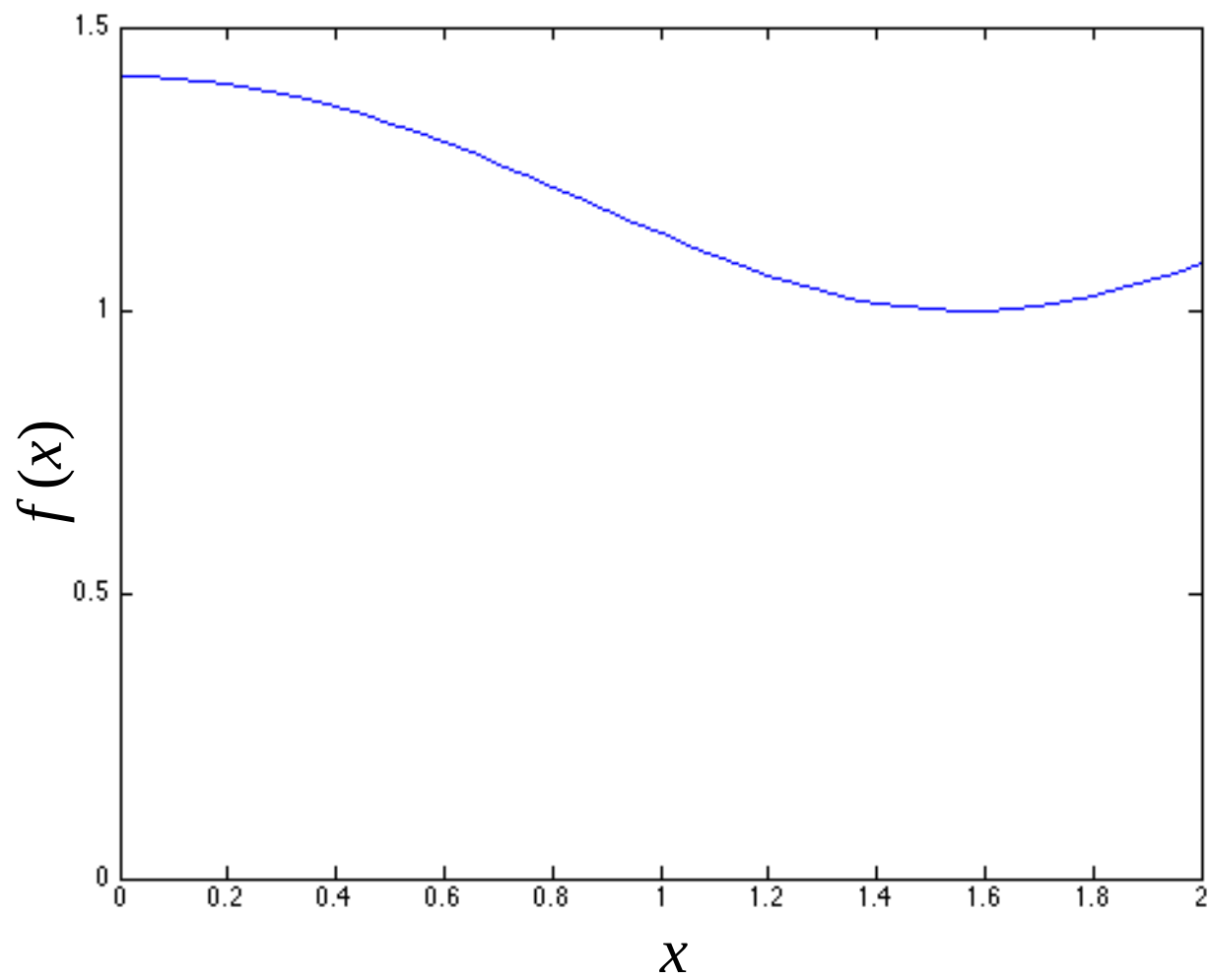
