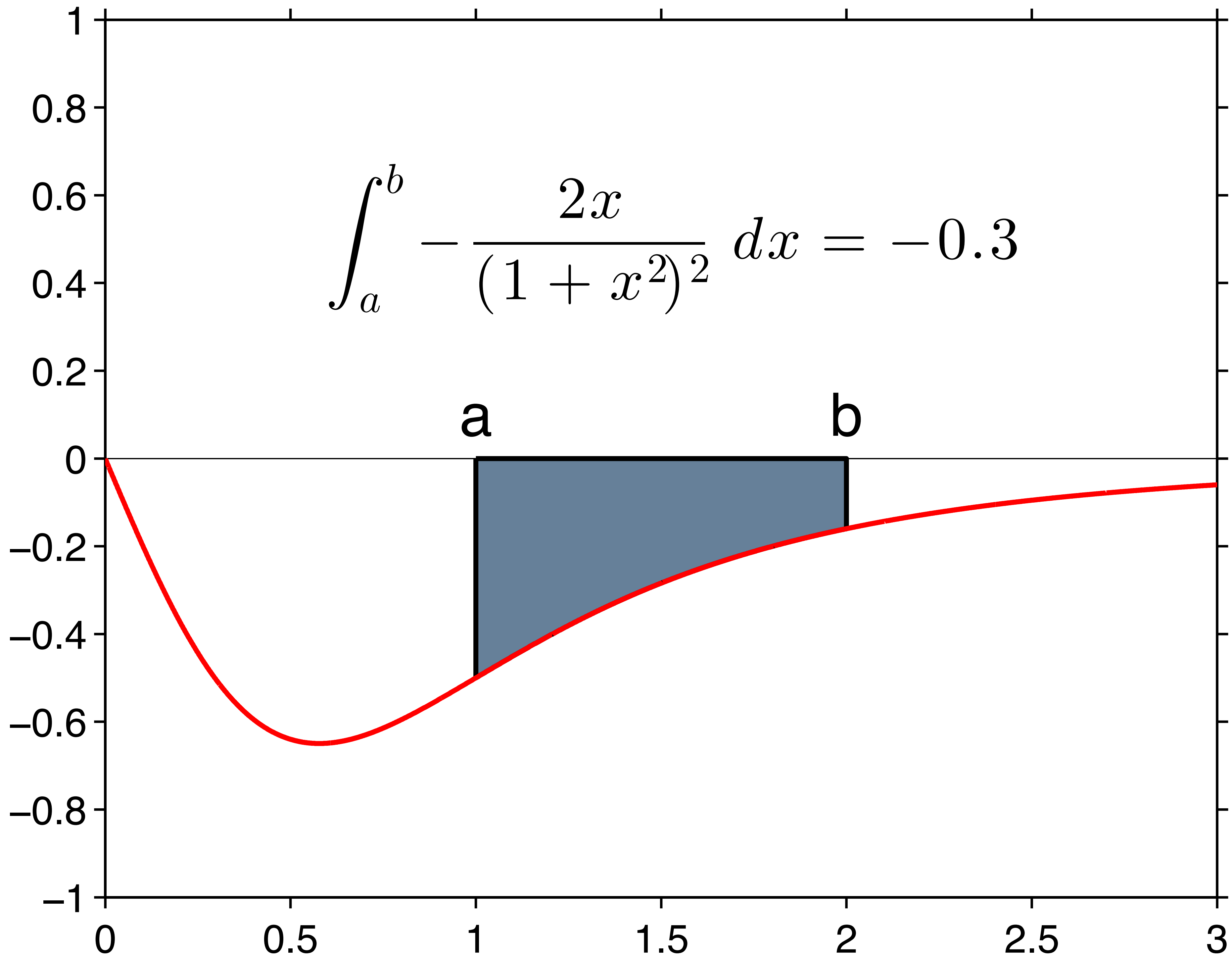
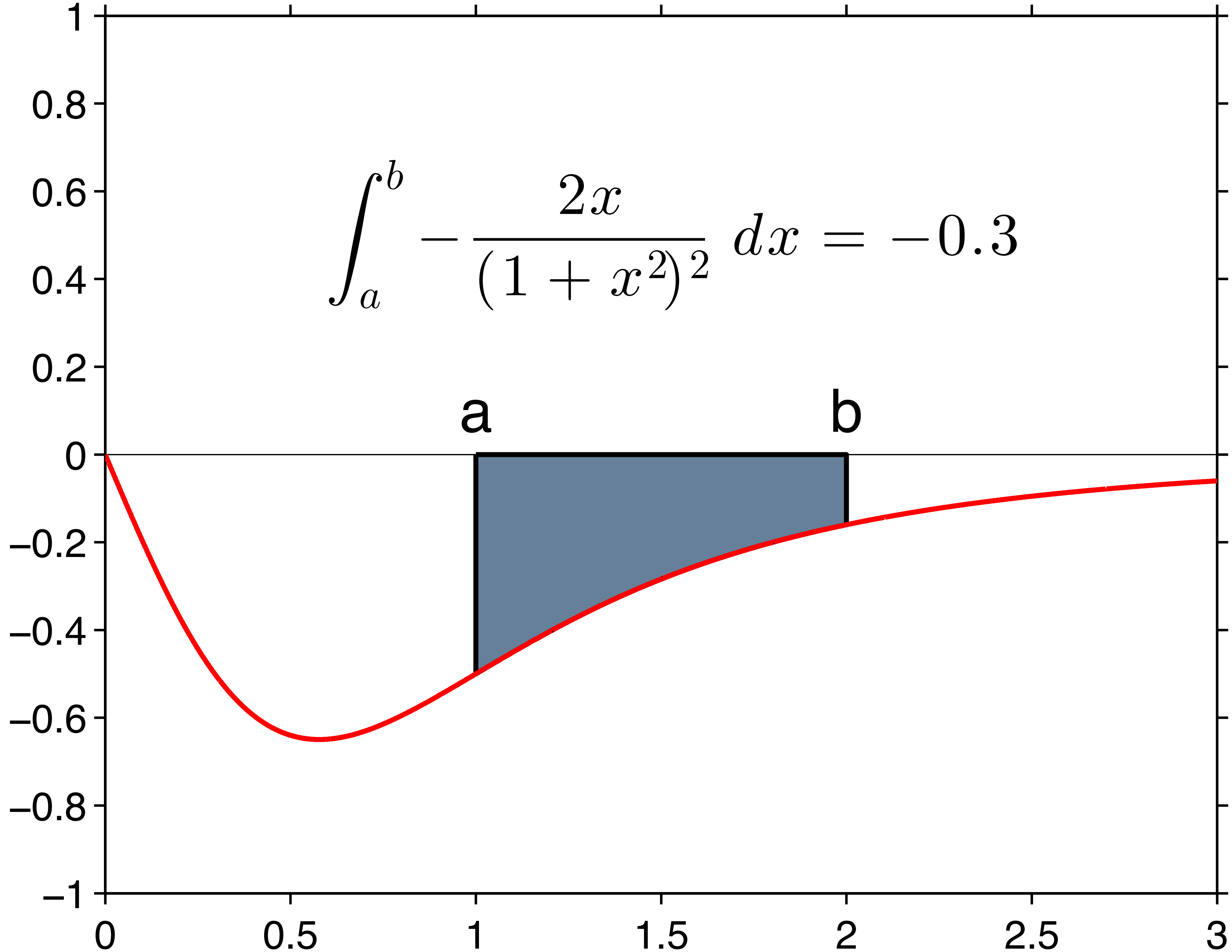
Challenge: Create this plot



