When we observe something different from what we expect in real life (i.e. four 3's in six rolls of a fair die), a natural question to ask is "Was this unexpected behavior due to random chance, or something else?"

Hypothesis testing allows us to answer the above question in a scientific and consistent manner, using the power of computation and statistics to conduct simulations and draw conclusions from our data.

1. Flip Flop

Sean is flipping a coin. He thinks it is unfair, but is not sure. He flips it 10 times, and gets heads 9 times. He wants to determine whether the coin was actually unfair, or whether the coin was fair and his result of 9 heads in 10 flips was due to random chance.

a. What is a possible model that he can simulate under?

b. What is an alternative model for Sean's coin? You don't necessarily have to be able to simulate under this model.

c. What is a good statistic that you could compute from the outcome of his flips? Calculate that statistic for your observed data.

Hint: If the coin was unfair, it could be biased towards heads or biased towards tails.

d. Complete the function `flip_coin_10_times`, which takes no arguments and returns the absolute difference between the observed number of heads in 10 flips of a fair coin and the expected number of heads in 10 flips of a fair coin.

```
def flip_coin_10_times():
    choices = make_array("Heads", "Tails")
    flips = _____
    num_heads = _____
    return _____
```

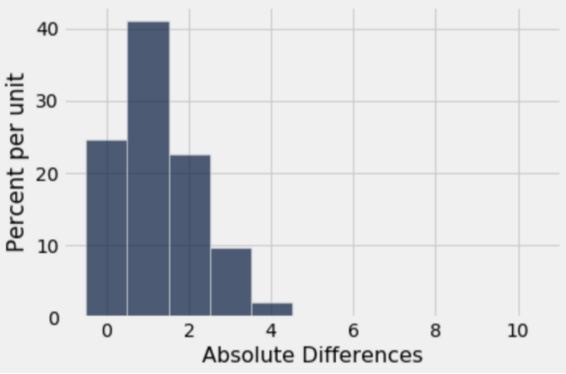
e. Complete the code below to simulate the experiment 10000 times and record the statistic in each of those trials in an array called `abs_differences`.

```
trials = _____

abs_differences = _____

for _____:
    abs_diff_one_trial = _____
    _____ = _____
```

f. Suppose we performed the simulation and plotted a histogram of `abs_differences`. The histogram is shown below.



Is our observed statistic from part c consistent with the model we simulated under?

2. Carnival Games

You are playing a wheel-spinning game at a carnival, where you can earn prizes based on where the wheel stops. The booth attendant claims the distribution of prizes is as below, but you think the game is rigged, and doesn't follow the listed probabilities.

Prize	**Chance**
Nothing	80%
Teddy bear	2%
Pinwheel	6%
Sticker	12%

You would like to test your claim so you can report the carnival for fraud. Before you design your test, consider: do you have *numerical* data or *categorical* data?

a. What is your hypothesis?

b. What is the booth attendant's hypothesis?

c. Which hypothesis (of the two we defined) can you simulate under?

d. What is a good statistic to use?

Hint: What is a good statistic for measuring the distance between two categorical distributions?

e. Write code that simulates playing the carnival game 1000 times, and return an array of proportions corresponding to how often each prize was won.

```
prize_chances = _____

my_simulation = _____
```

f. Based on the code for part e, write one line of additional code that extracts the number of teddy bears we would have won in our simulation. You can use the `my_simulation` variable defined above.

_____

3. Sp18 Midterm Q4 (Bonus)

Researchers are studying the effectiveness of a particular flu vaccine. A large random sample was taken from the population of people who took the vaccine in 2016. Among the sampled people, 48% did not get the flu. Another large random sample was taken in 2017, from among the people who took the vaccine that year. Among these sampled people, 40% did not get the flu.

a. A researcher thinks the vaccine was less effective in 2017 than in 2016. To test this, a null hypothesis is needed. Exactly one of the following choices is the correct null hypothesis.

> A. The vaccine was less effective in the 2017 population than in the 2016 population, due to chance.
> B. The vaccine was equally effective in the two samples but its effectiveness was different in the two populations due to chance.
> C. The vaccine was equally effective in the two populations but its effectiveness was different in the two samples due to chance.

b. The researcher says, "The observed value of my test statistic is 40% – 48% = - 8%." To perform the test, the statistic is simulated under the null hypothesis. One of the figures below is the empirical histogram of the simulated values. Which is it?