.08810981
## [49,] 1.35420804 -0.28317542  0.12204803 -0.208094191  0.22814148
## [50,] 1.15712160 -0.54276546 -0.35180959 -0.627310621  0.57822065
## [51,] 0.06082829 -0.54276546 -1.19017308 -2.124512156 -0.54203270

```

```

## [52,] 1.02162467 -0.61437650  0.85105976 -0.687198682 -0.40200103
## [53,] 1.00930677 -0.52486270  0.19494920 -1.645407665  0.78826816
## [54,] 0.94771726 -0.39059199  1.14266445 -0.717142713  1.06833150
## [55,] 0.91076355 -0.59647374 -0.42471076 -0.926750928  1.27837900
## [56,] 0.68904131 -0.54276546  0.34075155  0.300954331  1.13834733
## [57,] 1.50202286 -0.56961960 -0.24245783 -0.956694959  1.27837900
## [58,] 0.35645795 -0.32793232  1.14266445 -0.806974805  0.15812565
## [59,] 0.88612775 -0.81130688  0.48655389 -0.836918836  0.57822065
## [60,] -0.77678907 -1.24992453 -3.66881295 -2.663504709 -0.82209603
## [61,] -0.82606067 -1.10670244 -0.31535901 -1.046527051  0.08810981
## [62,] -0.44420570 -0.87396654 -1.26307425 -0.806974805  0.01809398
## [63,] 0.82453824 -0.97243173 -1.62758012 -0.447646437 -0.40200103
## [64,] -0.77678907 -1.07984830 -0.75276604 -0.148206130 -0.89211187
## [65,] -1.02314711 -0.79340412  0.59590565 -0.148206130  0.29815732
## [66,] -0.77678907 -1.00823725  0.70525741 -0.417702406 -0.12193769
## [67,] 0.13473571 -1.18726487 -2.42949302 -1.345967358 -1.52225438
## [68,] -0.77678907 -1.04404278 -1.62758012  0.031458055 -1.52225438
## [69,] 0.41804746 -1.24992453 -0.02375431 -0.747086744  0.71825232
## [70,] -0.97387550 -1.02614002 -2.24724008 -0.806974805  3.58890153
## [71,] -0.87533228 -0.65018203 -0.57051311  0.271010300  0.22814148
## [72,] 1.05857838 -0.73969583  1.10621386  1.648435713 -0.96212770
## [73,] 0.60281600 -0.60542512 -0.46116135  1.348995406 -0.89211187
## [74,] -0.01307912 -0.59647374  0.85105976  3.145637249  2.74871152
## [75,] -1.28182306 -1.11565382 -0.24245783  0.450674485  0.08810981
## [76,] -1.65136013 -0.40849475 -1.62758012 -1.046527051 -0.19195352
## [77,] 0.03619249 -1.28573006 -2.39304243 -1.046527051 -0.96212770
## [78,] -1.42963789  0.49559470 -0.49761194 -0.447646437  0.85828399
## [79,] -0.82606067 -1.20516763 -1.51822836 -1.405855419  2.53866402
## [80,] -0.37029829  1.37283001  0.12204803  1.049555099  0.08810981
## [81,] -1.23255145 -1.26782729 -1.33597542 -0.148206130 -0.96212770
## [82,] -0.34566248 -0.47115441 -0.60696370 -0.208094191 -0.96212770
## [83,] -1.13400823 -1.07984830  0.52300448  1.348995406 -1.52225438
## [84,] 0.06082829  1.36387863 -0.16955666  0.899834945 -1.03214354
## [85,] -1.42963789 -1.29468144  0.77815859 -0.447646437 -0.40200103
## [86,] -0.40725200 -1.21411901 -0.46116135 -0.447646437 -0.05192185
## [87,] -1.03546501 -0.65018203 -0.20600725  0.989667037 -0.68206436
## [88,] -1.66367803 -0.59647374  0.92396093  1.947876020 -0.82209603
## [89,] -1.67599593 -0.24736990  0.34075155  0.630338669 -1.10215937
## [90,] -1.13400823 -0.90082069 -0.24245783  1.229219283 -2.08238105
## [91,] -1.13400823 -0.45325165 -0.16955666 -0.297926283 -1.31220687
## [92,] -1.23255145 -0.73969583  0.19494920  0.750114792 -0.96212770
## [93,] -0.38261619 -0.72179307 -0.38826018  0.360842393 -1.38222271
## [94,] -0.87533228  0.44188642 -0.53406252 -0.447646437 -0.82209603
## [95,] -1.70063174 -0.31002956 -0.31535901 -0.447646437 -0.12193769
## [96,] -0.65361004 -0.73074445 -0.60696370 -0.148206130  4.35907571
## [97,] -1.46659160 -0.19366161  1.36136797  0.600394638  2.39863235
## [98,] -0.87533228 -0.82920964 -1.40887660 -1.046527051 -1.03214354
## [99,] -0.77678907 -1.13355658 -0.97146956 -0.297926283 -0.82209603
## [100,] -0.87533228  0.74623336 -0.57051311 -0.447646437 -0.82209603
## [101,] -1.13400823 -0.22946714 -2.42949302 -0.597366590 -0.19195352
## [102,] -0.49347731 -0.89186931 -1.70048129 -0.297926283 -0.82209603
## [103,] -0.81374277  0.10173395  0.34075155  0.450674485 -0.12193769

```