Challenge: Create this plot

Tips: Use the text and patch commands



Challenge: Calculate π using random numbers

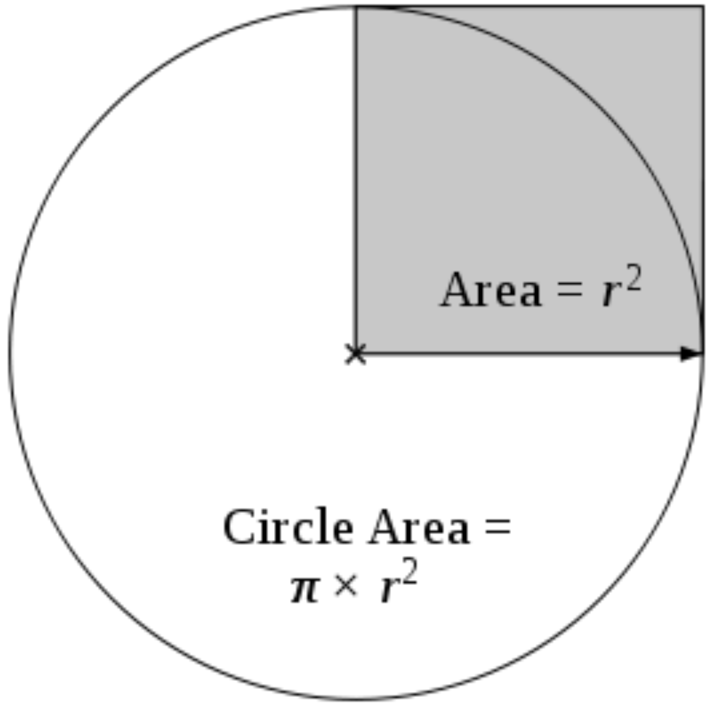
- Generate random (x,y) points in the square whose bottom left corner has coordinates (-1,-1) and whose top right corner has coordinates (1,1). This square has an **area of 4 units**.

