

1. The answers are below:

```
> fib = function(n) {  
+   s = numeric(n)  
+  
+   if (n <= 1) s[n] = 0  
+   else {  
+     s[1:(n - 1)] = fib(n - 1)  
+     if (n == 2) s[n] = 1  
+     else s[n] = s[n - 1] + s[n - 2]  
+   }  
+  
+   s  
+ }  
>  
> fib(1)  
[1] 0  
> fib(2)  
[1] 0 1  
> fib(3)  
[1] 0 1 1  
> fib(10)  
[1] 0 1 1 2 3 5 8 13 21 34
```

2. The answers are below:

```
(a) > clusters.medians = function(x, c) {  
+   lenc = length(c)  
+  
+   d = outer(c, x, function(cj, xi) abs(xi - cj))  
+   d.minnum = apply(d, 2, which.min)  
+  
+   con = outer(1:lenc, d.minnum, function(num, minnum) num == minnum)  
+  
+   xv = unlist(apply(con, 1, function(t) median(x[t])))  
+   xv  
+ }  
>  
> find.clusters.medians = function(x, c) {  
+   ctmp1 = c  
+   repeat {  
+     ctmp2 = clusters.medians(x, ctmp1)  
+     if (all(abs(ctmp1 - ctmp2) < 1e-07)) break  
+     else ctmp1 = ctmp2  
+   }  
+ }
```

```

+   }
+   ctmp1
+ }
>
> x = faithful$eruptions
> find.clusters.medians(x, c(2,4))
[1] 1.9830 4.3415
(b) > find.clusters.medians(x, c(2,3,4))
[1] 1.9830 3.9665 4.5330
(c) > find.clusters.medians(x, c(2,3,4,5))
[1] 1.967 3.600 4.150 4.600

```

3. The answers are below:

```

> sign.matrix = function(x) outer(x, x, function(x1, x2) sign(x1 - x2))
>
> conc = function(x, y) {
+   conc.mtx = sign.matrix(x)
+   conc.mty = sign.matrix(y)
+   conc.z = conc.mtx + conc.mty
+   c = length(which(conc.z != 0))
+   n = length(x)
+   c / (n * (n - 1))
+ }
>
> conc(x = 1:5, y = c(3, 1, 4, 5, 2))
[1] 0.6
> set.seed(782)
> x = round(rnorm(1000))
> y = x + round(rnorm(1000))
> conc(x, y)
[1] 0.8518939

```

4. The answers are below:

```

(a) > nba.df = read.csv("https://raw.githubusercontent.com/
zzdxzhangzhi/assignments/master/782/NBA2016-2017.csv",
+ stringsAsFactors = FALSE)
> names(nba.df) = c("team1", "team2", "wins")
> head(nba.df)

```

	team1	team2	wins
1	Atlanta Hawks	Boston Celtics	2
2	Atlanta Hawks	Brooklyn Nets	2
3	Atlanta Hawks	Charlotte Hornets	1
4	Atlanta Hawks	Chicago Bulls	3
5	Atlanta Hawks	Cleveland Cavaliers	3
6	Atlanta Hawks	Dallas Mavericks	2

```

>
>
> team.num = 30
> nba.names = nba.df$team1[seq(1, length(nba.df$team1), length = team.num)]
> nba.names
  [1] "Atlanta Hawks"      "Boston Celtics"      "Brooklyn Nets"
  [4] "Charlotte Hornets"   "Chicago Bulls"       "Cleveland Cavaliers"
  [7] "Dallas Mavericks"    "Denver Nuggets"      "Detroit Pistons"
 [10] "Golden State Warriors" "Houston Rockets"      "Indiana Pacers"
 [13] "Los Angeles Clippers" "Los Angeles Lakers"   "Memphis Grizzlies"
 [16] "Miami Heat"          "Milwaukee Bucks"      "Minnesota Timberwolves"
 [19] "New Orleans Pelicans" "New York Knicks"      "Oklahoma City Thunder"
 [22] "Orlando Magic"       "Philadelphia 76ers"    "Phoenix Suns"
 [25] "Portland Trail Blazers" "Sacramento Kings"     "San Antonio Spurs"
 [28] "Toronto Raptors"     "Utah Jazz"            "Washington Wizards"
>
> # likelihood.r = function(r, times) {
> #   mtx = outer(r, r, function(ri, rj) ri / (ri + rj))
> #   rankv = c(mtx[which(row(mtx) != col(mtx))]) ^ times
> #   log(prod(rankv))
> # }
>
> log.likelihood.r = function(r, times, s) {
+   rn = s - sum(r)
+   rr = c(r, rn)
+
+   if (all(rr > 0)) {
+     mtx = outer(rr, rr, function(ri, rj) log(ri / (ri + rj)))
+     rankv = c(t(mtx)[which(row(mtx) != col(mtx))])
+     sum(times * rankv)
+   } else {
+     -Inf
+   }
+ }
>
> s = 1000
> Q = function(r) {
+   -log.likelihood.r(r, nba.df$wins, s)
+ }
>
> result = optim(seq(1, team.num - 1, length = team.num - 1),
+               Q, method = "BFGS",
+               control = list(maxit = 200))
> result
$par
 [1] 28.920344 49.262769 8.487427 20.865839 26.562360 45.009903