```

## [104,] -1.45427369 -0.55171684 -1.77338246  0.001514024 -0.96212770
## [105,] -0.60433843 -0.54276546 -1.40887660  0.300954331 -1.03214354
## [106,] -0.71519955  0.19124776 -0.35180959  0.750114792 -0.68206436
## [107,] -0.92460389 -0.54276546 -0.89856839 -0.148206130 -1.38222271
## [108,] -0.34566248 -0.52486270 -0.31535901  0.899834945 -1.10215937
## [109,] -0.96155760 -0.93662621 -1.55467894 -0.148206130 -0.54203270
## [110,] -1.71294964 -0.88291793  1.21556562  0.151234178 -0.40200103
## [111,] -1.89771818  1.25646206 -1.99208598  0.001514024  0.50820482
## [112,] -0.59202053  0.08383119 -0.71631546  0.450674485 -0.82209603
## [113,] -1.52818111  0.30761571  2.01747852  0.151234178  0.22814148
## [114,] -1.95930769 -1.42895215  0.48655389  0.450674485 -0.82209603
## [115,] -1.13400823 -0.84711240  0.48655389  0.899834945 -1.10215937
## [116,] -2.42738798 -0.73969583 -0.60696370  0.600394638 -1.03214354
## [117,] -1.45427369 -0.77550136 -1.37242601  0.390786423 -0.96212770
## [118,] -0.71519955 -0.65018203 -0.64341428  0.899834945  0.57822065
## [119,] -0.28407297  0.97896926 -1.40887660 -1.046527051 -1.38222271
## [120,] -1.23255145  0.97896926 -1.33597542 -0.148206130 -0.89211187
## [121,] -1.91003608  0.05697705  0.19494920  0.151234178 -0.26196936
## [122,] -1.77453915 -0.25632128  3.14744670  2.696476788  1.34839483
## [123,] -0.71519955  1.87410733  1.32491738  2.097596174  0.15812565
## [124,]  0.06082829  3.10044648 -0.86211780  0.600394638 -0.96212770
## [125,] -1.39268418  1.76669076  0.08559744  0.450674485 -1.24219104
## [126,] -1.14632613 -0.15785609 -0.71631546  0.450674485 -1.03214354
## [127,] -0.70288165 -0.72179307 -0.27890842  0.600394638 -0.96212770
## [128,] -1.49122740 -0.18471023  1.50717031  2.696476788 -0.54203270
## [129,] -0.77678907 -0.63227927 -0.24245783  1.498715559 -0.82209603
## [130,] -1.18327984  1.75773938  0.04914686  0.750114792 -1.38222271
## [131,] -0.17321185 -0.88291793 -0.16955666 -0.447646437  1.55844234
## [132,] -0.14857605  0.58510851  0.12204803  0.151234178  0.29815732
## [133,] -0.23480136 -0.02358538  0.12204803  1.348995406 -0.12193769
## [134,] -0.37029829  1.08638583 -0.02375431  0.600394638  0.43818899
## [135,] -0.60433843 -0.98138311 -0.42471076 -0.597366590 -1.03214354
## [136,] -0.49347731  0.11068533 -0.60696370 -0.297926283 -0.40200103
## [137,] -0.92460389  2.13369737  0.63235624  0.450674485 -0.75208020
## [138,] -0.57970263  2.84085644  0.99686210  1.648435713 -0.26196936
## [139,]  0.60281600  1.12219135 -0.64341428  0.001514024 -0.82209603
## [140,] -0.19784766  0.55825437  0.88751034  1.348995406  0.08810981
## [141,] -0.08698653  0.42398365  1.21556562  0.450674485 -0.26196936
## [142,]  0.44268327  0.20019914 -0.06020490  0.151234178 -0.75208020
## [143,]  0.63976970  0.74623336  1.28846679  1.199275252 -0.19195352
## [144,]  0.76294873  2.33957912 -0.06020490  0.151234178 -0.54203270
## [145,] -0.92460389  1.38178139 -0.60696370 -0.297926283  0.85828399
## [146,]  0.19632522  1.10428859 -0.78921663  0.450674485  0.15812565
## [147,]  1.08321419  2.42014155 -0.49761194  0.151234178 -1.38222271
## [148,] -0.16089395  2.03523218  0.41365272  0.600394638 -0.96212770
## [149,]  0.39341166  0.80889302  0.04914686  0.600394638 -0.54203270
## [150,]  0.09778200  1.39968415 -0.02375431  0.600394638  0.92829983
## [151,]  0.61513390  0.70147646  0.92396093  1.348995406  1.62845817
## [152,] -0.25943717  0.29866433  0.41365272  0.750114792  0.85828399
## [153,]  0.13473571 -0.39059199  1.39781855  1.798155867  1.13834733
## [154,]  0.28255053  0.86260131 -0.31535901 -0.297926283 -0.12193769
## [155,] -0.51811312 -0.93662621 -0.97146956  0.151234178  0.22814148

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## [156,] 0.20864312 2.55441226 -0.16955666 0.750114792 -0.47201686
## [157,] 1.03394258 1.59661452 0.04914686 0.001514024 -0.75208020
## [158,] -0.67824585 0.62091403 0.99686210 2.247316327 -0.19195352
## [159,] 1.64983769 -0.58752236 1.21556562 1.648435713 -0.12193769
## [160,] 0.59049809 -0.59647374 0.99686210 0.899834945 -0.75208020
## [161,] -0.78910697 1.33702448 0.04914686 0.450674485 -0.82209603
## [162,] 0.84917404 0.82679579 0.63235624 0.151234178 0.50820482
## [163,] -0.18552975 0.83574717 0.77815859 0.750114792 0.43818899
## [164,] -0.05003283 0.99687202 -0.06020490 -0.297926283 0.43818899
## [165,] 0.96003516 0.37922675 -0.24245783 0.750114792 -0.68206436
## [166,] 0.89844565 1.81144766 -0.38826018 0.899834945 -0.82209603
## [167,] 0.55354439 1.22065654 0.85105976 1.049555099 0.78826816
## [168,] -0.22248346 0.92526097 -0.24245783 0.001514024 -0.82209603
## [169,] 0.71367712 0.21810190 1.17911504 1.498715559 0.36817315
## [170,] 0.49195487 2.02628080 1.79877500 1.648435713 0.85828399
## [171,] -0.98619340 0.62091403 -0.16955666 -0.148206130 -0.26196936
## [172,] -0.28407297 0.04802567 -0.31535901 0.001514024 -0.96212770
## [173,] 1.42811545 0.15544223 0.41365272 0.151234178 -0.61204853
## [174,] 0.87380985 2.96617577 0.30430096 0.300954331 -0.33198519
## [175,] 0.49195487 1.40863553 0.41365272 1.049555099 0.15812565
## [176,] 0.33182214 1.73983662 -0.38826018 0.151234178 1.41841067
## [177,] 0.20864312 0.22705328 0.01269627 0.151234178 1.41841067
## [178,] 1.39116174 1.57871176 1.36136797 1.498715559 -0.26196936