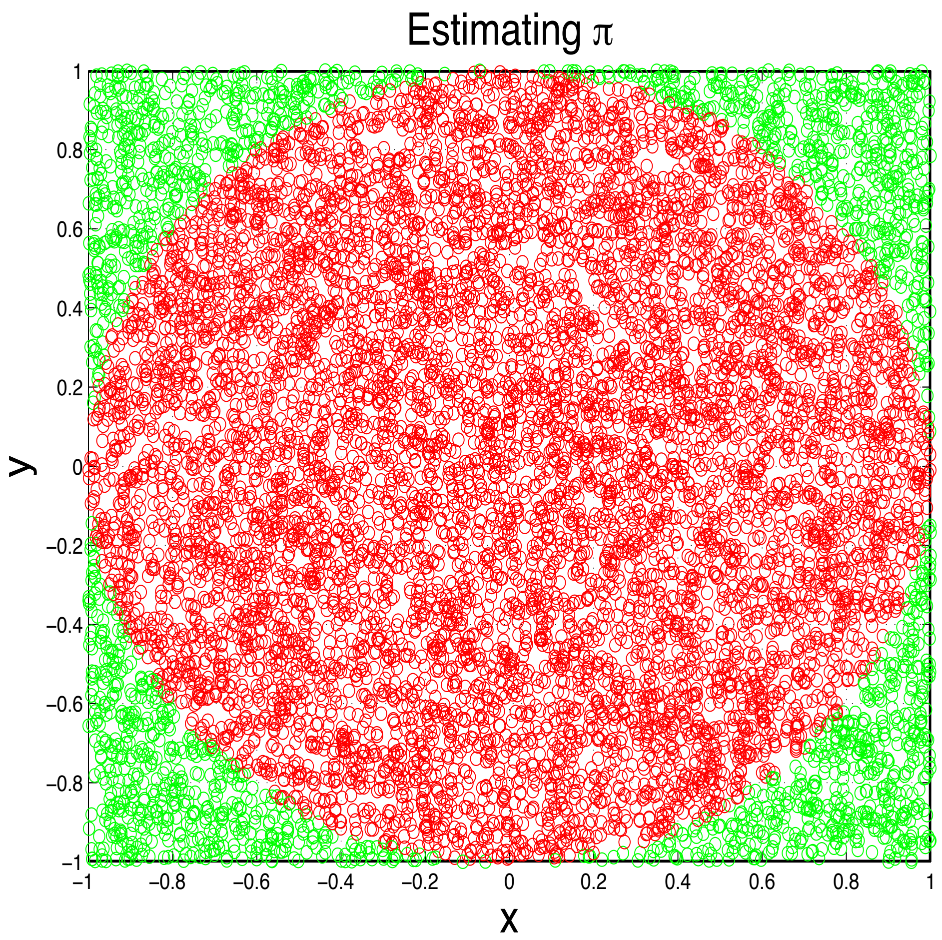
- Circumscribed by this square is the **unit** circle of **area π units** (as area of a circle is πr^2, when r=1, Area =π).

- The fraction of the points that lie within the unit disk is **π/4**.

- Use these facts to calculate π.

- How does the number of random numbers generated affect the accuracy?





