Assignment-

Abheek Ghosh
140123047

October 9, 2017

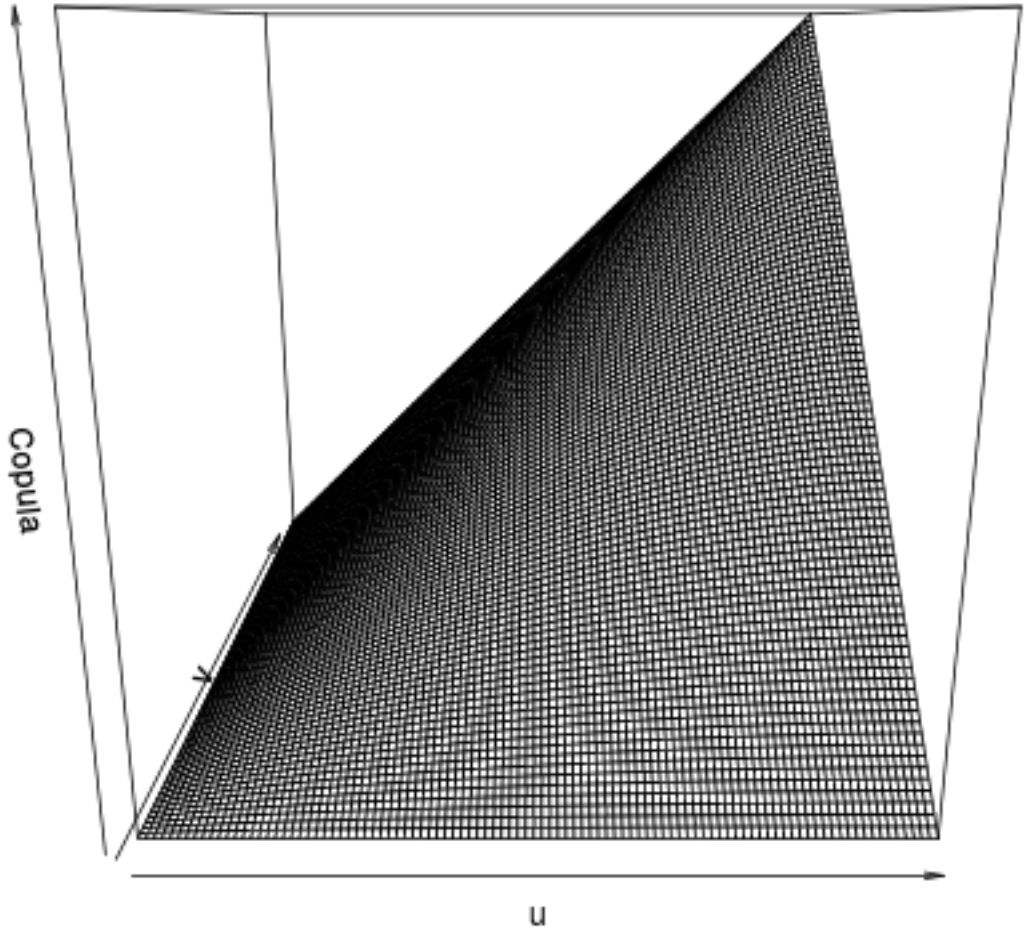
Question 1

Code for R

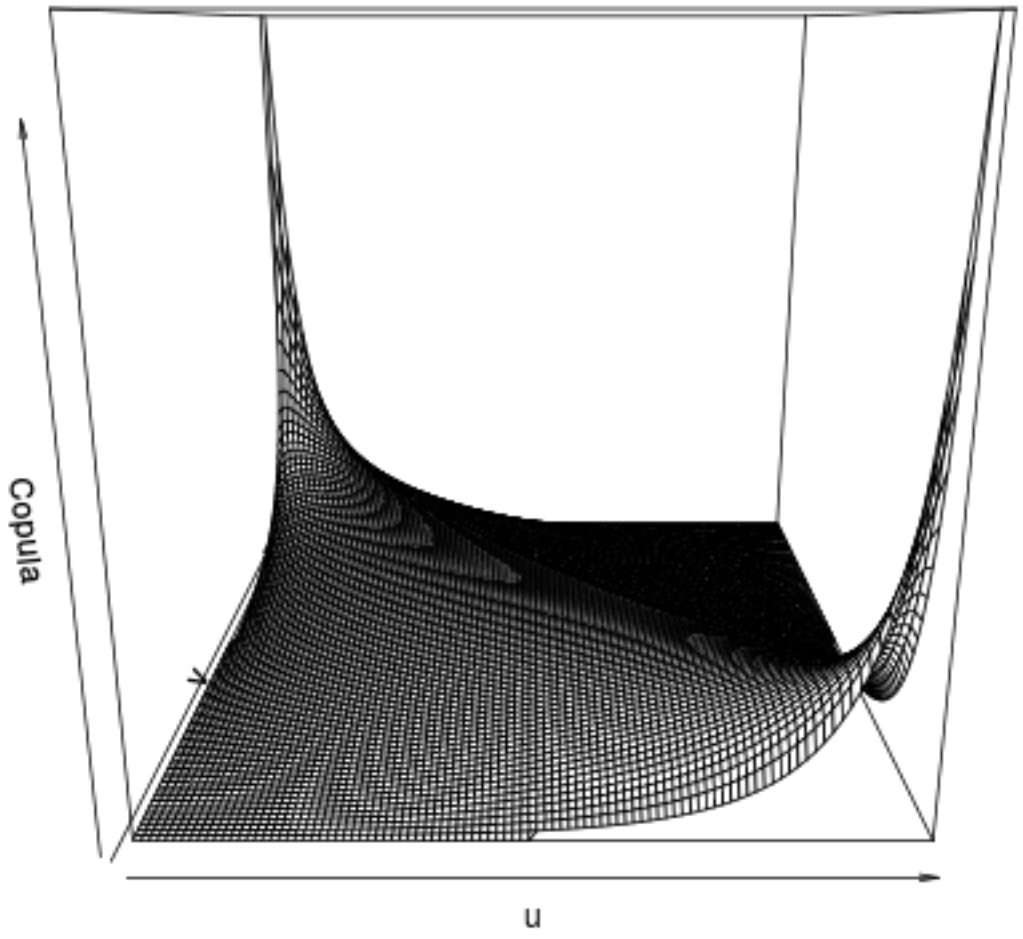
```
surfGumbel <- function(theta) {
   copula <- function(u, v) {
      y = exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta));
      return (y);
   }
   n = 100;
   X = seq(0, 1, length.out = n);
   Y = X;
   Z = numeric();
   for (i in 1:n) {
      for (j in 1:n) {
         Z = c(Z, copula(X[i], Y[j]));
      }
   }

   Z = matrix(Z, nrow = n, ncol = n);
   persp(X, Y, Z, xlab = "u", ylab = "v", zlab = "Copula",
    main = "Surface plot of bivariate gumbel copula with parameter 1.5");
   dev.copy(png, "plots/plot_q1_1.png"); dev.off ();
}

surfNormal <- function(theta) {
   copula <- function(u, v) {
      X = matrix(c(qnorm(u), qnorm(v)), nrow=2, ncol=1);
      Sig = matrix(c(1, theta, theta, 1), nrow=2, ncol=2);
      y = det(2*pi*Sig)^(-1/2) * exp(-t(X) %*% Sig^(-1) %*% X / 2);
      return (y);
   }
   n = 100;
   X = seq(0, 1, length.out = n);
```

```
31    Y = X;
32    Z = numeric();
33    for (i in 1:n) {
34       for (j in 1:n) {
35          Z = c(Z, copula(X[i], Y[j]));
36       }
37    }
38
39    Z = matrix(Z, nrow = n, ncol = n);
40    persp(X, Y, Z, xlab = "u", ylab = "v", zlab = "Copula",
41     main = "Surface plot of bivariate normal copula with parameter 0.7");
42    dev.copy(png, "plots/plot_q1_2.png"); dev.off ();
43 }
44
45 surfGumbel(1.5);
46 surfNormal(0.7);
```

