A Chance at Monte Carlo Activity — Monte Carlo Simulation Worksheet

Inscribed Circle

Area of the square: ______________

Area of the circle: ______________
(hint: find radius first)

Ratio of areas (circle to square): ______________

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?
____________

What is the area of the quarter circle wedge?
____________

Is the ratio the same as before? (YES or NO)
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:** \( N_{\text{in}} = 100 - N_{\text{out}} \)

\[
\frac{N_{\text{in}}}{100} \approx \frac{\pi}{4}, \text{ then } \pi \approx \frac{4N_{\text{in}}}{100}
\]

What is your estimate of \( \pi \)? ______________

**Collecting Data**

1. Use the **EV3** program to collect five estimates of \( \pi \) from 100 simulated points:
   __________, __________, __________, __________, __________

2. What is the average estimate \( \bar{x} \): __________

3. 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**:
   \[
   100 \times \frac{|3.14159 - \bar{x}|}{3.14159}
   \]

   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.
   \[
   SE = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n(n-1)}} = \sqrt{\frac{(x_1 - \bar{x})^2 + (x_2 - \bar{x})^2 + \cdots + (x_n - \bar{x})^2}{n(n-1)}}
   \]

   What is the percent error? __________  
   What is the standard error? __________

4. Reset the **EV3** program to use 500 simulations.
   __________, __________, __________, __________, __________

   The average estimate is: __________

   The percent error is: __________  
   The standard error is: ________________
5. Repeat the experiment for 1000 and 4000 simulations.

<table>
<thead>
<tr>
<th>1000 points</th>
<th>4000 points</th>
</tr>
</thead>
<tbody>
<tr>
<td>The average estimate is: __________</td>
<td>The average estimate is: __________</td>
</tr>
<tr>
<td>The percent error is: __________</td>
<td>The percent error is: __________</td>
</tr>
<tr>
<td>The standard error is: __________</td>
<td>The standard error is: __________</td>
</tr>
</tbody>
</table>

**Extra Credit**

1. Plot the estimation errors versus simulated points.