# Computer Project 2: Probability

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## Flipping Coins

For a fair coin, the chance of getting tails is 1/2.

### Counting the number of tails

Let's experiment with the total number of tails in $n$ trials.

#### Total number of tails in a small number of coin flips

Suppose we flip 10 coins (with 1 = Tails and 0 = Heads). Here are six samples of size 10.

```
n      = 10
trials = 6
for (i in 1:trials) {
   print(sample(c(0, 1), n, replace=TRUE))
}
```

```
##  [1] 0 1 1 0 1 1 1 1 0 1
##  [1] 1 0 1 1 0 0 1 0 1 1
##  [1] 1 0 0 0 0 1 0 1 0 0
##  [1] 1 1 0 0 1 1 1 0 0 1
##  [1] 0 1 0 0 1 1 1 1 1 1
##  [1] 0 1 0 0 0 1 1 0 0 1
```

Let's count the number of tails then subtract the expected number of tails. The expected number of tails is half the number of coin flips.

```
for (i in 1:trials) {
   print(sum(sample(c(0, 1), n, replace=TRUE))  -  n/2)
}
```

```
## [1] 3
## [1] 0
## [1] 3
## [1] -2
## [1] 1
## [1] -1
```

Based on the calculations, approximately what is the ± on the difference between the total number of tails and the expected total? (Remember: 95% of the area under a normal curve is ±2SD.) In other words, approximately what is the SD of the list of numbers shown above?

*Include your answer here.*

### Total number of tails in a large number of coin flips

Let's repeat the experiment with 10,000 coins.

```r
n = 10000
for (i in 1:trials) {
   print(sum(sample(c(0, 1), n, replace=TRUE))  -  n/2)
}
```

```
## [1] -6
## [1] 28
## [1] -92
## [1] 34
## [1] 84
## [1] 90
```

Based on the calculations, approximately what is the ± on the difference between the total number of tails and expected total?

*Include your answer here.*

Does the ± on the number of tails increase or decrease with the number of trails? Briefly justify your conclusion.

*Include your answer here.*

## Fraction of tails

Now let's look at the fraction of tails in $n$ trials.

### Fraction of tails in a small number of coin flips

Suppose we flip 10 coins and compute the fraction of tails (with 1 = Tails and 0 = Heads).

```
n      = 10
trials = 6
for (i in 1:trials) {
   print(sum(sample(c(0, 1), n, replace=TRUE)) / n)
}
```

```
## [1] 0.4
## [1] 0.5
## [1] 0.3
## [1] 0.3
## [1] 0.8
## [1] 0.5
```

The expected fraction of tails is 0.5. Let's compute the difference between the observed fraction and the expected fraction:

```
n      = 10
trials = 6
for (i in 1:trials) {
   print(sum(sample(c(0, 1), n, replace=TRUE)) / n  - 0.5)
}
```

```
## [1] -0.1
## [1] 0.2
## [1] -0.3
## [1] 0.2
## [1] -0.3
## [1] 0.2
```

Based on the calculations, approximately what is the $\pm$ on the difference between the observed fraction of tails and the expected fraction (0.5)? In other words, approximately what is the SD of the list of numbers shown above?

*Include your answer here.*

### Fraction of tails in a large number of coin flips

The expected fraction of tails is 0.5. Let's repeat the experiment with a larger number of coins.

```
n = 10000
for (i in 1:trials) {
   print(sum(sample(c(0, 1), n, replace=TRUE)) / n  - 0.5)
}
```

```
## [1] -0.0149
## [1] 0.0059
## [1] 0.0097
## [1] 0.0047
## [1] 5e-04
## [1] -0.0095
```

Based on the calculations, approximately what is the $\pm$ on the difference between the observed fraction of tails and 0.5

*Include your answer here.*

Does the $\pm$ on the difference between the observed fraction of tails and 0.5 increase or decrease with the number of trails? Briefly justify your conclusion.

*Include your answer here.*

## Binomial Formula

If we roll a die, the chance of getting a 4 is 1/6. If we roll 60 dice we expect to get about ten 4s. The number of ways of getting exactly ten 4s out of 60 rolls is:

```
n = 60
k = 10
choose(n, k)
```

```
## [1] 75394027566
```

The chance of getting exactly ten 4s is given by the binomial formula:

```
p = 1/6
dbinom(k, size=n, prob=p)
```

```
## [1] 0.1370131
```

The chance of getting ten or fewer 4s is:

```
pbinom(k, size=n, prob=p)
```

```
## [1] 0.5833866
```

Why do the two probabilities differ so much?

*Include your answer here.*