4/2/23: Simulations Exercises 74 - 77

ⓘ This is a preview of the published version of the quiz

Started: Sep 3 at 1am

Quiz Instructions

For this assignment, use **https://replit.com/@jschanker/Text2Code-Fall2021#TYPE-YOUR-CODE-HERE.js (https://replit.com/@jschanker/Text2Code-Fall2021#TYPE-YOUR-CODE-HERE.js)** . First, select the `TYPE-YOUR-CODE-HERE.js` file before entering any code.

Question 1 3 pts

Given the table below generated by the following code, select **ALL** of the trial numbers for which tails was received (i.e., a success: `flipCoinIsTails` returns `true`):

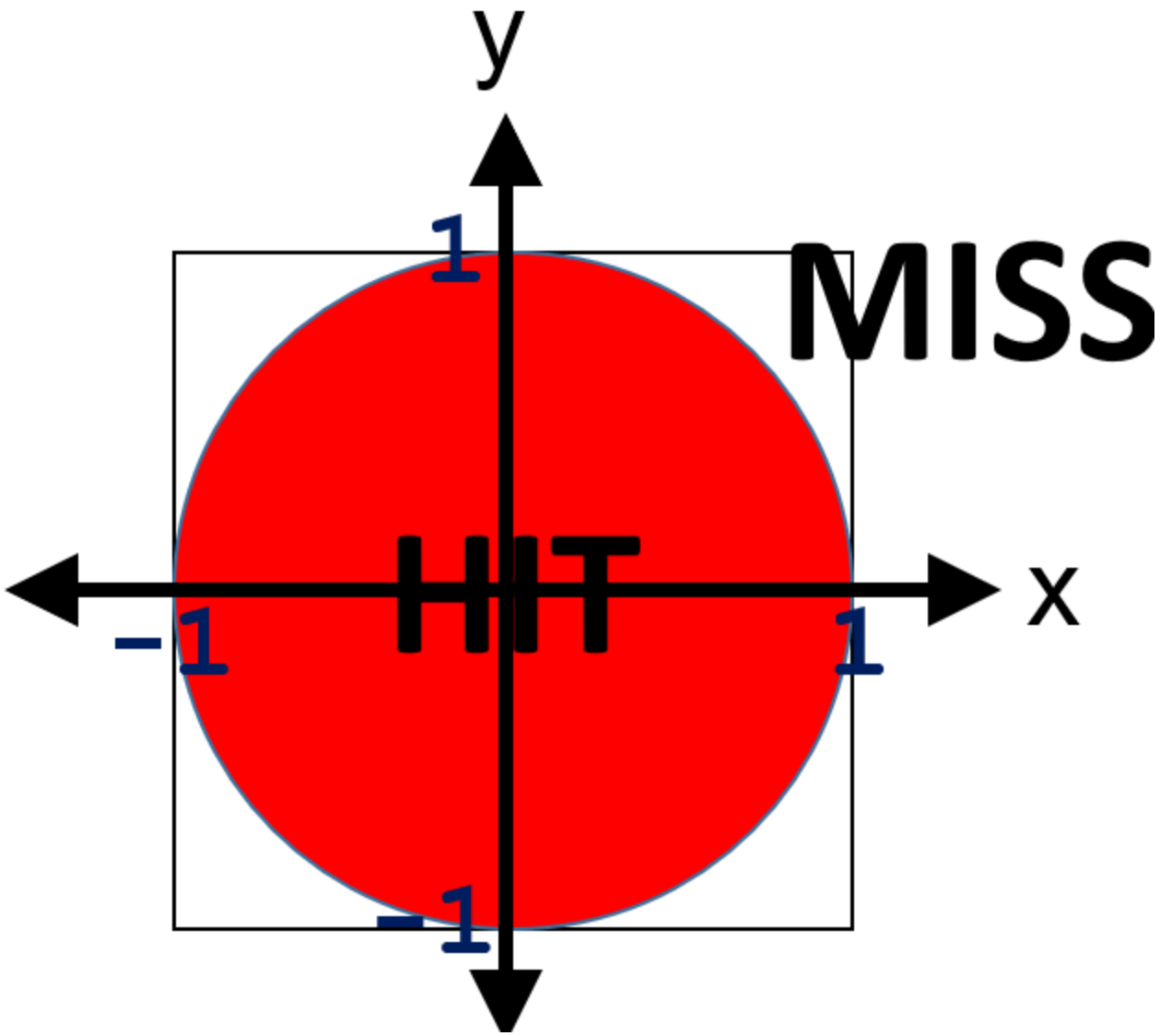
```
let empiricalProbability = (wasExperimentSuccess, trials) => {
  let numberOfTimesEventOccurred = range(0, trials)
    .repeatForEveryItemAndShowSteps((numOfSuccessesSoFar, trialNumber) => {
      if(wasExperimentSuccess()) return numOfSuccessesSoFar+1;
      else return numOfSuccessesSoFar;
    }).startingWithAccOf(0);
  return numberOfTimesEventOccurred/trials;
};

let flipCoinIsTails = () => Math.floor(Math.random()*2) === 1; // 0 is heads; 1 is tails

console.log(empiricalProbability(flipCoinIsTails,10));
```

```
ACCUMULATOR | ITEM
------------------
0           | 0
0           | 1
1           | 2
1           | 3
1           | 4
1           | 5
1           | 6
2           | 7
2           | 8
2           | 9
0.3
```