##          Phenols      Flavanoids Nonflavanoids Proanthocyanins        Color
## [1,] 0.806721729 1.0319080692 -0.65770780 1.22143845 0.251008784
## [2,] 0.567048088 0.7315652835 -0.81841060 -0.54318872 -0.292496232
## [3,] 0.806721729 1.2121137407 -0.49700500 2.12995937 0.268262912
## [4,] 2.484437221 1.4623993954 -0.97911340 1.02925134 1.182731669
## [5,] 0.806721729 0.6614853002 0.22615759 0.40027531 -0.318377423
## [6,] 1.557699140 1.3622851335 -0.17559941 0.66234866 0.729810822
## [7,] 0.327374446 0.4912910549 -0.49700500 0.67982021 0.082781041
## [8,] 0.487156874 0.4812796287 -0.41665360 -0.59560339 -0.003489596
## [9,] 0.806721729 0.9518166597 -0.57735640 0.67982021 0.061213382
## [10,] 1.094330099 1.1220109049 -1.13981619 0.45268998 0.932546820
## [11,] 1.046395371 1.2922051502 -1.13981619 1.37868246 0.298457635
## [12,] -0.151972837 0.4011882192 -0.81841060 -0.03651359 -0.025057256
## [13,] 0.487156874 0.7315652835 -0.57735640 0.38280376 0.233754657
## [14,] 1.286069013 1.6626279192 0.54756319 2.12995937 0.147484019
## [15,] 1.605633868 1.6125707883 -0.57735640 2.39203271 1.053325713
## [16,] 0.886612943 0.8817366764 -0.49700500 -0.22870071 0.967055075
## [17,] 0.806721729 1.1119994787 -0.25595080 0.66234866 0.492566569
## [18,] 1.046395371 1.3722965597 0.30650899 0.22555975 0.665107844
## [19,] 1.605633868 1.9029021478 -0.33630220 0.47016154 1.570949537
## [20,] 0.646939302 1.0018737906 -1.54157319 0.12073042 0.018078063
## [21,] 1.126286585 1.1420337573 -0.97911340 0.88947889 0.255322316
## [22,] 0.183570261 0.3811653668 -0.89876200 0.67982021 -0.240733849
## [23,] 0.503135117 0.8517023978 -0.73805920 0.17314508 -0.542681081
## [24,] 0.295417961 0.3411196621 -0.81841060 -0.22870071 -0.486605166
## [25,] 0.375309174 0.5813938906 -0.65770780 0.12073042 -0.663459973
## [26,] 0.535091602 0.6514738740 0.86896878 0.57499088 -0.637578782
## [27,] 0.886612943 0.9117709549 -0.17559941 -0.24617226 -0.111327893
## [28,] 0.167592018 0.1609139906 -0.73805920 -0.42088782 -0.477978102

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## [29,]	1.046395371	0.9418052335	0.06545479	0.29544598	-0.240733849
## [30,]	0.567048088	0.3010739573	-0.81841060	0.67982021	-0.154463212
## [31,]	1.126286585	1.2221251668	-0.57735640	1.37868246	0.276889975
## [32,]	0.902591186	1.1620566097	-1.13981619	0.62740554	0.794513800
## [33,]	0.199548504	0.6614853002	0.46721179	0.66234866	-0.525426953
## [34,]	1.046395371	0.7115424311	1.11002298	-0.42088782	0.147484019
## [35,]	0.087700804	0.5013024811	-0.57735640	-0.08892826	-0.370139806
## [36,]	0.646939302	0.9518166597	-0.81841060	0.47016154	0.018078063
## [37,]	0.487156874	0.6514738740	-0.17559941	-0.40341627	-0.197598531
## [38,]	0.247483232	0.4011882192	-0.57735640	-0.26364382	-0.348572146
## [39,]	0.167592018	0.6114281692	-0.65770780	-0.38594471	-0.585816399
## [40,]	1.126286585	1.0118852168	-1.30051899	0.85453577	0.018078063
## [41,]	1.365960227	1.2621708716	-0.17559941	1.30879623	0.462371846
## [42,]	0.247483232	0.6514738740	-0.73805920	-0.19375759	-0.335631551
## [43,]	1.525742654	1.5324793788	-1.54157319	0.19061664	0.160424615
## [44,]	0.551069845	0.6014167430	-0.33630220	0.12073042	-0.301123296
## [45,]	1.126286585	0.9718395121	-0.65770780	0.76717799	-0.007803128
## [46,]	0.886612943	0.6214395954	-0.49700500	-0.59560339	0.078467509
## [47,]	1.525742654	1.1420337573	-0.73805920	1.04672289	-0.068192574
## [48,]	1.286069013	1.3622851335	-1.22016759	0.95936511	0.449431250
## [49,]	0.726830515	0.8917481025	-0.33630220	1.37868246	0.492566569
## [50,]	0.934547672	1.5124565264	-0.33630220	0.85453577	1.657220175
## [51,]	0.678895787	1.2421480192	-1.54157319	2.30467493	0.923919756
## [52,]	0.247483232	0.9618280859	-1.13981619	1.22143845	0.233754657
## [53,]	2.532371949	1.7126850502	-0.33630220	0.48763309	0.859216778
## [54,]	1.126286585	0.7615995621	0.22615759	0.15567353	0.535701888
## [55,]	0.487156874	0.8717252502	-1.22016759	0.05084419	0.341592953
## [56,]	1.062373614	0.7515881359	-1.30051899	1.50098335	0.514134228
## [57,]	1.445851440	0.9718395121	-0.81841060	0.76717799	0.570210143
## [58,]	1.126286585	1.2021023145	-0.41665360	0.12073042	0.406295932
## [59,]	1.765416296	1.6426050669	-1.38087039	0.78464955	0.751378481
## [60,]	-0.503494178	-1.4609370523	-0.65770780	-2.04574255	-1.340684477
## [61,]	-0.391646479	-0.9403428904	2.15459116	-2.06321410	-0.771298270
## [62,]	-0.439581207	-0.6199772522	1.35107717	-1.69631142	0.298457635
## [63,]	-0.311755265	-0.2395430570	-0.33630220	-1.50412430	-0.542681081
## [64,]	1.925198724	1.0719537740	-1.38087039	0.48763309	-0.262301509
## [65,]	-0.647298363	-0.2795887618	0.70826598	-0.97997762	-0.909331290
## [66,]	0.199548504	0.6214395954	0.06545479	0.85453577	-0.197598531
## [67,]	1.094330099	1.1520451835	-0.81841060	1.20396690	0.104348700
## [68,]	-0.295777022	-0.0293031070	-0.73805920	-0.96250606	-0.163090276
## [69,]	0.375309174	-0.7301029403	1.51177997	-2.04574255	-0.814433589
## [70,]	-0.711211334	-0.7501257927	-1.78262739	1.58834113	-0.952466609
## [71,]	-1.909579543	-1.0104228737	0.06545479	-0.22870071	-0.866195971
## [72,]	1.046395371	0.8316795454	-1.22016759	0.48763309	-0.723849419
## [73,]	-0.663276606	-0.1894859260	-0.73805920	-0.97997762	-0.568562272
## [74,]	1.605633868	0.8617138240	-1.22016759	0.64487710	-0.736790015
## [75,]	1.733459810	0.1108568597	-1.86297878	0.10325886	-0.797179461
## [76,]	-1.094689161	-0.4597944332	-0.17559941	-0.77031895	-0.542681081
## [77,]	-0.551428907	0.0007311716	-0.97911340	-0.22870071	-0.197598531
## [78,]	-0.918928490	-0.7100800880	0.54756319	-1.11975007	-1.038737246
## [79,]	-0.631320120	-0.1794744999	-0.09524801	2.04260159	-0.715222356
## [80,]	0.854656458	0.5213253335	0.54756319	0.62740554	-1.073245501