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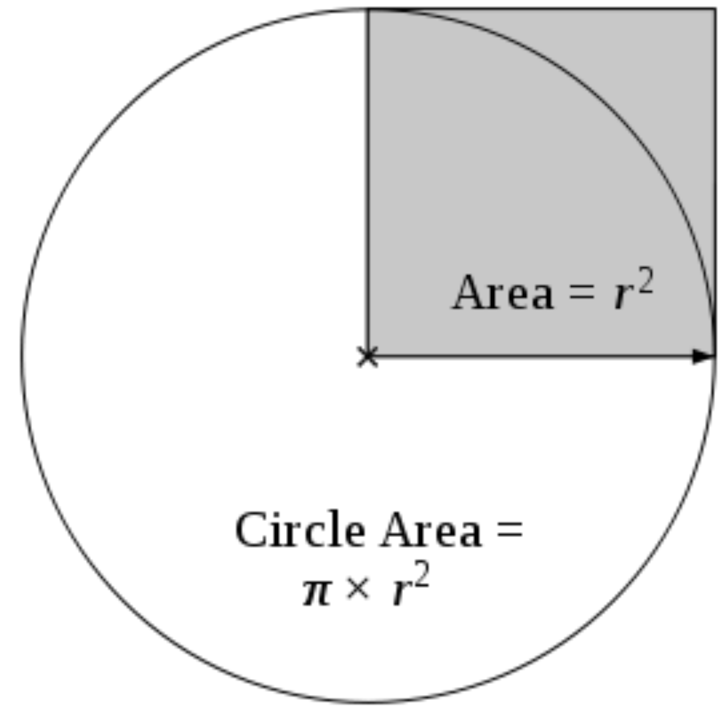

