FA2 Simulating Probabilities

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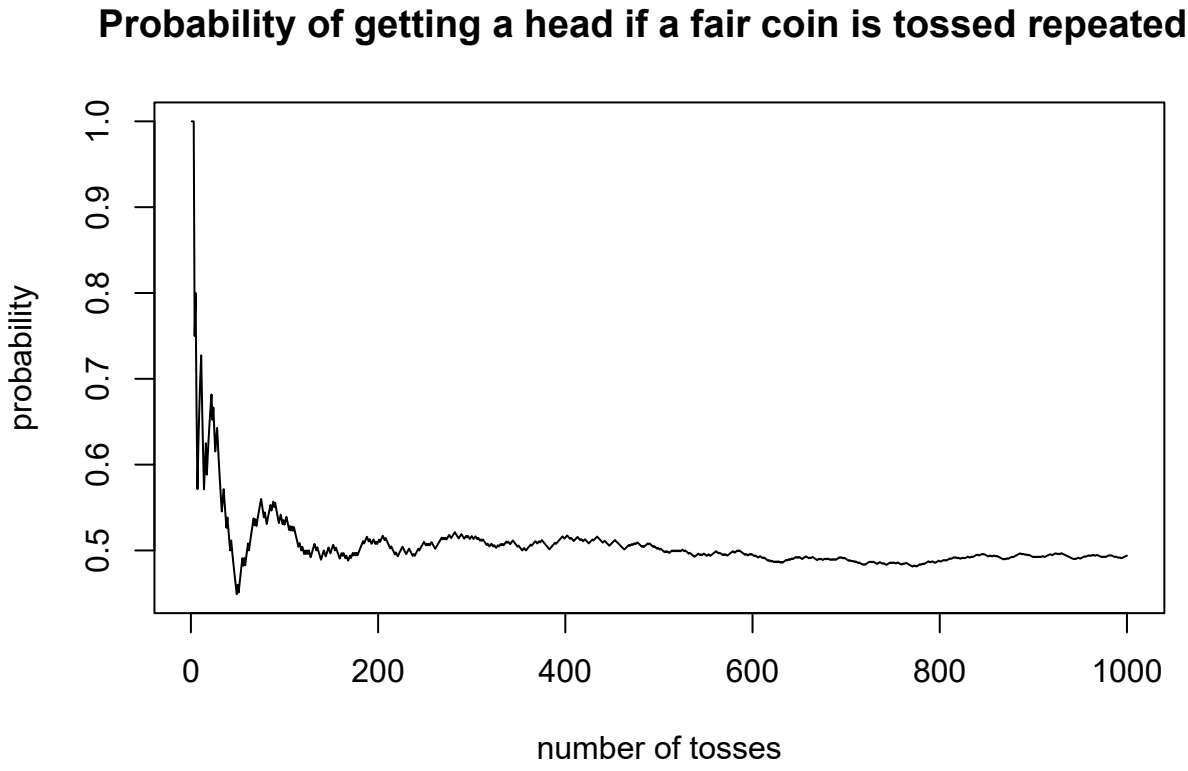
1. Use R to illustrate that the probability of getting:

a. a head is 0.5 if a fair coin is tossed repeatedly

```
# number of experiments
num_exp <- 1000

# simulate experiment
coin_tosses <- sample(c("H", "T"), num_exp, replace = TRUE)

# get the cumulative percentage of heads
heads <- cumsum(coin_tosses == "H")/ (1:num_exp)

# create a dataframe
coin_tosses_mat <- matrix(coin_tosses, ncol =1)
coin_tosses_df <- as.data.frame(coin_tosses_mat)
colnames(coin_tosses_df) <- "Result"

# display preview
coin_tosses_df[,"Cumulative % (Heads)"] <- heads
knitr::kable(head(coin_tosses_df, 10))
```

Result	Cumulative % (Heads)
H	1.0000000
H	1.0000000
H	1.0000000
T	0.7500000
H	0.8000000
T	0.6666667
T	0.5714286
H	0.6250000
H	0.6666667
H	0.7000000

```
# plot line graph
plot(1:num_exp, heads, type = "l",
     xlab = "number of tosses", ylab = "probability",
     main = "Probability of getting a head if a fair coin is tossed repeatedly")
```