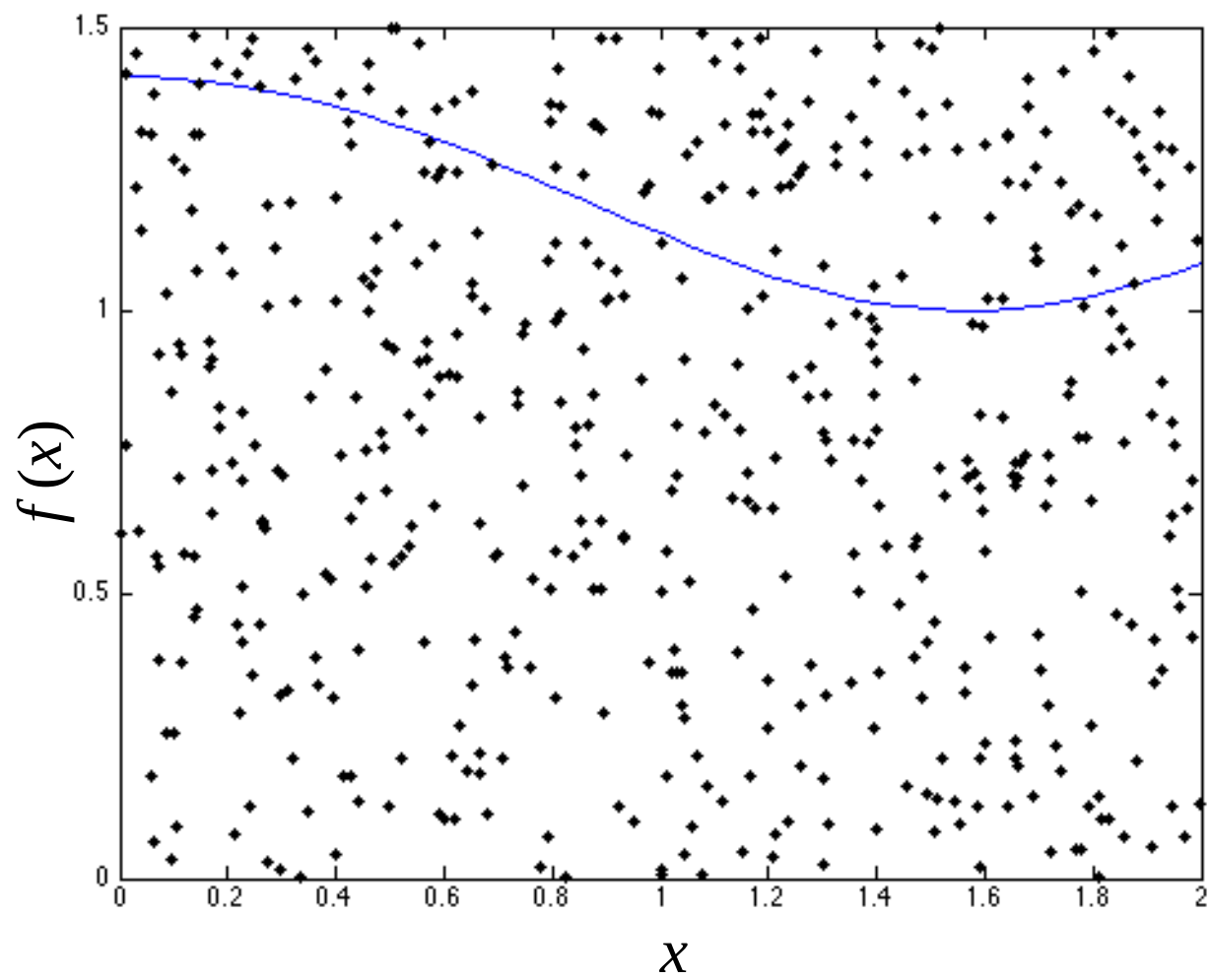