## [81,]	0.199548504	0.2309939740	-0.49700500	-0.28111538	-1.103440224
## [82,]	-0.151972837	0.5013024811	-0.81841060	0.31291753	-0.499545762
## [83,]	-0.471537693	-0.4497830070	0.30650899	-0.33353004	-1.232846180
## [84,]	-1.030776190	-0.4397715808	1.99388837	0.05084419	-0.111327893
## [85,]	-0.151972837	0.1809368430	-1.13981619	1.32626779	-0.866195971
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## [87,]	-0.823059034	-0.3396573189	0.54756319	-0.05398515	-1.125007884
## [88,]	-0.599363635	-0.4197487284	0.30650899	-0.43835938	-1.060304905
## [89,]	-0.551428907	-0.3396573189	0.94932018	-0.42088782	-0.974034268
## [90,]	-0.151972837	-0.4397715808	0.46721179	-0.36847316	-1.431268647
## [91,]	-1.110667404	-0.5298744165	1.27072578	0.08578730	-1.146575543
## [92,]	-1.350341045	-0.7801600713	1.11002298	0.06831575	-0.628951718
## [93,]	-1.462188745	-0.5699201213	1.75283417	0.05084419	-0.866195971
## [94,]	0.247483232	0.2209825478	-0.89876200	0.69729177	-1.254413840
## [95,]	1.158243070	0.2309939740	-1.54157319	-0.42088782	-0.779925334
## [96,]	0.327374446	0.2410054002	-0.33630220	2.95112251	-1.060304905
## [97,]	-1.110667404	-1.0404571523	-1.78262739	-0.05398515	-1.103440224
## [98,]	0.407265660	0.4712682025	-0.57735640	0.31291753	-0.930898949
## [99,]	1.957155209	1.7226964764	-0.97911340	0.62740554	-0.240733849
## [100,]	0.886612943	0.9618280859	0.70826598	2.12995937	-1.189710862
## [101,]	-0.104038109	0.1408911382	-0.81841060	-0.33353004	-0.758357674
## [102,]	-1.350341045	-0.6700343832	-0.57735640	-0.42088782	-1.125007884
## [103,]	0.423243903	0.0808225811	-0.17559941	-0.49077405	-0.974034268
## [104,]	0.327374446	-0.3897144499	0.06545479	-0.29858693	-1.293235627
## [105,]	-0.151972837	-0.1093945165	-0.33630220	-0.19375759	-0.913644822
## [106,]	-0.982841462	-0.1894859260	2.39564536	-0.29858693	-1.017169587
## [107,]	-1.030776190	0.0007311716	0.06545479	0.06831575	-0.715222356
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## [109,]	0.103679047	0.0107425978	0.22615759	0.85453577	-1.017169587
## [110,]	0.710852273	0.8917481025	-0.57735640	1.57086958	-1.038737246
## [111,]	1.413894955	0.5513596121	-0.97911340	3.47526919	-0.930898949
## [112,]	0.407265660	0.2410054002	-0.81841060	-0.64801805	-1.319116818
## [113,]	-0.870993762	0.0007311716	1.91353697	-0.94503451	-0.542681081
## [114,]	0.295417961	-0.0192916808	0.46721179	-0.26364382	-0.853255375
## [115,]	0.423243903	0.2610282525	0.54756319	-0.96250606	-0.930898949
## [116,]	0.263461475	0.1408911382	1.27072578	0.73223488	-1.362252137
## [117,]	-0.503494178	-0.4297601546	-0.49700500	-0.10639981	-1.340684477
## [118,]	-0.471537693	0.0607997287	-0.17559941	0.03337264	-1.293235627
## [119,]	-1.062732675	-0.7801600713	0.54756319	-1.32940874	-0.715222356
## [120,]	-0.471537693	-0.3897144499	0.06545479	0.48763309	-1.629691113
## [121,]	0.966504157	0.7615995621	-0.33630220	0.41774687	-0.779925334
## [122,]	1.413894955	3.0542161597	0.86896878	0.48763309	0.406295932
## [123,]	-0.151972837	0.1008454335	0.54756319	0.20808820	-1.284608563
## [124,]	0.519113359	0.6214395954	-0.49700500	0.73223488	-1.060304905
## [125,]	0.902591186	1.0018737906	-1.22016759	2.30467493	-0.974034268
## [126,]	0.487156874	0.6214395954	0.06545479	-0.42088782	-0.991288395
## [127,]	0.710852273	1.1220109049	0.22615759	0.31291753	-0.482291634
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## [131,]	-1.254471589	-0.7801600713	-1.22016759	-1.13722163	-0.413275124
## [132,]	-1.590014687	-0.8101943499	-0.97911340	-1.32940874	0.147484019