- [ ] 0
- [ ] 9
- [ ] 5
- [ ] 4
- [ ] 7
- [ ] 3
- [ ] 8
- [ ] 2
- [ ] 1
- [ ] 6

Question 2 1 pts

Exercise 75 a) **Random Dart Throwing - Probability of hitting center**: Suppose a dart is randomly thrown at the 2 x 2 square shown below (from x = -1 to x =1, y = -1 to 1) so all points are equally likely to be hit. If it lands inside the square, what is the probability that it lands in the unit circle (circle with radius 1 centered at the origin - red region below)?



Perimeter of square - Circumference of circle = 4S - 2πr = 4(2) - 2π(1) = 8 - 2π

Area of circle = πr**2 = π(1)**2 = π

Area of circle/Area of square = (πr**2) / (S**2) = (π(1)**2) / ((2)**2) = π/4

Area of square - Area of circle = S**2 - πr**2 = (2)**2 - π(1)**2 = 4 - π

Area of square/Area of circle = (S**2) / (πr**2) = ((2)**2) / (π(1)**2) = 4/π

Perimeter of square/Circumference of circle = 4S /(2πr) = 4(2)/(2π(1)) = 8/(2π) = 4/π

Question 3 6 pts

Exercise 75 b) Random Dart Throwing - Approximating π: We will now get the approximate probability of the dart hitting the unit circle (red region) through the

simulation of throwing 10000000 darts (10 million). This should be close to your answer to the actual probability given in 75a. You will then use this answer to approximate π!

For the first two blanks (x and y), use `Math.random()` with the appropriate Math operations as illustrated in the notes to generate numbers between **-1 and 1**. These will correspond to the x and y coordinates of the randomly selected point.

For the third blank (what you're `return`ing), you want to return true exactly when the point (x, y) is **contained within** the **red** unit circle (circle with radius 1 centered at the origin). This means that (x, y) is a distance less than (or less than or equal to) 1 from the point (0,0). The Pythagorean Theorem can be used to get the distance of (x, y) from (0, 0); whether x and/or y is negative doesn't matter when you square them. You want the result of this calculation to be less than or equal to 1. If you forgot how to write this as a single line (no if!), recall the Distance/Circle collision exercises from **Functions (https://molloy.instructure.com/courses/34841/quizzes/67258)**. One final note about this is that it doesn't matter whether you use less than or less than or equal to; both will be correct. This is because the probability that the dart will be **EXACTLY 1** away from the center is 0. Technically, since the computer is incapable of generating every Real number between 0, the probability will be more than 0, but extremely small.

For the inputs to empiricalProbability, which function will tell you whether the single dart throw landed in the red region (DON'T USE () here since you want the function itself, not the true/false it evaluates to) and how many trials do you want?

