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What is Monte Carlo

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Monte Carlo simulation

- Very powerful computational method.
- Use of random numbers.
- Can be applied to various problems and widely used: both engineering and science.

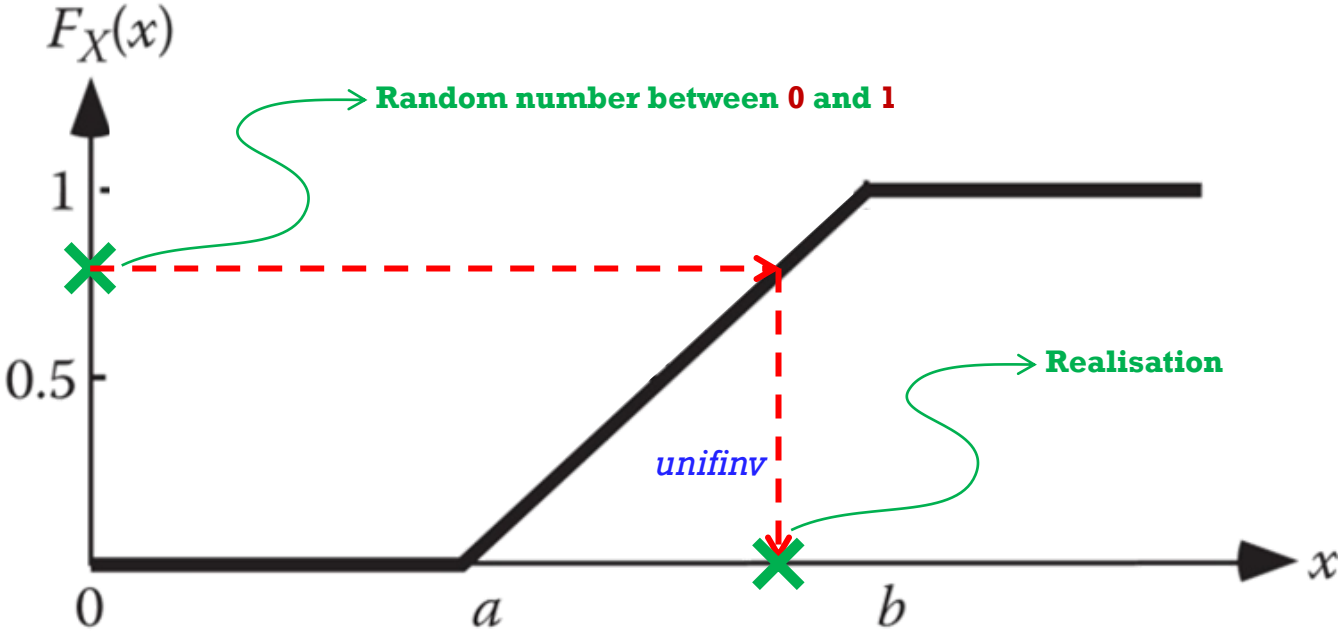
- Numerical experiments – sampling from empirical data or probabilistic models

Essential Matlab functions:

- ***randn*** - random samples from the standard normal distribution with mean = 0 and standard deviation = 1, i.e. ***N*(0,1)**.
- ***rand*** - random samples from the uniform distribution ranging between 0 and 1, i.e. ***U*(0,1)**.