```

```

18.735556 26.484090
[9] 21.994617 127.851303 59.221865 27.412854 47.775175 12.710449
32.153364 26.968452
[17] 28.090105 17.226476 19.848702 15.942769 38.873109 14.320608
13.473253 11.341333
[25] 28.116503 17.982849 83.968346 43.789158 47.019261

$value
[1] 761.4917

$counts
function gradient
      147      143

$convergence
[1] 0

$message
NULL

>
> ratio = 100 / max(result$par)
> r.value = result$par * ratio
> rr.value = c (r.value, (s - sum(result$par)) * ratio)
> rr.value
[1] 22.620297 38.531300 6.638514 16.320396 20.775979 35.204884
14.654177 20.714760
[9] 17.203279 100.000000 46.320893 21.441200 37.367766 9.941587
25.149031 21.093608
[17] 21.970918 13.473837 15.524833 12.469774 30.404938 11.200987
10.538221 8.870722
[25] 21.991566 14.065441 65.676566 34.250068 36.776521 30.966569
>
> rank.table = data.frame(nba.names, rr.value, stringsAsFactors = FALSE)
> ordered.rank = rank.table[order(rank.table$rr.value, decreasing = TRUE),]
> colnames(ordered.rank) = c("name", "rank")
> rownames(ordered.rank) = 1:team.num
> ordered.rank
      name      rank
1 Golden State Warriors 100.000000
2 San Antonio Spurs 65.676566
3 Houston Rockets 46.320893
4 Boston Celtics 38.531300
5 Los Angeles Clippers 37.367766
6 Utah Jazz 36.776521
7 Cleveland Cavaliers 35.204884

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```

8      Toronto Raptors 34.250068
9      Washington Wizards 30.966569
10     Oklahoma City Thunder 30.404938
11      Memphis Grizzlies 25.149031
12      Atlanta Hawks 22.620297
13 Portland Trail Blazers 21.991566
14      Milwaukee Bucks 21.970918
15      Indiana Pacers 21.441200
16      Miami Heat 21.093608
17      Chicago Bulls 20.775979
18      Denver Nuggets 20.714760
19      Detroit Pistons 17.203279
20      Charlotte Hornets 16.320396
21      New Orleans Pelicans 15.524833
22      Dallas Mavericks 14.654177
23      Sacramento Kings 14.065441
24 Minnesota Timberwolves 13.473837
25      New York Knicks 12.469774
26      Orlando Magic 11.200987
27      Philadelphia 76ers 10.538221
28      Los Angeles Lakers 9.941587
29      Phoenix Suns 8.870722
30      Brooklyn Nets 6.638514
>

```

```

(b) > log.likelihood.r.deriv = function(r, i, times1, times2) {
+   rlen = length(r)
+
+   if (all(r > 0)) {
+     mtx1 = outer(r[i], r[-i], function(ri, rj) rj / ri * (ri + rj))
+     mtx2 = outer(r[i], r[-i], function(ri, rj) 1 / (ri + rj))
+     deriv1 = c(t(mtx1),
+               1 / r[i]) * times1[(rlen * (i - 1) + 1) : (rlen * i)]
+     deriv2 = c(t(mtx2),
+               1 / (s - sum(r))) * times2[(rlen * (i - 1) + 1) : (rlen * i)]
+
+     sum(deriv1) - sum(deriv2)
+   } else {
+     -Inf
+   }
+ }
>
> Q.derivs = function(r) {
+   order.team2 = order(nba.df$team2)
+   wins.team2 = nba.df$wins[order.team2]
+   rlen = length(r)
+   gradients = numeric(rlen)