Surface plot of bivariate gumbel copula with parameter 1.5



Surface plot of bivariate normal copula with parameter 0.7

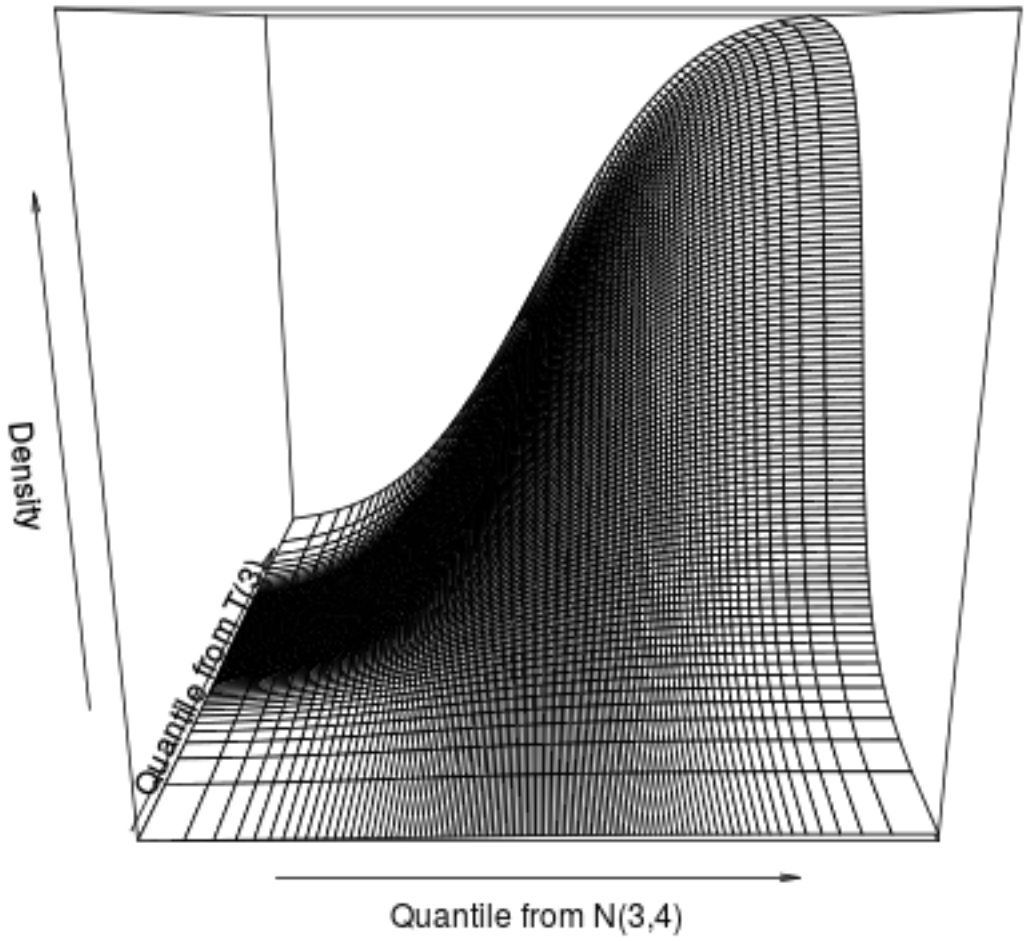


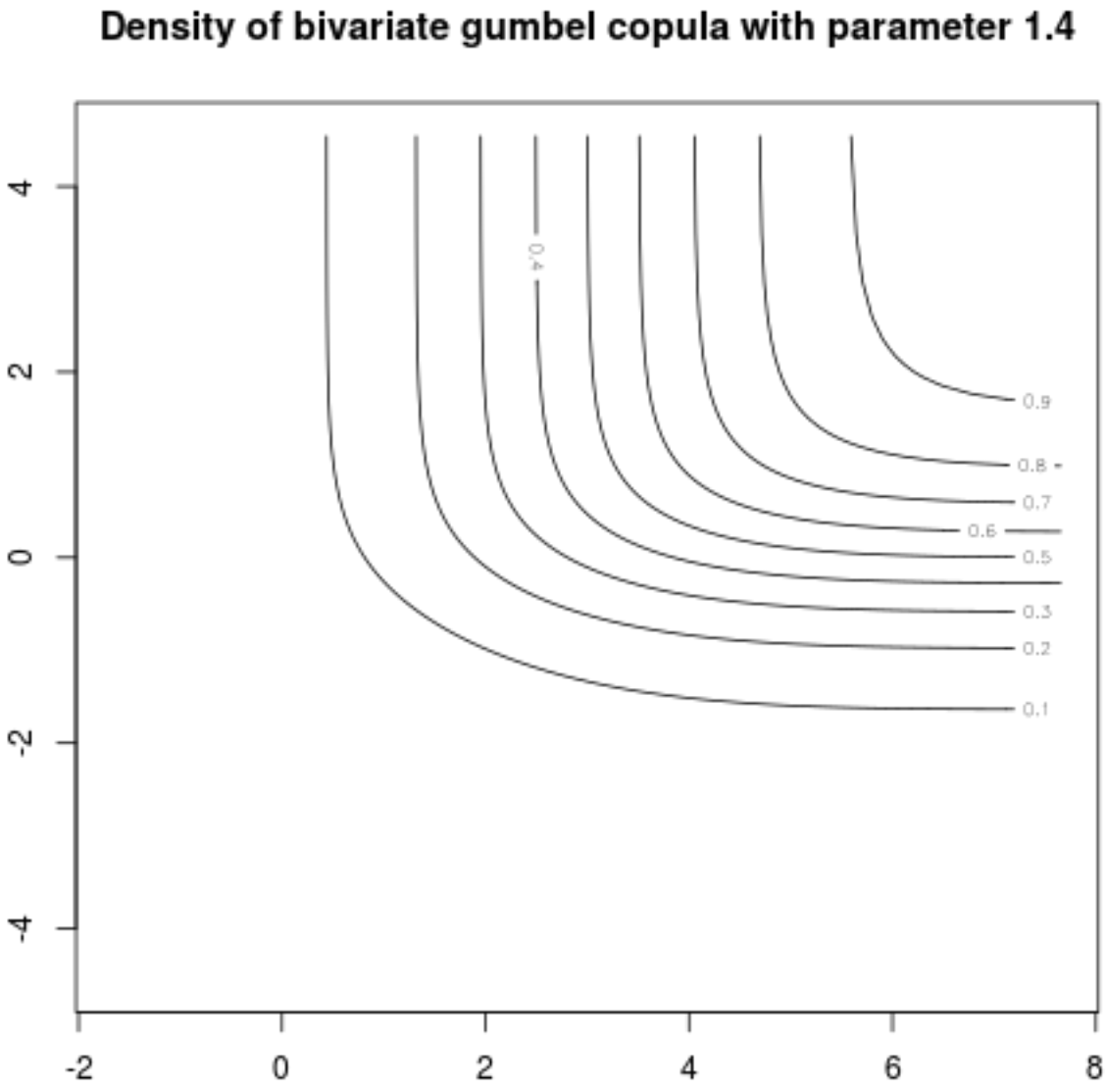
Question B

Code for R

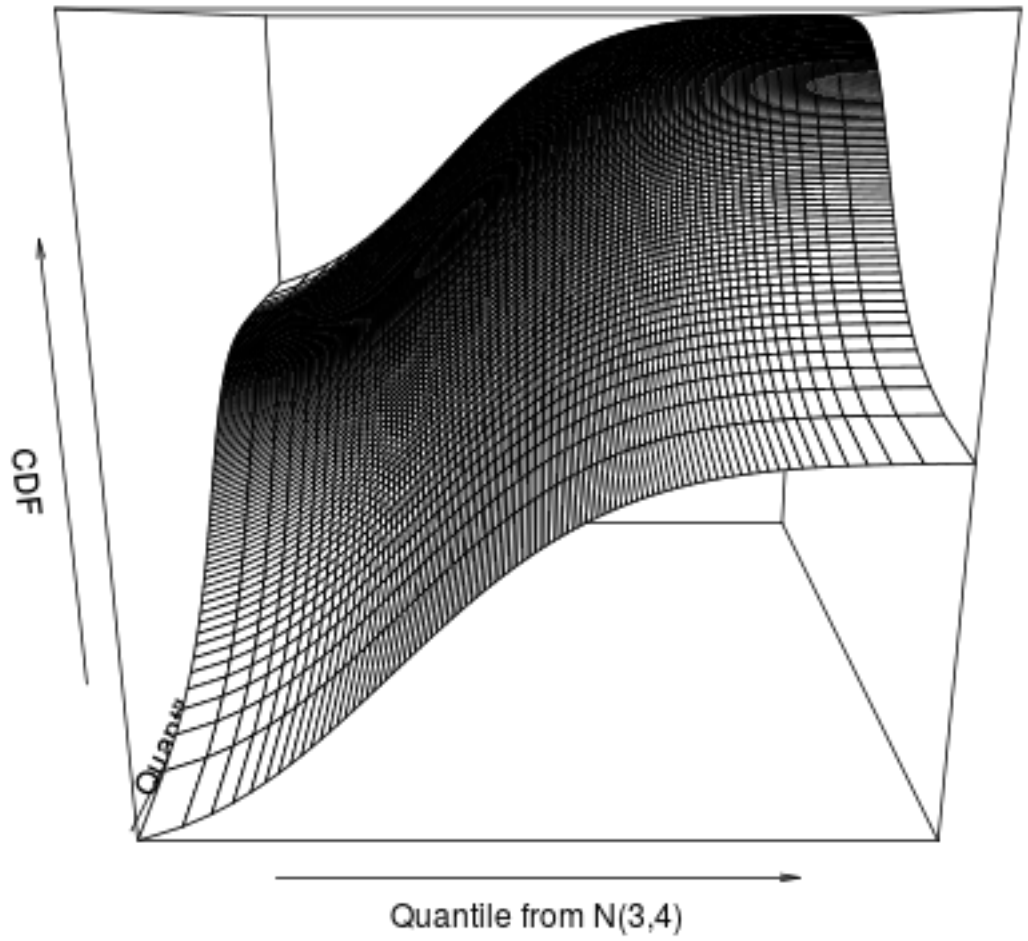
```
contGumbel <- function(theta, mu, sig, df) {
   copula <- function(u, v) {
      y = exp(-((-log(u))^theta + (-log(v))^theta)^(1/theta));
      return (y);
   }
   n = 100;
   X = seq(1/n, 1 - 1/n, length.out = n);
   Y = X;
   Z = numeric();
   for (i in 1:n) {
      for (j in 1:n) {