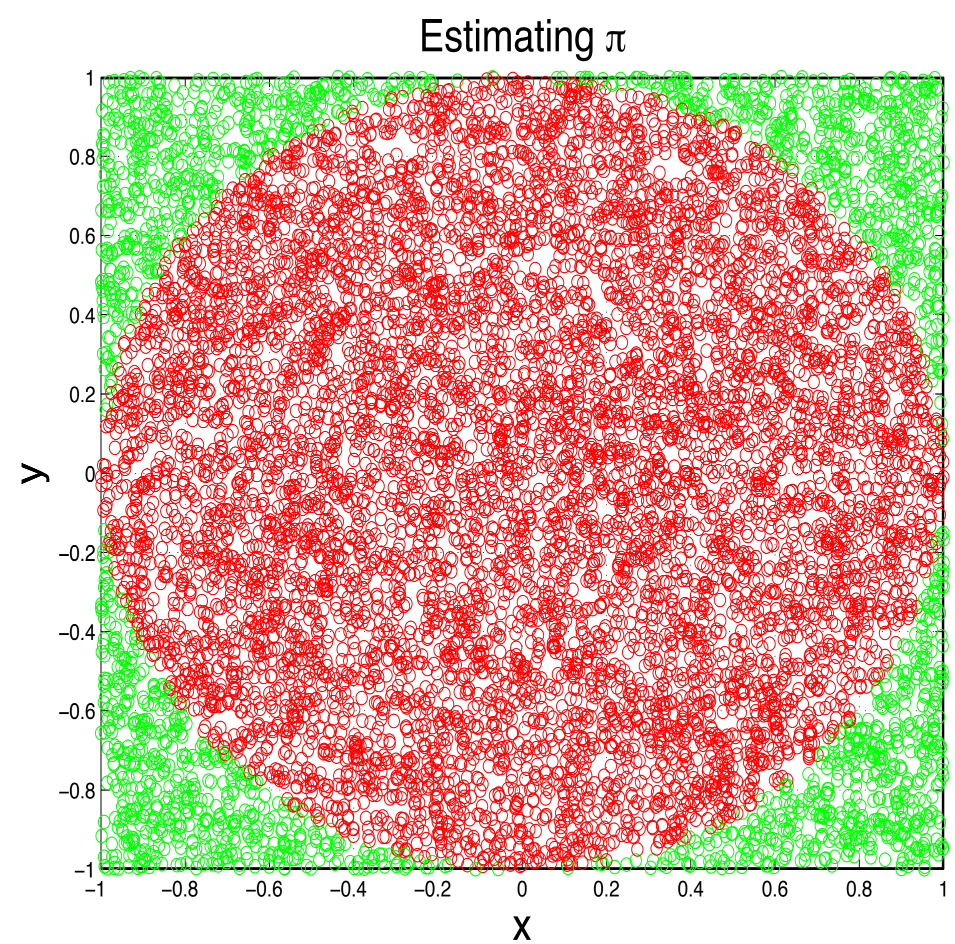

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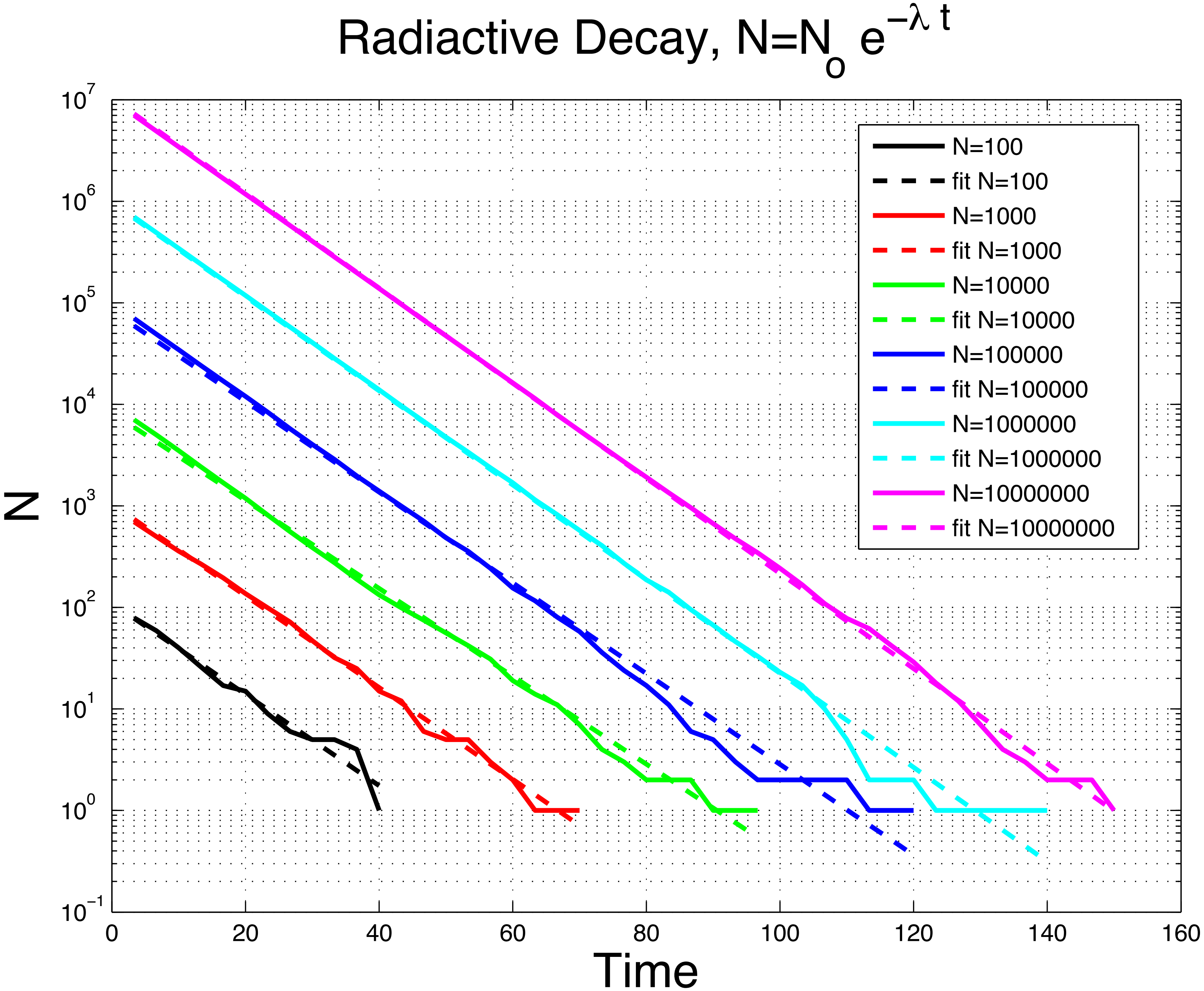
Example: Radioactive Decay

Theory: Spontaneous Decay

Spontaneous decay is a natural process in which a particle, with no external stimulation, and at one instant in time, decays into other particles.

Because the exact moment when any one particle decays is random, it does not matter how long the particle has been around or what is happening to the other particles.



The number of decay events, -dN, over an interval dT is proportional to the number of atoms N

$$-\frac{dN}{dt} \propto N$$

The probability of decay -dN/N is proportional to dT

$$-\frac{dN}{N} = \lambda \cdot dt$$

Each radionuclide has its own decay constant, λ, describing its decay. λ has units of 1/time.

