# 9.3 Monte Carlo Simulation to Model Deterministic Behavior

# File: *Area.nb*

*Introduction to Computational Science: Modeling and Simulation for the Sciences*
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# Ex. Area Under a Curve

## Monte Carlo simulation to find the area under a curve that is above the *x*-axis from *x* = *a* to *x* = *b*

**For example, find area under $f(x) = x^2$**
**between $x = 2$ and $x = 3$.**

**General concept:**

**Throw darts at rectangle containing area**

**Count percentage that hit under curve**

**Take that percentage of area of rectangle**

- **Clear out old values for *f* and *x* and then define *f*.**
- **Find the value exactly using a definite integral.**
- **Plot *f* from 2 to 3 in *Mathematica*.**
- **Plot *f* in *Mathematica* showing the origin and the desired region.**
- **We generate random floating point *y* values between 0 and 9 and corresponding random floating point *x* values between 2 and 3. For each pair, we determine if the random *y* value is below the function at the random *x* value. If so, we consider that the "dart" with coordinates of the random *x* and *y* values hit below the curve.**

  **Generate a table, *dartTbl*, of ten 0s and 1s so that an entry is 1 if a random *y* value is less than the function at a random *x* value and that the element is 0 otherwise.**
- **Calculate the fraction (*fractionUnder*) of darts that hit under the curve.**
- **Calculate the area (*rectArea*) of the rectangular dartboard.**
- **Determine an estimate for the area under the curve between 2 and 3.**
- **We get a better estimate if we use more "darts." Copy the statements that assign values to *dartTbl*, *fractionUnder*, *rectArea*, and *area* into one cell. Revise the statement that assigns a value to *dartTbl* to**

**generate a table of 1000 values but not to display the result. Execute the subsequent commands to obtain a better estinate of the area under the curve.**

### We obtain a better result if we perform this process a number of times and calculate the average (mean) area. The standard deviation gives an indication of how good the result is.

- **Generate a 100-by-100 table of 0s and 1s, where each row consists of one simulation of throwing 100 darts.**
- **Calculate the fraction (*fractionUnder*) of darts that hit under the curve for each row (simulation), placing the results in a list.**
- **Find the mean and standard deviation of the results for our simulations, and express the answers as floating point numbers.**

### Repeat the process for the transpose

- **Take the transpose of *dartTbls.***
- **Calculate the fraction (*fractionUnder*) of darts that hit under the curve for each row (simulation), placing the results in a list.**
- **Find the mean and standard deviation of our simulation results, and express the answers as floating point numbers.**

### Estimate the area using values from the entire table

- **Flatten the table *dartTbls.***
- **Calculate the fraction (*fractionUnder*) of darts that hit under the curve for the entire table (simulation), and find the area as a floating point number.**