         Z = c(Z, copula(X[i], Y[j]));
      }
   }

   X = qnorm(X, mean = mu, sd = sig);
   Y = qt(Y, df = df);
   # print(X); print(Y); print(Z);
   Z = matrix(Z, nrow = n, ncol = n, byrow = TRUE);
   persp(X, Y, Z, xlab = "Quantile from N(3,4)", ylab = "Quantile from T(3)", zlab = "Density"
       ,
    main = "Density of bivariate gumbel copula with parameter 1.4");
   dev.copy(png, "plots/plot_q2_1.png"); dev.off ();
   contour(X, Y, Z, main = "Density of bivariate gumbel copula with parameter 1.4");
   dev.copy(png, "plots/plot_q2_2.png"); dev.off ();

   for (i in 2:n) {
      for (j in 2:n) {
         Z[i, j] = Z[i-1, j] + Z[i, j-1] - Z[i-1, j-1];
      }
   }
   persp(X, Y, Z, xlab = "Quantile from N(3,4)", ylab = "Quantile from T(3)", zlab = "CDF",
    main = "CDF of bivariate gumbel copula with parameter 1.4");
   dev.copy(png, "plots/plot_q2_3.png"); dev.off ();
   contour(X, Y, Z, main = "CDF of bivariate gumbel copula with parameter 1.4");
   dev.copy(png, "plots/plot_q2_4.png"); dev.off ();
}


theta = 1.4;
mu = 3;
sig = 2;
df = 3;
contGumbel(theta, mu, sig, df);
```