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## [133,] -1.829688329 -0.9403428904 -0.73805920 -1.32940874 0.276889975
## [134,] -0.950884976 -0.8302172023 -1.54157319 -1.31193719 -0.025057256
## [135,] -0.471537693 -1.4509256261 1.91353697 -0.59560339 0.169051679
## [136,] -1.078710918 -1.3708342166 2.15459116 -1.13722163 0.880784438
## [137,] -1.462188745 -1.5610513142 1.35107717 -1.38182341 -0.521113421
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## [142,] -1.430232259 -1.5310170356 0.06545479 -1.66136831 0.233754657
## [143,] -1.190558618 -1.5109941832 1.11002298 -1.81861232 -0.305436828
## [144,] -0.471537693 -1.2306742499 0.86896878 -0.99744918 -0.283869168
## [145,] -1.462188745 -1.2506971023 -0.57735640 -0.78779050 1.359586476
## [146,] -1.270449832 -1.4809599046 0.54756319 -0.50824560 -0.456410443
## [147,] -2.101318456 -1.6911998547 0.30650899 -1.59148209 -0.068192574
## [148,] -0.950884976 -1.3808456427 0.86896878 -1.27699407 1.118028691
## [149,] -0.583385392 -1.2707199546 0.70826598 -0.59560339 1.450170645
## [150,] -1.414254017 -0.6400001046 -0.17559941 -0.78779050 1.872896769
## [151,] -1.430232259 -0.4597944332 -1.13981619 -0.59560339 1.527814219
## [152,] -1.302406317 -0.6700343832 -0.97911340 -0.57813183 2.476791231
## [153,] -0.151972837 -0.7501257927 -0.81841060 -0.05398515 0.880784438
## [154,] -0.791102548 -1.2006399713 1.99388837 0.48763309 2.356012338
## [155,] -1.302406317 -1.4509256261 1.35107717 -0.33353004 1.096461031
## [156,] -0.886972005 -1.4008684951 1.99388837 -0.07145670 1.225866988
## [157,] -0.791102548 -1.2006399713 0.94932018 -0.05398515 1.704669026
## [158,] -0.631320120 -1.4509256261 2.15459116 -0.78779050 1.053325713
## [159,] 0.806721729 -0.7200915142 1.35107717 1.93777225 3.425768243
## [160,] 0.487156874 -0.9303314642 1.27072578 1.22143845 2.886576759
## [161,] 0.007809591 -1.1105371356 1.11002298 -0.96250606 1.118028691
## [162,] -0.743167820 -1.4709484785 1.11002298 -1.38182341 0.354533549
## [163,] -1.030776190 -1.4309027737 1.91353697 -1.10227851 0.225127593
## [164,] -1.446210502 -1.3307885118 0.30650899 -1.13722163 0.095721637
## [165,] -1.510123473 -1.3508113642 0.38686039 -0.97997762 1.950540342
## [166,] -1.621971173 -1.5610513142 1.27072578 -0.77031895 0.673734908
## [167,] -0.950884976 -1.1105371356 0.54756319 -0.22870071 2.425028848
## [168,] -1.302406317 -1.3708342166 0.30650899 -1.08480696 2.243860510
## [169,] -1.190558618 -1.1906285451 0.22615759 -0.08892826 1.553695410
## [170,] -0.503494178 -1.0704914308 -0.73805920 -0.84020517 1.484678900
## [171,] -1.669905901 -1.5410284618 0.30650899 -1.50412430 0.190619338
## [172,] -1.446210502 -1.5210056094 0.94932018 -1.66136831 2.088572931
## [173,] -0.982841462 -1.3307885118 0.62791458 -0.61307494 2.002302725
## [174,] -0.982841462 -1.4208913475 1.27072578 -0.92756295 1.139596350
## [175,] -0.791102548 -1.2807313808 0.54756319 -0.31605849 0.967055075
## [176,] -1.126645647 -1.3407999380 0.54756319 -0.42088782 2.217979318
## [177,] -1.030776190 -1.3508113642 1.35107717 -0.22870071 1.829761450
## [178,] -0.391646479 -1.2707199546 1.59213137 -0.42088782 1.786626131

##          Hue    Dilution   Proline
## [1,] 0.36115849 1.84272147 1.010159388
## [2,] 0.40490846 1.11031723 0.962526349
## [3,] 0.31740852 0.78636920 1.391223700
## [4,] -0.42634104 1.18074072 2.328006800
## [5,] 0.36115849 0.44833648 -0.037767469

```

```

## [6,] 0.40490846 0.33565890 2.232740722
## [7,] 0.27365854 1.36384178 1.724654973
## [8,] 0.44865844 1.36384178 1.740532653
## [9,] 0.53615839 0.33565890 0.946648670
## [10,] 0.22990857 1.32158768 0.946648670
## [11,] 1.27990794 0.78636920 2.423272878
## [12,] 0.92990815 0.29340481 1.692899614
## [13,] 0.84240820 0.40608239 1.819921051
## [14,] 1.27990794 0.16664254 1.280079943
## [15,] 1.06115807 0.54692935 2.540767708
## [16,] 1.41115786 0.37791299 1.788165692
## [17,] 0.49240841 0.05396496 1.692899614
## [18,] 0.75490825 -0.05871261 1.216569224
## [19,] 1.19240799 0.29340481 2.963113987
## [20,] 0.01115870 1.05397844 0.311541483
## [21,] 0.57990836 1.54694284 0.105131647
## [22,] 0.31740852 1.27933359 0.073376288
## [23,] 0.66740831 1.95539905 0.914893310
## [24,] 0.57990836 1.43426526 0.851382592
## [25,] 0.71115828 1.70187450 0.311541483
## [26,] 0.75490825 0.82862329 0.263908444
## [27,] -0.16384119 0.85679269 1.422979059
## [28,] 0.27365854 0.22298133 1.708777293
## [29,] 1.27990794 1.11031723 0.533828998
## [30,] 0.36115849 1.37792647 0.914893310
## [31,] 1.01740810 0.13847314 1.708777293
## [32,] 0.57990836 0.37791299 2.439150558
## [33,] 1.19240799 0.36382829 0.771994193
## [34,] 1.27990794 0.54692935 1.550000497
## [35,] 0.62365833 0.36382829 1.105425466
## [36,] 0.36115849 1.20891011 0.549706678
## [37,] 0.57990836 0.23706602 0.422685241
## [38,] 0.71115828 -0.14322079 1.137180826
## [39,] 0.97365812 0.11030375 0.867260271
## [40,] -0.29509111 1.29341829 0.041620929
## [41,] -0.03259127 1.08214784 0.152764686
## [42,] -0.20759117 0.54692935 0.914893310
## [43,] -0.33884109 1.33567238 1.105425466
## [44,] -0.60134093 0.54692935 -0.212421946
## [45,] -0.33884109 1.03989375 0.438562920
## [46,] -0.38259106 1.01172435 1.057792427
## [47,] 0.36115849 1.16665602 1.010159388
## [48,] -0.20759117 1.01172435 0.756116514
## [49,] 0.49240841 0.19481193 0.994281709
## [50,] 0.71115828 0.68777632 1.629388895
## [51,] 0.71115828 0.42016708 1.280079943
## [52,] 1.23615797 1.06806314 1.645266575
## [53,] 0.22990857 0.91313147 1.407101380
## [54,] 0.75490825 0.44833648 1.994575527
## [55,] -0.16384119 0.82862329 0.994281709
## [56,] 0.09865865 0.58918345 1.184813865
## [57,] -0.07634125 0.98355496 0.708483475

```

