1. **A Chance at Monte Carlo Activity —   
   Monte Carlo Simulation Worksheet – Answer Key**
2. **Inscribed Circle**

|  |  |
| --- | --- |
|  | Area of the square: **4**  Area of the circle: **π** (hint: find radius first)  Ratio of areas (circle to square): **4/π** |

1. **Single Quadrant**

|  |  |
| --- | --- |
|  | Both the area of the square and the area of the circle are divided by four.  What is the area of the un-shaded square? **1**  What is the area of the quarter circle wedge? π/4  Is the ratio the same as before? (YES or NO) |

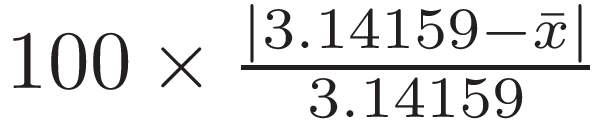
1. **Estimating the Area**

|  |  |
| --- | --- |
|  | Find the number of points inside the wedge versus the total number of points (100).  *Hint: it may help to count the points outside; for example: Nin = 100 - Nout*  **100 - 21 = 79**  If , then  What is your estimate of π? **4\*79/100 = 3.16** |

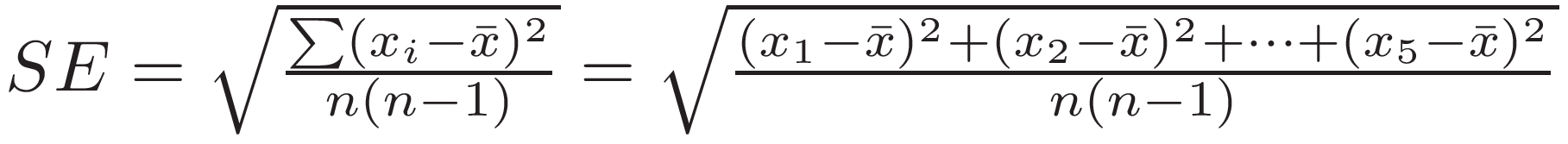
1. **Collecting Data**
2. Use the EV3 program to collect five estimates of pi from 100 simulated points:

**2.92, 3.04, 3.36, 3.16, 3.36 (examples)**

1. What is the average estimate : **3.168**
2. Below are two ways to evaluate the quality of the estimate. Since we already have a “gold standard” for pi, we can compute the **percent error:**



The **standard error** is a better measure of quality when we do not have a gold standard (when we estimate an unknown quantity). The standard error measures how widely the different estimates differ from the average.



What is the percent error? **0.84%** What is the standard error? **0.087**

1. Reset the EV3 program to use 500 simulations.

**3.16, 3.136, 3.184, 3.112, 3.168 (note that we have gained about an extra digit of precision)**

The average estimate is: **3.152**

The percent error is: **0.33%** The standard error is: **0.013**

**By contrast to the 100-points simulation, the mean estimate is closer to the actual value of pi, and the individual estimates are less scattered about the mean.**

1. Repeat the experiment for 1000 and 4000 simulations.

|  |  |
| --- | --- |
| 1000 points | 4000 points |
| The average estimate is: \_\_\_\_\_\_\_\_\_\_  The percent error is: \_\_\_\_\_\_\_\_\_\_  The standard error is: \_\_\_\_\_\_\_\_\_\_ | The average estimate is: \_\_\_\_\_\_\_\_\_\_  The percent error is: \_\_\_\_\_\_\_\_\_\_  The standard error is: \_\_\_\_\_\_\_\_\_\_ |

1. **Extra Credit**
2. Plot the estimation errors versus simulated points.