Finally, for the last blank, based on your answer to the previous question, what math operation(s) do you want to do to `approximateProbability` to get an approximate to **π**?

DON'T INCLUDE SPACES IN YOUR ANSWERS AND ONLY INCLUDE PARENTHESES WHEN YOU USE `Math.random()`.

```
let empiricalProbability = (wasExperimentSuccess, trials) => {
  let numberOfTimesEventOccurred = range(0, trials)
    .repeatForEveryItem((numOfSuccessesSoFar, trialNumber) => {
      if(wasExperimentSuccess()) return numOfSuccessesSoFar+1;
      else return numOfSuccessesSoFar;
    }).startingWithAccOf(0);
  return numberOfTimesEventOccurred/trials;
};

let didDartHitRedRegion = () => {

  let x =

;
```

```
  let y =

;

  return

;
};

// simulate throwing of 10000000 darts

let approximateProbability = empiricalProbability(

,

);

let piApproximate =

;
console.log("pi is approximately equal to", piApproximate); // should log number close to 3.141592653589793
```

Question 4 7 pts

Contrary to popular belief, weather forecasters don't choose random percentages for whether it'll rain on a given day. Instead, when weather forecasters say that there is a 30% chance of rain today, it means that on average, it rained on about 30 out of 100 days with weather conditions similar to today.

We will use a simplified model for determining whether it will rain 1 week from now **given that it is raining today**:

Suppose we have the following probabilities for any given day:

Probability of rain tomorrow **given** rain today: 30%

Probability of rain tomorrow **given** no rain today: 40%

To simulate if it rains one week from now, our experiment will simulate **7 days of weather,** keeping track of whether it's raining on that day or not to determine the probability that it rains on the following day. If it's raining at the end of the 7 days, then we will return `true`; otherwise we will return `false`.

Note here the accumulator (`isRainingToday`) is a **Boolean** representing whether it rains on day `dayNumber`; fill in the starting accumulator accordingly, noting that we are assuming that it rains on day 0.

`result` will be assigned a number between 0 and 1. Use it to determine the inequality you want for __resultInequality1__ (raining today, probability of rain tomorrow?) and the inequality you want for __resultInequality2__ (NOT raining today, probability of rain tomorrow?).

DON'T INCLUDE SPACES OR PARENTHESES IN ANY OF YOUR ANSWERS.

Below is a sample table of one week's weather (`showSteps` was added to see the table but **DON'T ADD THIS IF YOU RUN IT 1 MILLION TIMES!**):

```
/*
ACCUMULATOR | ITEM
------------------
true        | 0    => Rains on day 0 (by assumption, rains today)
false       | 1    => Not raining on day 1
false       | 2    => Not raining on day 2
false       | 3    => Not raining on day 3
true        | 4    => Raining on day 4
false       | 5    => Not raining on day 5
true        | 6    => Raining on day 6
false  => OUTPUT: NOT RAINING ON DAY 7 so rainsOneWeekFromNow returns false this time
*/
```

```
let empiricalProbability = (wasExperimentSuccess, trials) => {
  let numberOfTimesEventOccurred = range(0, trials)
    .repeatForEveryItem((numOfSuccessesSoFar, trialNumber) => {
      if(wasExperimentSuccess()) return numOfSuccessesSoFar+1;
      else return numOfSuccessesSoFar;
    }).startingWithAccOf(0);
  return numberOfTimesEventOccurred/trials;
};

let rainsOneWeekFromNow = () => {
  let rainsAfter7Days = range(0, __endNum__)
    .repeatForEveryItem((isRainingToday, dayNumber) => {
      let result = Math.random();
     if(isRainingToday && __resultInequality1__ || !isRainingToday && __resultInequality2__) return true; //
rains tomorrow
     else return __return__; // does not rain tomorrow
     }).startingWithAccOf(__startAcc__);
  return rainsAfter7Days;
};

// simulate 1000000 (1 million) weeks of weather
let approximateProbability = empiricalProbability(__experiment__, __trials__);
console.log("Probability it rains one week from now is approximately", approximateProbability);
```

__endNum__ =

__resultInequality1__ =

__resultInequality2__ =

__return__ =

__startAcc__ =

__experiment__ =

__trials__ =

Question 5 1 pts

Exercise 76b) (Rains one week from now - estimated percentage) Running the code from part (b), what is the approximate probability that it rains one week from now given the assumptions? Round your answer to a whole number percentage (e.g., write 54%, not 0.54 or .54123).