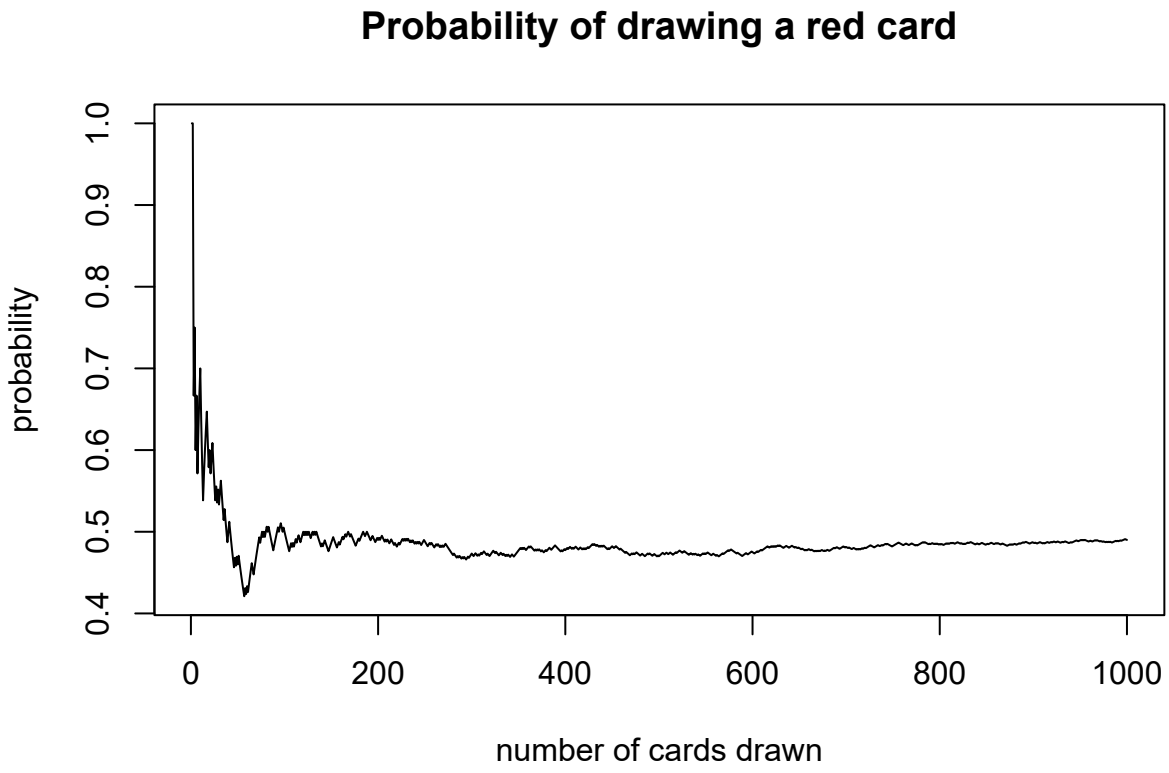
The theoretical probability of getting a head when tossing a fair coin is 0.5. In this simulation of 1000 coin tosses, the experimental probability of getting the desired outcome obtained is around 0.5. The line graph of cumulative percentage demonstrated that as we keep tossing, say 1000 times, the probability of getting a head over multiple experiments will roughly be around 0.5.

b. a red card is 0.5 if cards are drawn repeatedly with replacement from a well-shuffled deck

```
# number of experiments
num_exp <- 1000

# simulate experiment
draw_card <- sample(c("Spade", "Heart", "Club", "Diamond"), num_exp, replace = TRUE)
# get the cumulative percentage of red cards
red_cards <- c("Heart", "Diamond")
draw_red <- cumsum(draw_card %in% red_cards)/(1:num_exp)

# create data frame
draw_card_mat <- matrix(draw_card, ncol =1)
draw_card_df <- as.data.frame(draw_card_mat)
colnames(draw_card_df) <- "Card"

draw_card_df[,"Cumulative % (Red Card)"] <- draw_red
knitr::kable(head(draw_card_df, 10))
```

Card	Cumulative % (Red Card)
Heart	1.0000000
Heart	1.0000000
Club	0.6666667
Heart	0.7500000
Spade	0.6000000
Heart	0.6666667
Spade	0.5714286
Diamond	0.6250000
Heart	0.6666667
Heart	0.7000000

```
plot(1:num_exp, draw_red, type = "l",
     xlab = "number of cards drawn", ylab = "probability",
     main = "Probability of drawing a red card")
```