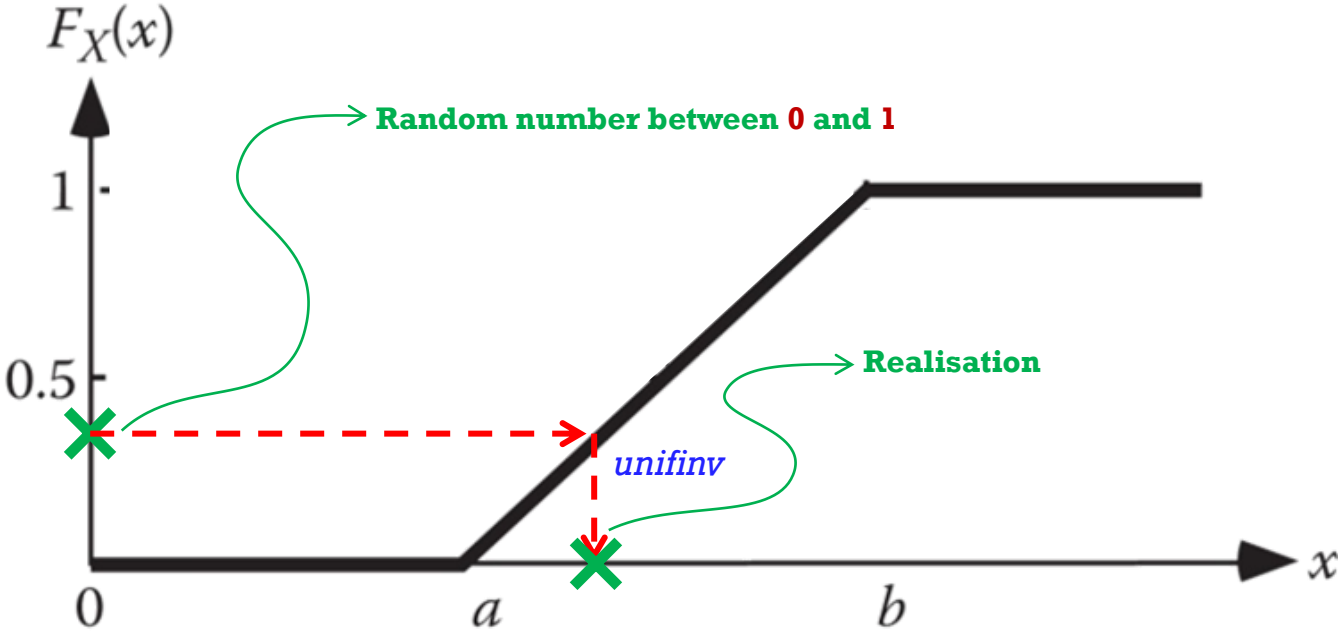
Monte Carlo simulation

CDF uniform distribution



Monte Carlo simulation

CDF uniform distribution



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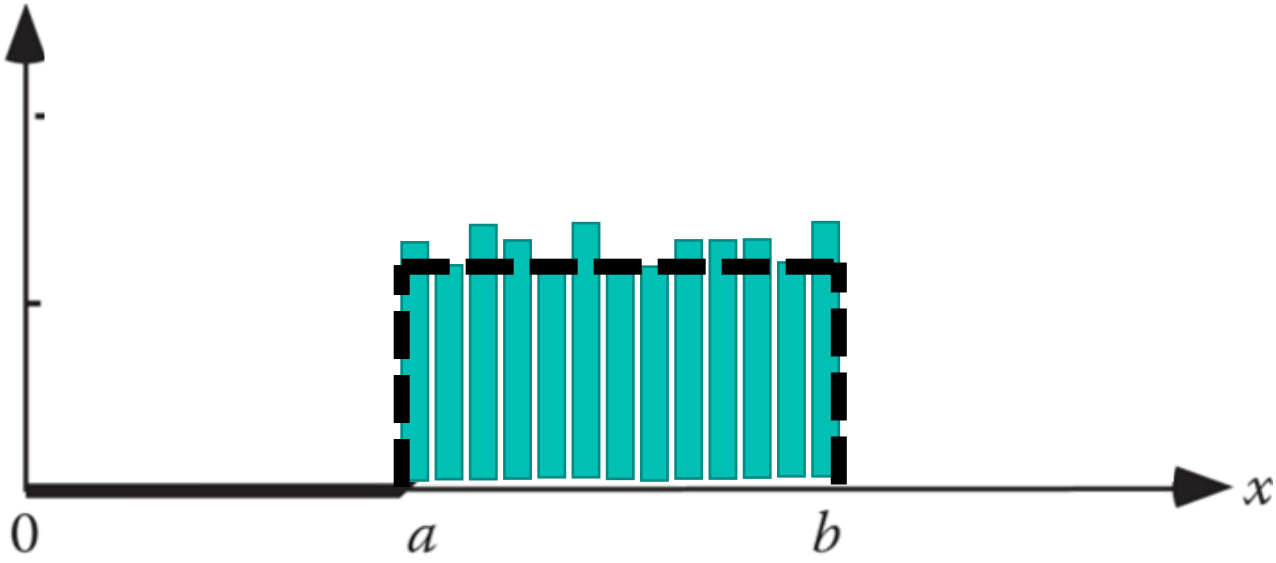
Monte Carlo simulation

