Mini Project 1
Kaden Chan

Section 1:

1. a) integrating the function .2e^(-.1t) - .2e^(-.2t) from 15 to inf, we get
    - 1e^(-.2t) - 2e^(-.1t)](15, inf) -> which is 2e^(-1.5) - 1e^(-3) = **.3965**, roughly

    b) i. Simulate the lifetime T, the lifetime of Satellite A and its back up B, which is max of X_A and X_B. So, we simulate 1 draw for X_A and X_B -> take the maximum to simulate draw for T.

    b) ii. Loop through 1000 lifetime simulations and store in vector Tarr,

    b) iii. hist(Tarr) -> plot density curve over histogram. The density curve closely follows the histogram bars, even after running the simulation several times.

    b) iv. Printing the mean of array several times always reported within 1 of 15: [14,16], the given mean and often much closer to 15 than 14 or 16.

    b) v. The simulated probability of satellites lasting over 15 years was always within .05 after running several tests. [.3465, .4465]

    b) vi. All estimations for E(T) were within 1 of the the mean (15), and all estimations of probability > 15 were within .5 of the calculated probability (.3965). Most were a lot closer to the actual mean/probability than the end of the range.

    c)

100 trials	mean =17.74	mean =14.79	mean =15.25	mean =15.45	mean =13.90
>15	.49	.35	.4	.4	.36
10000 trials	Mean=14.95	mean=14.81	mean=14.78	mean=15.09	mean=15.02
>15	.3924	.3857	.389	.4	.397

The 100 trials had a lot more variance, with a result over 2.5 away from mean and .1 away from probability > 15.

The 10000 trials was a lot stricter, result never .22 away from exact mean, and .01 away from probability > 15

2. Using a Circle with radius (.5) centered at (.5,.5), and checking to see if a randomly selected point inside a unit square (0,0) (0,1) (1,0) (1,1), is inside the circle. The ratio of the circle (area = pi*$(½)^2$ = pi/4) to the square (1) is just pi/4 -> implies that when we run the simulation, the proportion of points inside the circle, multiplied by 4 should be pi.

    After running the simulation several times. The results were always within .03 of pi.