```

```

+   for (i in 1:rlen) {
+     gradients[i] = log.likelihood.r.deriv(r, i, nba.df$wins, wins.team2)
+   }
+
+   gradients
+ }
>
> result.deriv = optim(seq(1, 29, length = 29), Q, gr = Q.derivs,
+                       method = "BFGS")
> result.deriv
$par
  [1]  1  2  3  4  5  6  7  8  9 10 11 12 13 14 15 16 17 18 19
20 21 22 23 24 25 26 27 28 29

$value
[1] 1109.275

$counts
function gradient
      29          1

$convergence
[1] 0

$message
NULL

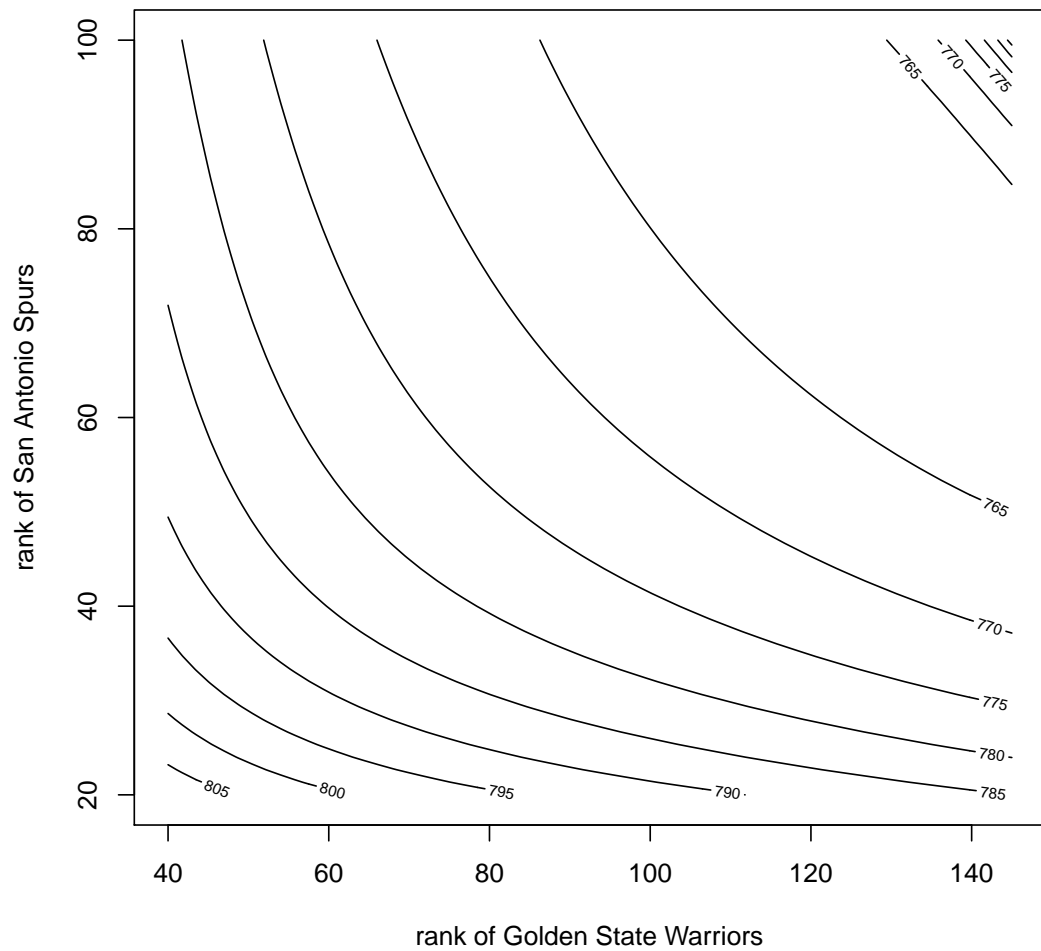
>
(c) > ranks = c(result$par, s - sum(result$par))
> ranks.sort = sort(ranks, decreasing = TRUE)
> first2 = c(which(round(ranks) == round(ranks.sort[1])),
+            which(round(ranks) == round(ranks.sort[2]))))
> first2
[1] 10 27
>
> Q2 = function(r1, r2) {
+   m = max(length(r1), length(r2))
+   if (length(r1) < m)
+     r1 = rep(r1, length = m)
+   if (length(r2) < m)
+     r2 = rep(r2, length = m)
+
+   ans = numeric(m)
+   for (i in 1:m) {
+     ranks[first2] = c(r1[i], r2[i])
+     ans[i] = -log.likelihood.r(ranks[-length(ranks)], nba.df$wins, s)