Question 6 0 pts

What do you think the approximate probability of winning with the below strategy will be (written in a whole number percentage)? You can write any educated guess that comes to your mind, giving a reason. Don't run any code or change this answer once you do, it doesn't count for points! It'll mark you wrong since I had to put in some answer as correct and I can't anticipate all numbers/explanations.

Exercise 77a)(To win in Vegas or not...WARNING: it's called Gambler's Ruin for a reason): In Roulette, there are 18 red, 18 black, and 2 green slots so if you bet on red or black, you have an 18/(18+18+2) = 18/38 = 9/19 or about 47.368% chance of winning. Estimate your probability of winning if you employ the following strategy:

- You have $400 to start.
- You bet $100 per turn on either red or black. If you win, you win $100 and if you lose, you lose $100.
- You stop when you get to $500 (made $100) or lose the $400 you started with.

Question 7 9 pts

Exercise 77b)(To win in Vegas or not...WARNING: it's called Gambler's Ruin for a reason): In Roulette, there are 18 red, 18 black, and 2 green slots so if you bet on red or black, you have an 18/(18+18+2) = 18/38 = 9/19 or about 47.368% chance of winning. Estimate your probability of winning if you employ the following strategy:

- You have $400 to start.
- You bet $100 per turn on either red or black. If you win, you win $100 and if you lose, you lose $100.
- You stop when you get to $500 (made $100) or lose the $400 you started with.

This time, you will be defining a function that repeatedly simulates a roulette wheel spin each time. Based on the result of this spin, you will either win with probability 9/19, increasing your money by $100, or you will lose decreasing your money by $100 until you either have no money ($0) or reach $500. Unlike the weather prediction example in which the number of days being simulated was fixed, the number of spins will depend on how often you win/lose:

```
let empiricalProbability = (wasExperimentSuccess, trials) => {
  let numberOfTimesEventOccurred = range(0, trials)
    .repeatForEveryItem((numOfSuccessesSoFar, trialNumber) => {
      if(wasExperimentSuccess()) return numOfSuccessesSoFar+1;
      else return numOfSuccessesSoFar;
    }).startingWithAccOf(0);
  return numberOfTimesEventOccurred/trials;
};

let winsOneHundred = () => {
  let moneyAtEnd = range(0, Infinity)
    .repeatForEveryItem((currentMoney, spinNumber) => {
       if(__testForWin__ < 9/19) return __moneyUpdateWin__; // win
       else return __moneyUpdateLoss__; // loss
     })
    .until((currentMoney, spinNumber) => __stopConditions__)
    .startingWithAccOf(__startMoney__).__itemOrAcc__;
  return __checkWinBoolean__;
};

// simulate 1000000 (1 million) "rounds" of game;
// each round starts with $400 and spins wheel until success ($500) or failure ($0)
// every round MUST end in one of these two possibilities
// (e.g., stop if (1) W, (2) LWW, (3) LLWWW, (4) LWLWW, (5) LWLWLLWLLL, etc.)
let approximateProbability = empiricalProbability(__experiment__, __trials__);
```

```
console.log("Probability of winning $100 with strategy is", approximateProbability);

__testForWin__ =

__moneyUpdateWin__ =

__moneyUpdateLoss__ =

__startMoney__ =

__stopConditions__ =

__itemOrAcc__ =

__checkWinBoolean__ =

__experiment__ =

__trials__ =
```

Question 8 1 pts

Exercise 77c) (Winning in roulette with strategy - estimated percentage) Running the code from part (b), what is the approximate probability that you win $100 with this strategy from now given the assumptions? Round your answer to a whole number percentage (e.g., write 54%, not 0.54 or .54123).

Quiz saved at 1:00am Submit Quiz