```
## [58,]  0.49240841  0.32157420  1.661144254
## [59,] -0.29509111  0.36382829  1.708777293
## [60,]  0.40490846 -1.11506488 -0.720507695
## [61,]  1.27990794 -1.32633534 -0.212421946
## [62,]  0.09865865 -1.43901291 -0.942795210
## [63,]  1.19240799 -0.21364428 -0.371198742
## [64,]  1.14865802  0.36382829 -1.038061288
## [65,]  2.15490741 -0.53759231 -1.244471124
## [66,]  1.01740810 -0.43899943 -0.218773018
## [67,]  0.71115828  0.80045390 -0.777667342
## [68,]  0.71115828  1.22299481 -0.752263054
## [69,]  0.27365854 -0.96013322  0.009865569
## [70,]  1.41115786  0.64552223 -0.091751580
## [71,] -0.22509116 -1.11506488  0.390929881
## [72,]  1.76115765  0.77228450 -1.069816648
## [73,]  0.09865865  0.23706602 -0.872933420
## [74,]  1.54240778  1.25116420  0.756116514
## [75,]  0.14240862  0.73003041  0.441738456
## [76,]  1.19240799 -0.66435458 -1.012657001
## [77,]  1.01740810 -0.18547489 -1.126976294
## [78,]  0.01115870 -0.12913610 -0.784018414
## [79,]  0.44865844 -0.42491473  0.009865569
## [80,]  1.01740810  0.73003041 -0.901513243
## [81,]  1.84865760  0.71594572 -1.488987391
## [82,]  0.88615818  0.74411511 -0.104453724
## [83,]  1.54240778  0.15255784 -0.371198742
## [84,] -0.51384098 -0.84745564 -0.736385375
## [85,] -0.73259085  0.65960693 -0.720507695
## [86,]  1.19240799  0.77228450 -0.942795210
## [87,]  1.62990773 -0.49533822 -0.799896093
## [88,]  1.76115765  0.84270799 -0.587135186
## [89,]  0.18615860  0.19481193 -0.212421946
## [90,]  0.49240841  0.84270799 -0.387076422
## [91,]  0.53615839 -0.48125352 -0.847529132
## [92,]  0.40490846  0.05396496 -0.942795210
## [93,]  0.01115870 -0.77703216 -0.799896093
## [94,]  0.84240820  0.96947026 -1.450880959
## [95,]  0.88615818  0.49059057 -1.276226483
## [96,]  0.88615818  0.02579557  0.603690789
## [97,] -0.03259127 -0.49533822 -0.387076422
## [98,]  1.19240799  0.18072723 -1.012657001
## [99,]  0.36115849  0.22298133 -0.275932664
## [100,] 2.02365749  0.30748951 -1.082518791
## [101,] 1.36740789  0.49059057 -0.117155868
## [102,] 0.36115849  0.22298133 -0.587135186
## [103,] -0.68884088  1.08214784 -0.980901641
## [104,] -0.07634125 -0.24181367 -1.053938968
## [105,] 0.36115849  1.34975708 -0.237826233
## [106,] -0.42634104  0.96947026 -1.371492561
## [107,] 0.18615860  0.78636920 -0.752263054
## [108,] -0.33884109 -0.26998307 -0.822124845
## [109,] -0.42634104  0.57509875 -1.381019169
```

```
## [110,]  0.01115870  0.91313147 -0.212421946
## [111,] -0.90759075  0.27932011 -0.587135186
## [112,] -0.25134114  0.23706602 -1.339737202
## [113,]  1.19240799 -0.15730549 -0.444236069
## [114,]  0.62365833 -0.42491473 -0.993603785
## [115,] -0.12009122  0.81453860 -1.149205046
## [116,]  3.29240673  0.36382829 -1.079343255
## [117,] -0.03259127  1.01172435 -0.799896093
## [118,]  0.44865844  0.49059057 -1.276226483
## [119,] -1.12634062 -0.69252397 -1.190487013
## [120,] -0.12009122  0.61735284 -0.580784114
## [121,] -0.68884088  1.09623253 -0.387076422
## [122,] -0.12009122  1.51877344 -0.895162171
## [123,] -0.16384119  0.71594572 -1.212715765
## [124,] -0.99509069  0.68777632 -1.165082726
## [125,] -0.90759075  1.44834996 -1.165082726
## [126,] -0.42634104  0.94130087 -1.171433797
## [127,] -1.17009059  0.32157420 -1.253997732
## [128,]  0.05490867 -0.24181367 -0.891986635
## [129,] -0.29509111  0.23706602 -1.285753091
## [130,] -0.73259085 -0.05871261 -0.529975539
## [131,] -0.86384077 -1.86155382 -0.371198742
## [132,] -0.95134072 -1.67845276 -0.688752336
## [133,] -1.30134051 -1.76296094 -0.593486258
## [134,] -0.77634083 -1.86155382 -0.466464820
## [135,] -0.90759075 -1.55169049 -0.307688024
## [136,] -0.99509069 -1.45309761 -0.164788907
## [137,] -0.90759075 -1.88972321 -0.085400508
## [138,] -0.60134093 -1.29816594 -0.736385375
## [139,] -0.64509090 -1.11506488 -0.529975539
## [140,] -0.29509111 -0.65026988 -0.498220180
## [141,] -0.82009080 -0.42491473 -0.466464820
## [142,] -1.12634062 -0.19955958  0.105131647
## [143,] -0.29509111 -0.77703216 -0.720507695
## [144,] -0.20759117 -0.79111685 -0.625241617
## [145,] -1.34509048 -0.86154034  0.343296842
## [146,] -1.56384035 -1.31225064  0.263908444
## [147,] -1.65134030 -1.80521503 -1.053938968
## [148,] -1.82634020 -1.05872609 -0.387076422
## [149,] -1.78259022 -1.39675882 -0.307688024
## [150,] -1.69509027 -1.80521503 -0.625241617
## [151,] -1.60759033 -1.84746912 -0.784018414
## [152,] -2.08884004 -1.60802927 -0.847529132
## [153,] -1.52009038 -1.80521503 -1.022183609
## [154,] -1.73884025 -1.55169049 -0.228299625
## [155,] -1.65134030 -1.49535170 -0.339443383
## [156,] -1.56384035 -1.59394458 -0.069522829
## [157,] -1.69509027 -1.36858943 -0.847529132
## [158,] -1.25759054 -1.24182715  0.422685241
## [159,] -1.69509027 -0.91787912 -0.275932664
## [160,] -1.69509027 -1.17140367 -0.402954102
## [161,] -1.73884025 -1.45309761 -0.720507695
```