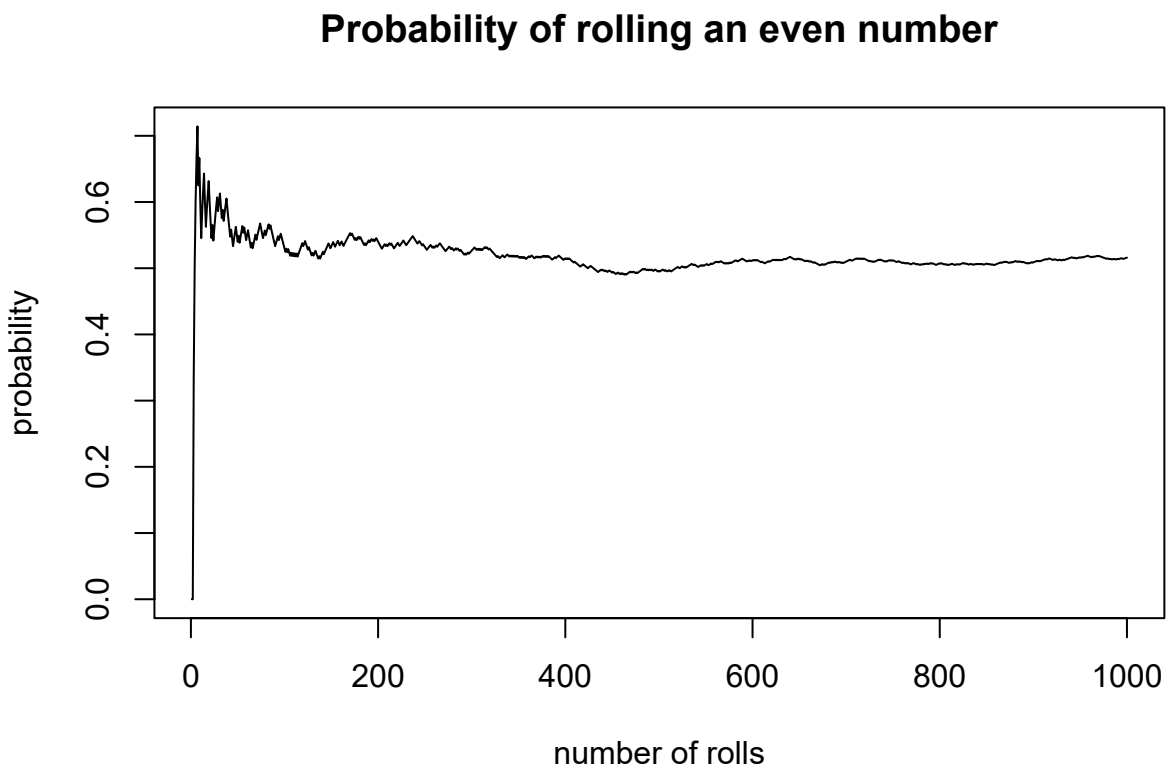
There are four suits in a standard deck with 13 cards each. The theoretical probability of drawing a card from a certain suit is 0.25. If we want to get a red card, we will be pulling from two suits and thus, the theoretical probability of this is 0.5. In this simulation, we draw a card 1000 times and observed an experimental probability of around 0.5. The line graph shows us that as we keep repeating the process for a higher number of times, the probability of getting a red card will be about 0.5.

c. an even number is 0.5 if a fair die is rolled repeatedly.

```
num_exp <- 1000
# simulate experiment
roll_die <- sample(c(1,2,3,4,5,6), num_exp, replace = TRUE)

# get the proportion of even numbers
even_num <- c(2,4,6)
roll_even <- cumsum(roll_die %in% even_num)/(1:num_exp)

# create data frame
roll_die_mat <- matrix(roll_die, ncol=1)
roll_die_df <- as.data.frame(roll_die_mat)
colnames(roll_die_df)<- "Result"

roll_die_df[,"Cumulative % (Even Num)"] <- roll_even
knitr::kable(head(roll_die_df, 10))
```

Result	Cumulative % (Even Num)
5	0.0000000
5	0.0000000
4	0.3333333
6	0.5000000
2	0.6000000
6	0.6666667
2	0.7142857
1	0.6250000
6	0.6666667
5	0.6000000

```
plot(1:num_exp, roll_even, type = "l",
     xlab = "number of rolls", ylab = "probability",
     main = "Probability of rolling an even number")
```



The six possible outcomes (1,2,3,4,5,6) when rolling a fair die are equally likely and therefore each has a theoretical probability of 1/6 or about 0.16. Thus, getting an even number would have a 0.50 probability. In this simulation, we roll the die 1000 times and obtained an experimental probability of about 0.50. As observed in the line graph, the cumulative proportion of even numbers get near 0.50 as we do more rolls.

2. An experiment consists of tossing two fair coins. Use R to simulate this experiment 100 times and obtain the relative frequency of each possible outcome. Hence, estimate the probability of getting one head and one tail in any order.

```
toss_two_coins <- sample(c("HT", "HH", "TH", "TT"), 100 ,replace = TRUE)

table_relfreq <- table(toss_two_coins)/100
knitr::kable(table_relfreq)
```

toss_two_coins	Freq
HH	0.27
HT	0.26
TH	0.27
TT	0.20

In the table above is the relative frequency of each possible outcome when tossing two fair coins 100 times. There are four equally likely possible outcomes. The probability of getting a head and a tail is approximately 0.50 as shown in the experimental probability obtained.