Appendix: R Code

```
# Mini Project 1
# Name: Kaden Chan
# Section 1. Answers to the specific questions asked
# Section 2: R code. Your code must be annotated.
# No points may be given if a brief look at the code
# does not tell us what it is doing.

# 1b i. Simulate 1 draw for A and B block lifetimes
A <- rexp(1, rate = 1 / 10)
B <- rexp(1, rate = 1 / 10)

# Lifetime T is max (A,B)
T <- max(A, B)
cat("1b (i): T = ", T)

# 1b ii. Simulate 1000
Tarr <- numeric(1000)
for (i in 1:1000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr[i] <- max(A, B)
}

#1b iii. Histogram
hist(Tarr, breaks = 20, probability = TRUE)

#super impose pdf
curve(
 0.2 * exp(-0.1 * x) - 0.2 * exp(-0.2 * x),
 add = TRUE,
 col = "red",
 lwd = 2,
 n = 1000
)

#1b iv. estimate E(T) with mean of Tarr
cat("\n1b (iv): mean of simulation: ", mean(Tarr))

#1b v. calc proportion of lifetimes above 15
above15 <- 0
for (i in 1:1000) {
```

```
 if (Tarr[i] > 15) {
   above15 <- above15 + 1
 }
}

cat(
 "\n1b (v): simulated probability for satelite lasting > 15 yrs: ",
 above15 / 1000
)

#1b vi. E(T) and > 15 estimate 4 more times
cat("\n 1b (vi): Calc 4 more times")
above15.1 <- 0
Tarr1 <- numeric(1000)
for (i in 1:1000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr1[i] <- max(A, B)
 if (Tarr1[i] > 15) {
   above15.1 <- above15.1 + 1
 }
}
cat("\n1. mean of simulation: ", mean(Tarr1))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.1 / 1000)

above15.2 <- 0
Tarr2 <- numeric(1000)
for (i in 1:1000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr2[i] <- max(A, B)
 if (Tarr2[i] > 15) {
   above15.2 <- above15.2 + 1
 }
}
cat("\n2. mean of simulation: ", mean(Tarr2))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.2 / 1000)
above15.3 <- 0
Tarr3 <- numeric(1000)
for (i in 1:1000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
```

```
 Tarr3[i] <- max(A, B)
 if (Tarr3[i] > 15) {
   above15.3 <- above15.3 + 1
 }
}
cat("\n3. mean of simulation: ", mean(Tarr3))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.3 / 1000)

above15.4 <- 0
Tarr4 <- numeric(1000)
for (i in 1:1000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr4[i] <- max(A, B)
 if (Tarr4[i] > 15) {
   above15.4 <- above15.4 + 1
 }
}
cat("\n4. mean of simulation: ", mean(Tarr4))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.4 / 1000)

#1c 100 trials - E(T) and > 15 estimate 5 times
cat("\n\n1c: 100 TRIALS")
above15.1 <- 0
Tarr1 <- numeric(100)
for (i in 1:100) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr1[i] <- max(A, B)
 if (Tarr1[i] > 15) {
   above15.1 <- above15.1 + 1
 }
}
cat("\n1. mean of simulation: ", mean(Tarr1))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.1 / 100)

above15.2 <- 0
Tarr2 <- numeric(100)
for (i in 1:100) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr2[i] <- max(A, B)
```

```r
 if (Tarr2[i] > 15) {
   above15.2 <- above15.2 + 1
 }
}
cat("\n2. mean of simulation: ", mean(Tarr2))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.2 / 100)
above15.3 <- 0
Tarr3 <- numeric(100)
for (i in 1:100) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr3[i] <- max(A, B)
 if (Tarr3[i] > 15) {
   above15.3 <- above15.3 + 1
 }
}
cat("\n3. mean of simulation: ", mean(Tarr3))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.3 / 100)

above15.4 <- 0
Tarr4 <- numeric(100)
for (i in 1:100) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr4[i] <- max(A, B)
 if (Tarr4[i] > 15) {
   above15.4 <- above15.4 + 1
 }
}
cat("\n4. mean of simulation: ", mean(Tarr4))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.4 / 100)

above15.5 <- 0
Tarr5 <- numeric(100)
for (i in 1:100) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr5[i] <- max(A, B)
 if (Tarr5[i] > 15) {
   above15.5 <- above15.5 + 1
 }
}
```

```r
cat("\n5. mean of simulation: ", mean(Tarr5))
cat("\nsimulated probability for satelite lasting > 15 yrs: ", above15.5 / 100)

#1c 10000 trials - E(T) and > 15 estimate 5 times
cat("\n\n1c: 10000 TRIALS")
above15.1 <- 0
Tarr1 <- numeric(10000)
for (i in 1:10000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr1[i] <- max(A, B)
 if (Tarr1[i] > 15) {
   above15.1 <- above15.1 + 1
 }
}
cat("\n1. mean of simulation: ", mean(Tarr1))
cat(
 "\nsimulated probability for satelite lasting > 15 yrs: ",
 above15.1 / 10000
)

above15.2 <- 0
Tarr2 <- numeric(10000)
for (i in 1:10000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr2[i] <- max(A, B)
 if (Tarr2[i] > 15) {
   above15.2 <- above15.2 + 1
 }
}
cat("\n2. mean of simulation: ", mean(Tarr2))
cat(
 "\nsimulated probability for satelite lasting > 15 yrs: ",
 above15.2 / 10000
)
above15.3 <- 0
Tarr3 <- numeric(10000)
for (i in 1:10000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr3[i] <- max(A, B)
```

```r
 if (Tarr3[i] > 15) {
   above15.3 <- above15.3 + 1
 }
}
cat("\n3. mean of simulation: ", mean(Tarr3))
cat(
 "\nsimulated probability for satelite lasting > 15 yrs: ",
 above15.3 / 10000
)

above15.4 <- 0
Tarr4 <- numeric(10000)
for (i in 1:10000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr4[i] <- max(A, B)
 if (Tarr4[i] > 15) {
   above15.4 <- above15.4 + 1
 }
}
cat("\n4. mean of simulation: ", mean(Tarr4))
cat(
 "\nsimulated probability for satelite lasting > 15 yrs: ",
 above15.4 / 10000
)

above15.5 <- 0
Tarr5 <- numeric(10000)
for (i in 1:10000) {
 A <- rexp(1, rate = 1 / 10)
 B <- rexp(1, rate = 1 / 10)
 Tarr5[i] <- max(A, B)
 if (Tarr5[i] > 15) {
   above15.5 <- above15.5 + 1
 }
}
cat("\n5. mean of simulation: ", mean(Tarr5))
cat(
 "\nsimulated probability for satelite lasting > 15 yrs: ",
 above15.5 / 10000
)
```

```r
#2 Estimate Pi by guessing for square range and checking circle
insideCircle <- 0
for (i in 1:10000) {
 x <- runif(1)
 y <- runif(1)
 # find distance from (.5, .5)
 d <- sqrt((x - .5) * (x - .5) + (y - .5) * (y - .5))
 if (d < .5) {
   insideCircle <- insideCircle + 1
 }
}
cat("\n2. Probability inside circle (simulated): ", insideCircle / 10000)
cat("\nEstimated pi: ", 4 * insideCircle / 10000)
```