```

## [162,]  0.01115870 -1.11506488 -0.212421946
## [163,] -0.38259106 -0.70660867 -0.561730898
## [164,] -1.21384056 -1.21365776 -0.228299625
## [165,] -1.12634062 -1.31225064 -0.418831781
## [166,] -0.77634083 -1.21365776 -0.720507695
## [167,] -0.47009101 -1.48126700 -0.164788907
## [168,] -1.03884067 -1.21365776 -0.196544266
## [169,] -0.95134072 -1.14323428  0.009865569
## [170,] -1.25759054 -0.97421791 -0.371198742
## [171,] -1.30134051 -1.10098018 -0.752263054
## [172,] -1.69509027 -1.38267412 -0.879284492
## [173,] -1.47634041 -1.26999655 -0.275932664
## [174,] -1.38884046 -1.22774246 -0.021889790
## [175,] -1.12634062 -1.48126700  0.009865569
## [176,] -1.60759033 -1.48126700  0.279786124
## [177,] -1.56384035 -1.39675882  0.295663803
## [178,] -1.52009038 -1.42492821 -0.593486258
## attr(,"scaled:center")
##      Alcohol        Malic         Ash Alkalinity Magnesium
## 13.0006180     2.3363483    2.3665169   19.4949438 99.7415730
##      Phenols       Flavanoids Nonflavanoids Proanthocyanins Color
## 2.2951124      2.0292697    0.3618539    1.5908989 5.0580899
##      Hue          Dilution       Proline
## 0.9574494      2.6116854    746.8932584
## attr(,"scaled:scale")
##      Alcohol        Malic         Ash Alkalinity Magnesium
## 0.8118265     1.1171461    0.2743440    3.3395638 14.2824835
##      Phenols       Flavanoids Nonflavanoids Proanthocyanins Color
## 0.6258510      0.9988587    0.1244533    0.5723589 2.3182859
##      Hue          Dilution       Proline
## 0.2285716      0.7099904    314.9074743

```

```

pca_results <- prcomp(data, scale. = TRUE)
pca_results

```

```

## Standard deviations (1, .., p=13):
## [1] 2.1692972 1.5801816 1.2025273 0.9586313 0.9237035 0.8010350 0.7423128
## [8] 0.5903367 0.5374755 0.5009017 0.4751722 0.4108165 0.3215244
##
## Rotation (n x k) = (13 x 13):
##          PC1      PC2      PC3      PC4      PC5
## Alcohol -0.144329395 -0.483651548 -0.20738262 -0.01785630 0.26566365
## Malic   0.245187580 -0.224930935  0.08901289  0.53689028 -0.03521363
## Ash     0.002051061 -0.316068814  0.62622390 -0.21417556 0.14302547
## Alkalinity 0.239320405  0.010590502  0.61208035  0.06085941 -0.06610294
## Magnesium -0.141992042 -0.299634003  0.13075693 -0.35179658 -0.72704851
## Phenols  -0.394660845 -0.065039512  0.14617896  0.19806835 0.14931841
## Flavanoids -0.422934297  0.003359812  0.15068190  0.15229479 0.10902584
## Nonflavanoids 0.298533103 -0.028779488  0.17036816 -0.20330102 0.50070298
## Proanthocyanins -0.313429488 -0.039301722  0.14945431  0.39905653 -0.13685982
## Color    0.088616705 -0.529995672 -0.13730621  0.06592568 0.07643678
## Hue     -0.296714564  0.279235148  0.08522192 -0.42777141 0.17361452
## Dilution -0.376167411  0.164496193  0.16600459  0.18412074 0.10116099
## Proline -0.286752227 -0.364902832 -0.12674592 -0.23207086 0.15786880
##          PC6      PC7      PC8      PC9      PC10
## Alcohol -0.21353865 -0.05639636 -0.39613926 -0.50861912 -0.21160473
## Malic   -0.53681385  0.42052391 -0.06582674  0.07528304 0.30907994
## Ash     -0.15447466 -0.14917061  0.17026002  0.30769445 0.02712539
## Alkalinity 0.10082451 -0.28696914 -0.42797018 -0.20044931 -0.05279942
## Magnesium -0.03814394  0.32288330  0.15636143 -0.27140257 -0.06787022
## Phenols  0.08412230 -0.02792498  0.40593409 -0.28603452 0.32013135
## Flavanoids 0.01892002 -0.06068521  0.18724536 -0.04957849 0.16315051
## Nonflavanoids 0.25859401  0.59544729  0.23328465 -0.19550132 -0.21553507
## Proanthocyanins 0.53379539  0.37213935 -0.36822675  0.20914487 -0.13418390
## Color    0.41864414 -0.22771214  0.03379692 -0.05621752 0.29077518
## Hue     -0.10598274  0.23207564 -0.43662362 -0.08582839 0.52239889
## Dilution -0.26585107 -0.04476370  0.07810789 -0.13722690 -0.52370587
## Proline -0.11972557  0.07680450 -0.12002267  0.57578611 -0.16211600
##          PC11     PC12     PC13
## Alcohol 0.22591696  0.26628645 -0.01496997
## Malic   -0.07648554 -0.12169604 -0.02596375
## Ash     0.49869142  0.04962237  0.14121803
## Alkalinity -0.47931378  0.05574287 -0.09168285
## Magnesium -0.07128891 -0.06222011 -0.05677422
## Phenols -0.30434119  0.30388245  0.46390791
## Flavanoids 0.02569409  0.04289883 -0.83225706
## Nonflavanoids -0.11689586 -0.04235219 -0.11403985
## Proanthocyanins 0.23736257  0.09555303  0.11691707
## Color    -0.03183880 -0.60422163  0.01199280
## Hue     0.04821201 -0.25921400  0.08988884
## Dilution -0.04642330 -0.60095872  0.15671813
## Proline -0.53926983  0.07940162 -0.01444734

```

```

explained_variance <- pca_results$sdev^2 / sum(pca_results$sdev^2)
explained_variance[0:3]

```

```
## [1] 0.3619885 0.1920749 0.1112363
```

```
pca_transformed_data <- scaled_data %*% pca_results$rotation[, 1:2]
```

Proportion of variance explained by the first three components: 0.3619885, 0.1920749, 0.1112363