Special Topic:  
Monte Carlo Simulations

# Introduction

- Recall our use of Euler & RK4 to approximate the integral functions that cannot be integrated analytically
- We can also do this with random numbers: think of throwing lots of darts randomly at a plot, then counting the fraction underneath the curve....





# Throwing Darts for Area

- Now we can estimate the area as:

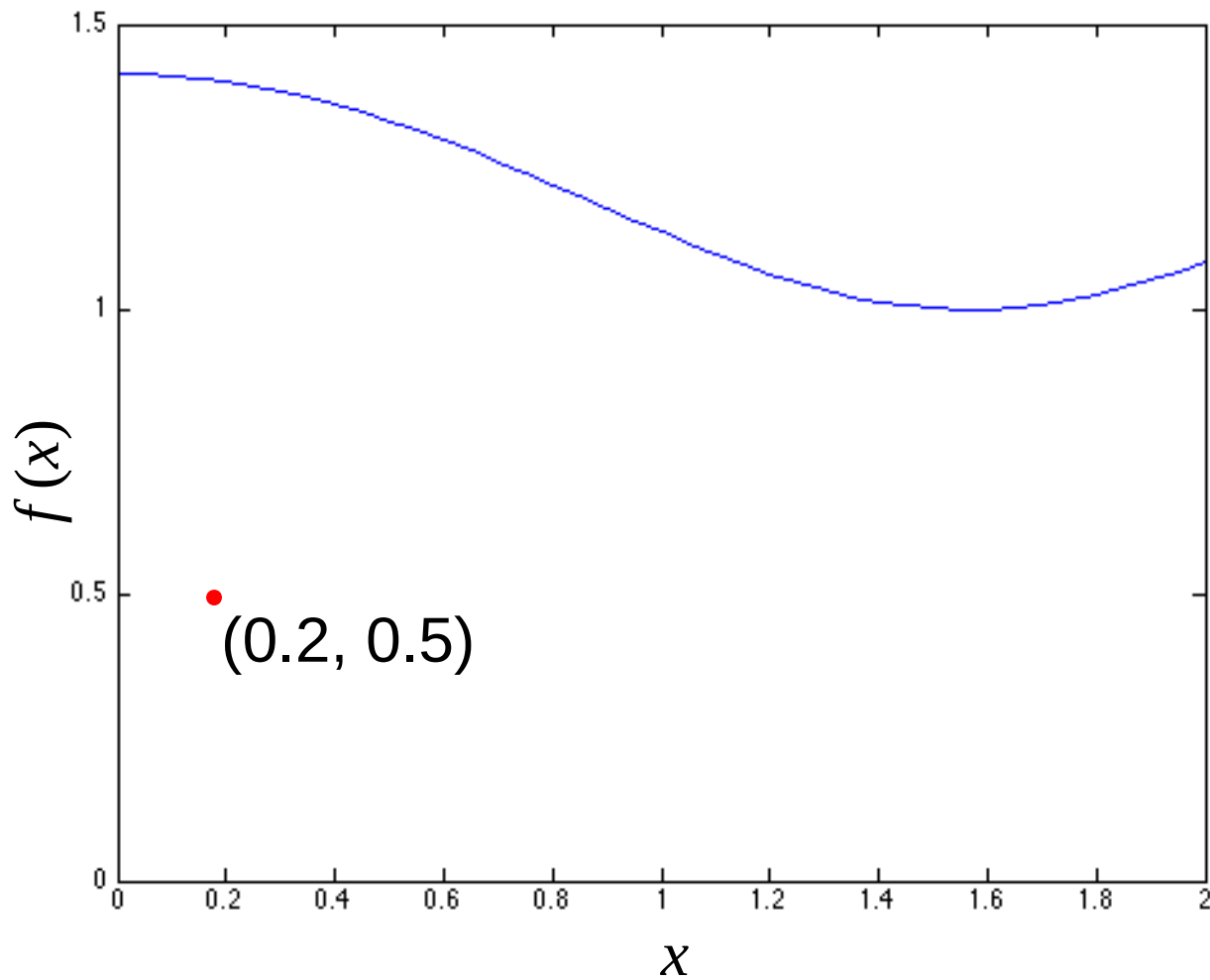
$$(area\ of\ enclosing\ rectangle) * (\#\ below) / (\#\ darts)$$

- Area of enclosing rectangle =  $2 * 1.5 = 3.0$
- So how do we know # below?