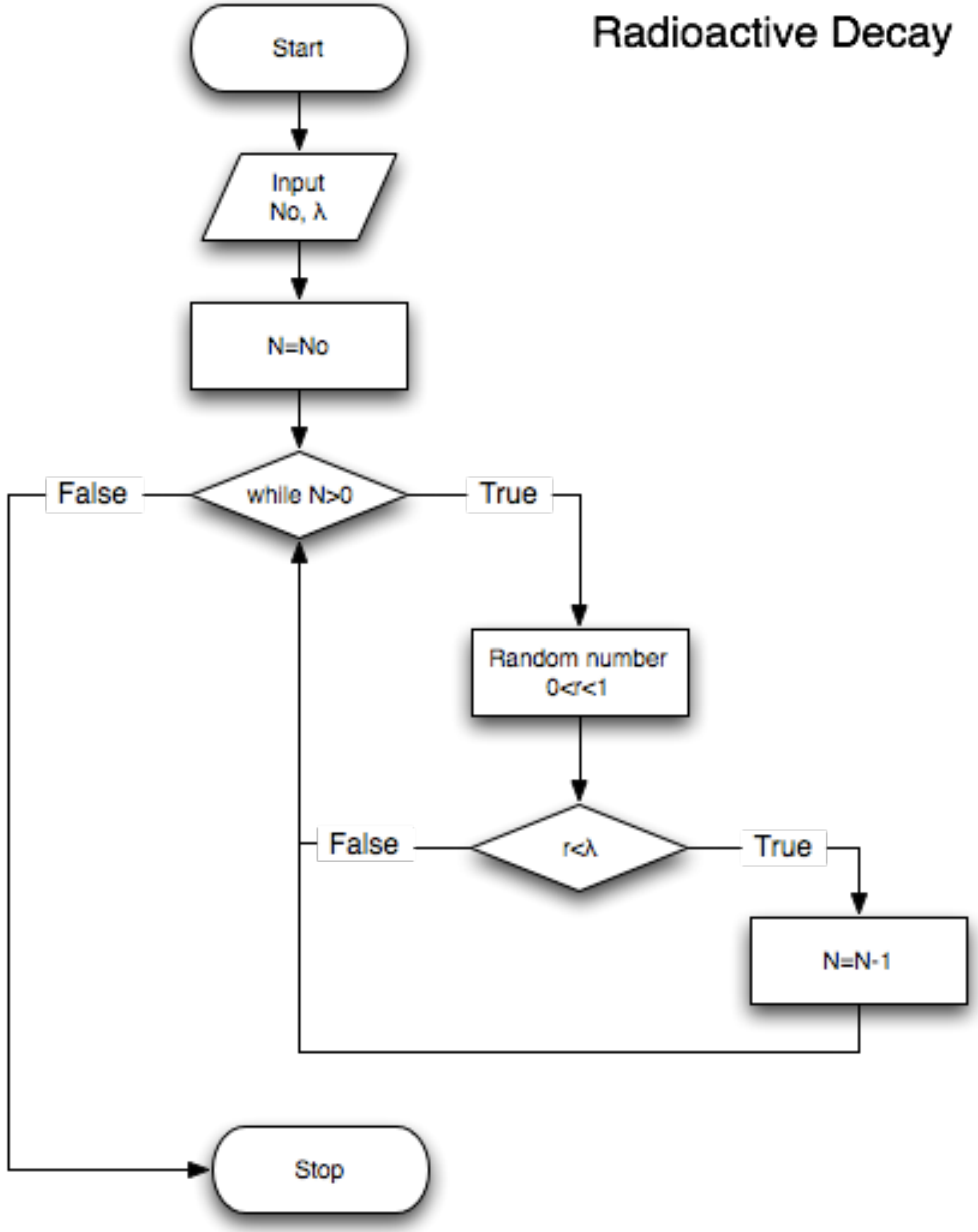
$$N(t)=N_0 e^{-\lambda t}=N_0 e^{-\frac{t}{\tau}}$$

$$\tau = \frac{1}{\lambda}, \text{ and } \lambda = \frac{1}{\tau}$$

$$t_{\frac{1}{2}} = \frac{\ln 2}{\lambda} = \tau \ln 2$$

$$\text{decay rate} = \ln(\lambda\ \Delta N)$$

Simulating Radioactive Decay



- Implement and visualize a Monte Carlo Simulation of radioactive decay. Start with 10^n radioactive atoms where n is 2,3,4,5,6, and 7.
- First of all start with λ=0.3. Time for one generation is λ^{-1}.
- Determine when the decay starts to be stochastic.
- Plot the decay versus time.
- Plot the decay rate ($\lambda\Delta N$) versus time.
- Try a range of λ, and verify that the decay is still exponential and that λ determines the decay rate.