```
type_data <- with_target_data[,1]  
type_data
```

```
pca_data_withtype <- cbind(type_data, pca_transformed_data)
pca_data_withtype
```

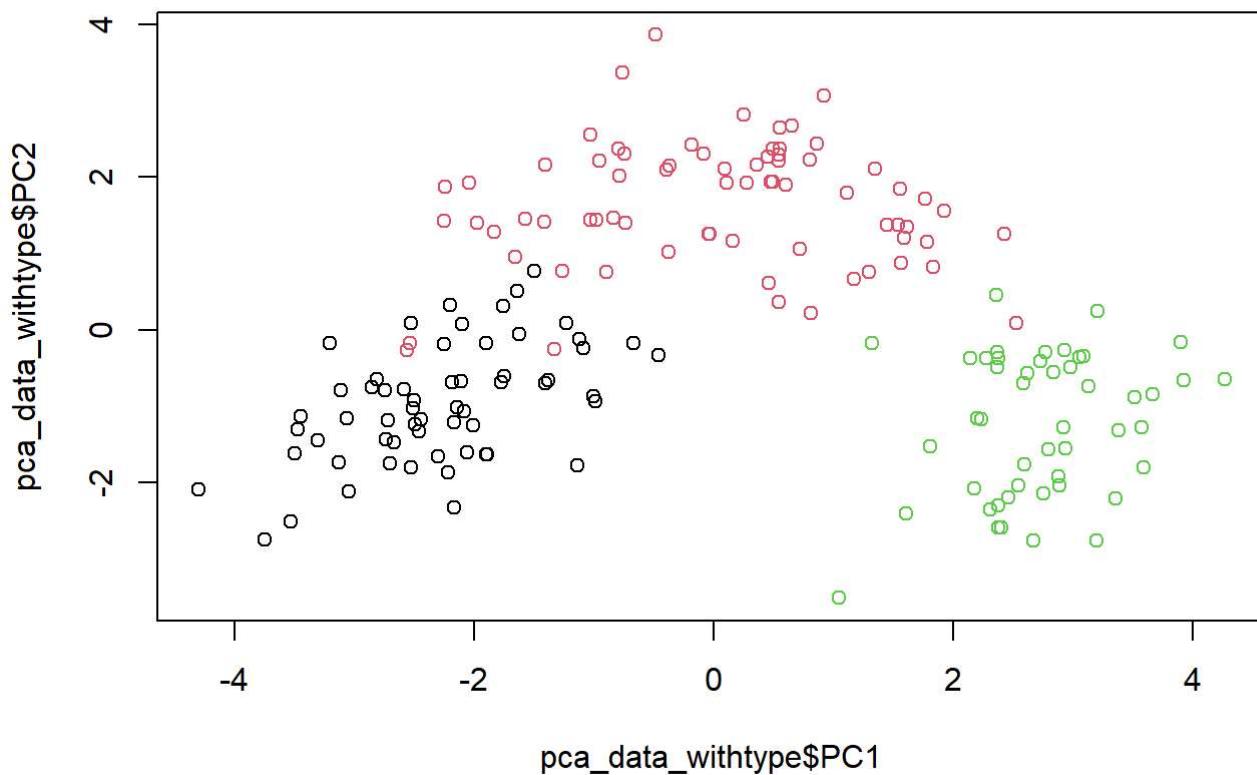
Type	PC1	PC2
<dbl>	<dbl>	<dbl>
1	-3.30742097	-1.43940225
1	-2.20324981	0.33245507
1	-2.50966069	-1.02825072
1	-3.74649719	-2.74861839
1	-1.00607049	-0.86738404
1	-3.04167373	-2.11643092
1	-2.44220051	-1.17154534
1	-2.05364379	-1.60443714

Type <dbl>	PC1 <dbl>	PC2 <dbl>
1	-2.50381135	-0.91548847
1	-2.74588238	-0.78721703

1-10 of 178 rows

Previous 1 2 3 4 5 6 ... 18 Next

```
plot(pca_data_withtype$PC1, pca_data_withtype$PC2, col=pca_data_withtype$Type)
```



Question 3

Question 3.1

- *Null Hypothesis (H_0)* is “The observed distribution of wine types does not significantly differ from an equal distribution among the three types”
- *Alternative Hypothesis (H_A)* is “The observed distribution of wine types significantly differ from an equal distribution among the three types”

Question 3.2

```

observed_freq <- table(type_data)

n <- length(type_data)
expected_freq <- rep(n / length(observed_freq), length(observed_freq))

expected_freq

```

```
## [1] 0.3333333 0.3333333 0.3333333
```

```

chi_sq_test <- chisq.test(observed_freq, p = expected_freq)
chi_sq_test

```

```

##
## Chi-squared test for given probabilities
##
## data: observed_freq
## X-squared = 4.4607, df = 2, p-value = 0.1075

```

Question 3.3

$\$ = 0.1075$ = \$ Since p-value is greater than α , the Null hypothesis (H_0) can't be rejected. The chi-square statistic can also be compared with the critical value received from a chi-square distribution table, keeping in mind that $df = 2$. That critical value is 5.991. This value, since it's greater than the calculated χ^2 statistic, does not show statistical significance.

Question 4

Question 4.1 and 4.2

```

feature <- with_target_data$Alcohol
quantiles <- quantile(feature, probs = c(1/3, 2/3))

# Step 2: Categorize each row based on which third it belongs to
third_category <- cut(feature, breaks = c(-Inf, quantiles, Inf), labels = c("Bottom Third", "Middle Third", "Top Third"))

# Step 3: Create a contingency table
contingency_table <- table(with_target_data>Type, third_category)

# Display the contingency table
contingency_table

```

```

##     third_category
##     Bottom Third Middle Third Top Third
## 1          0        17      42
## 2          54       14       3
## 3          6        28      14

```

Question 4.3

- *Null Hypothesis (H_0)* is “The wine type is independent of its alcohol content”
- *Alternative Hypothesis (H_A)* is “the wine type is dependent on its alcohol content”

Question 4.4

```
chisq.test(contingency_table)
```

```
##  
## Pearson's Chi-squared test  
##  
## data: contingency_table  
## X-squared = 121.35, df = 4, p-value < 2.2e-16
```

Question 4.5

\$ = 2.2 = \$ Since p-value is greater than α , the *Null hypothesis (H_0)* can be rejected. Similar to the above analysis, the chi-square statistic can also be compared with the critical value from a chi-square distribution table for $df = 4$. That critical value is 9.488. This value, since it's lesser than the calculated χ^2 statistic, shows statistical significance.