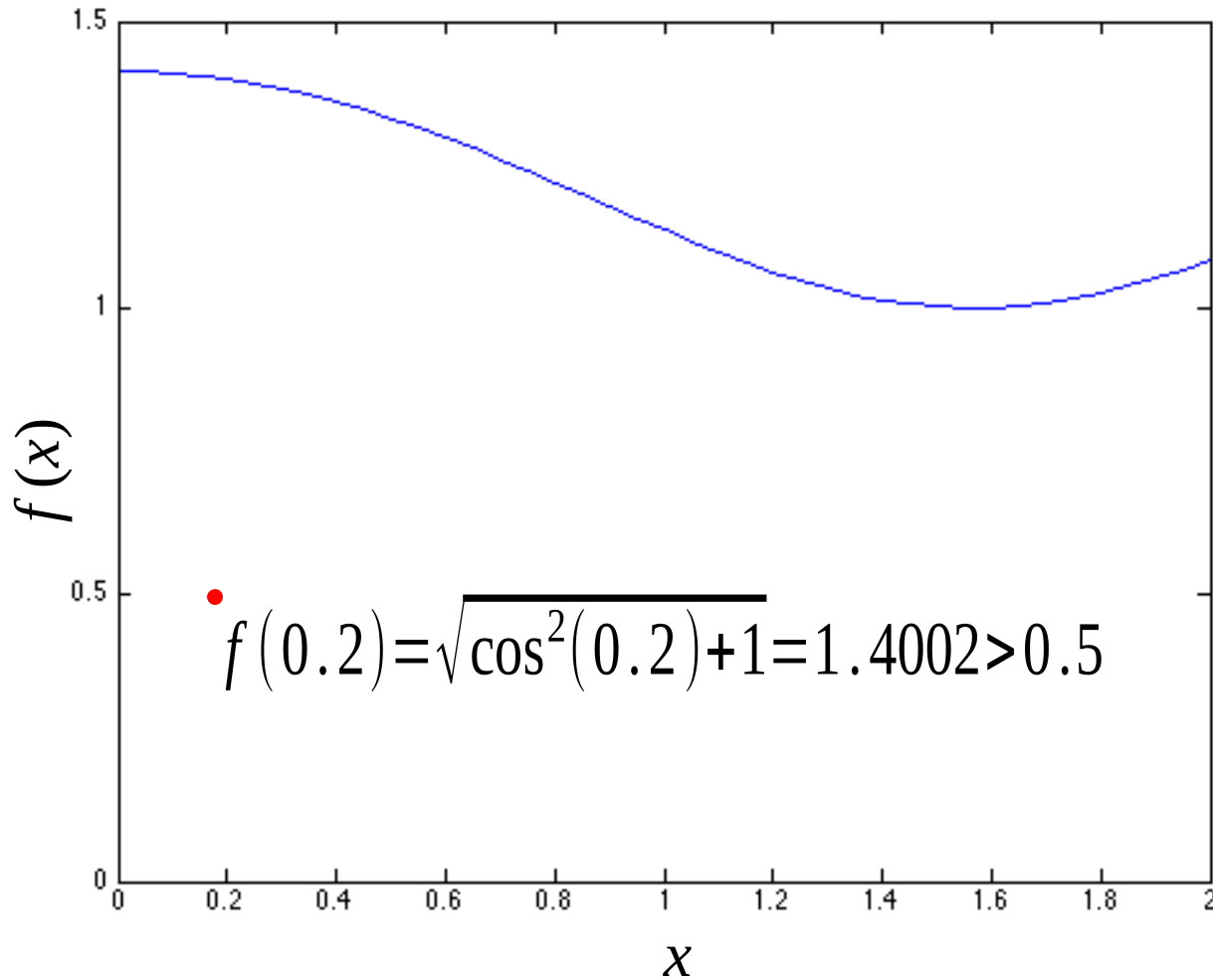
# Determining Whether a Point is Above or Below $f(x)$

- Each “dart” has an  $(x, y)$  coordinate
- We plug  $x$  into the formula
- If  $f(x) > y$  then the dart is below the function; otherwise, it is above the function.

# Example



# Example





# Application Example

## Estimating Robot Position from Lidar Scans (SLAM)