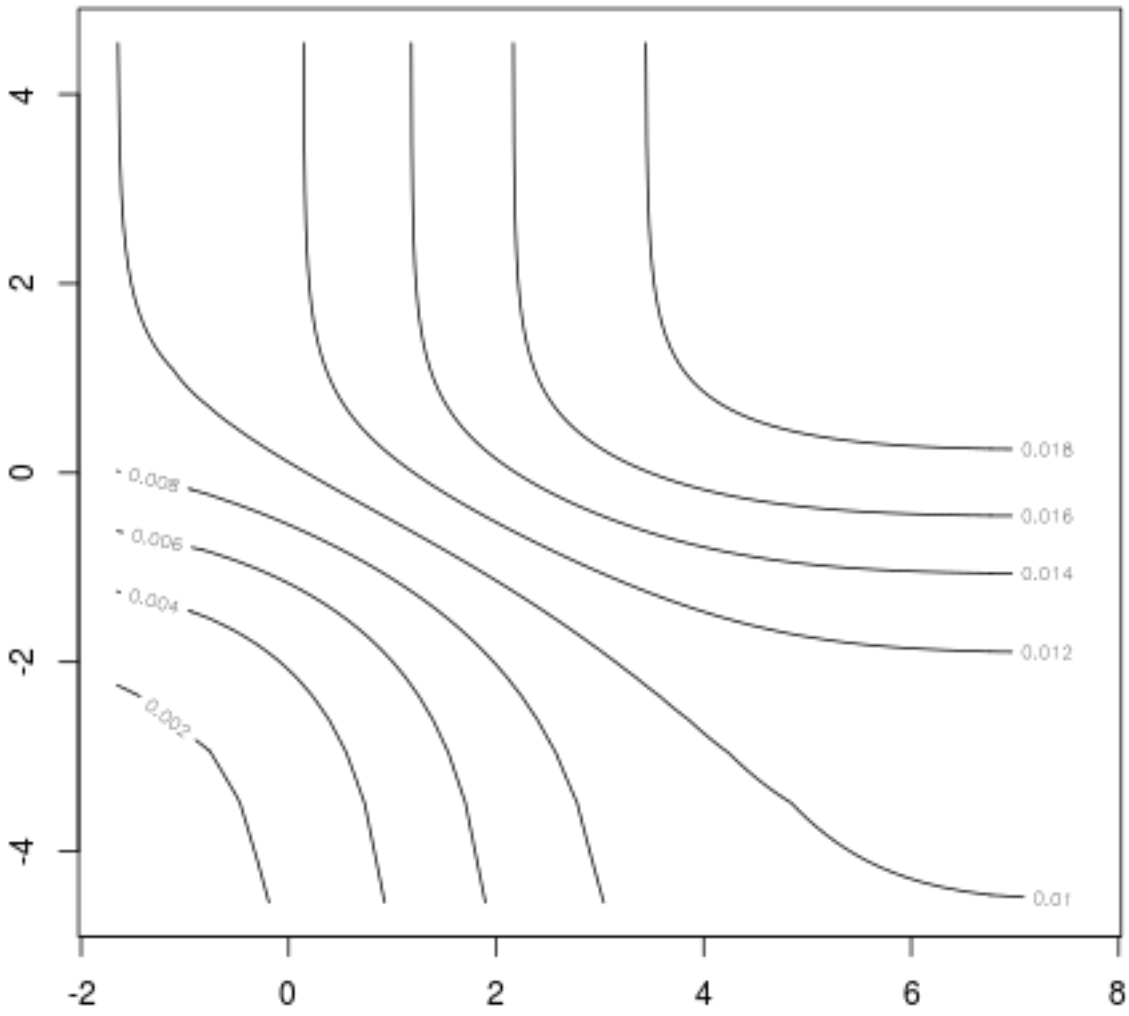
Density of bivariate gumbel copula with parameter 1.4




Density of bivariate gumbel copula with parameter 1.4
4
2
0
-2
-4
-2
0
2
4
6
8
0.4
0.9
0.8
0.7
0.6
0.5
0.3
0.2
0.1

CDF of bivariate gumbel copula with parameter 1.4




CDF of bivariate gumbel copula with parameter 1.4
4
2
0
-2
-4
-2
0
2
4
6
8
0.018
0.016
0.014
0.012
0.01
0.008
0.006
0.004
0.002