```

```

+   }
+
+   ans
+ }
>
> r1 = seq(40, 145, length = 61)
> r2 = seq(20, 100, length = 61)
> z = outer(r1, r2, Q2)
> contour(r1, r2, z,
+         xlab = paste("rank of", nba.names[first2[1]]),
+         ylab = paste("rank of", nba.names[first2[2]]))
>

```



```

> r1 = seq(40, 145, length = 1001)
> r2 = seq(20, 100, length = 6)
> z = outer(r1, r2, Q2)

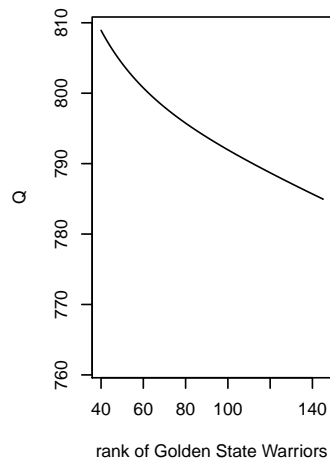
```

```

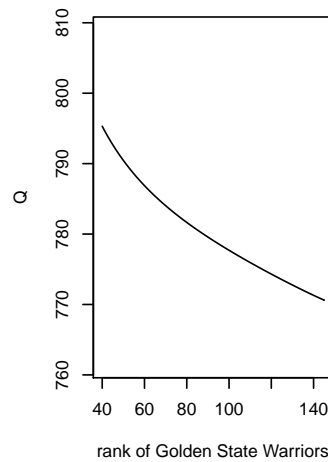
> par(mfrow = c(2, 3))
> ran = range(z)
> for(j in 1:length(r2)) {
+   plot(r1, z[, j], ylim = ran, type = "l",
+       main = paste("rank of",
+                   nba.names[first2[2]],
+                   "=",
+                   r2[j]),
+       xlab = paste("rank of", nba.names[first2[1]]),
+       ylab = "Q")
+ }
>

```

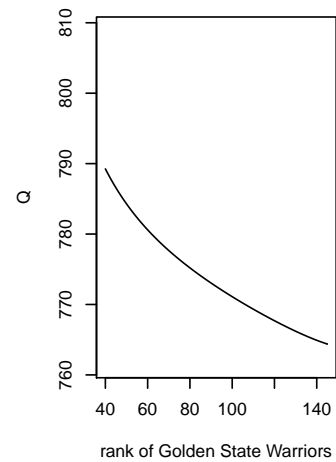
rank of San Antonio Spurs = 20



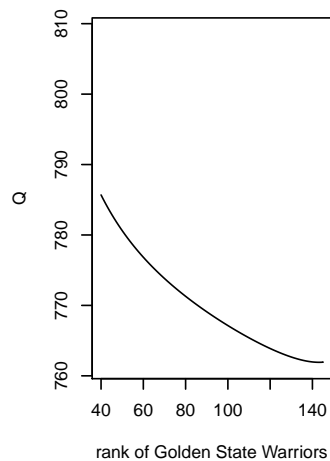
rank of San Antonio Spurs = 36



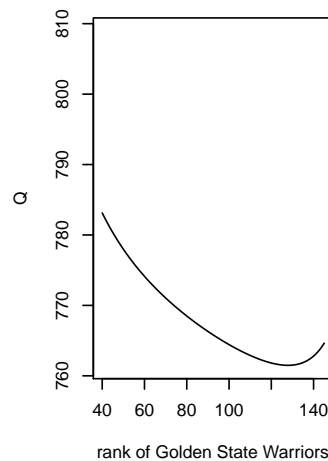
rank of San Antonio Spurs = 52



rank of San Antonio Spurs = 68



rank of San Antonio Spurs = 84



rank of San Antonio Spurs = 100