pdf uniform distribution



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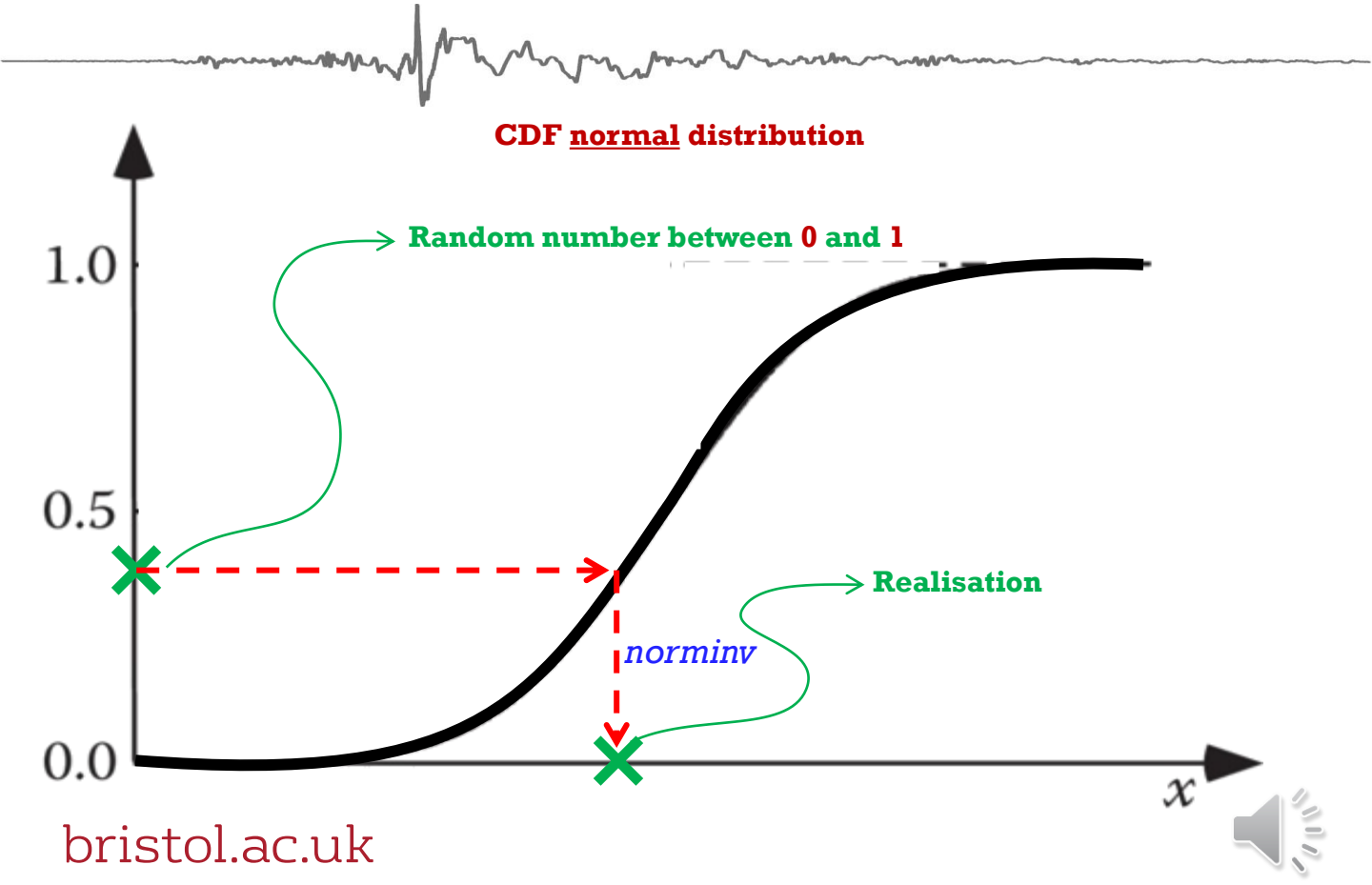
Monte Carlo simulation



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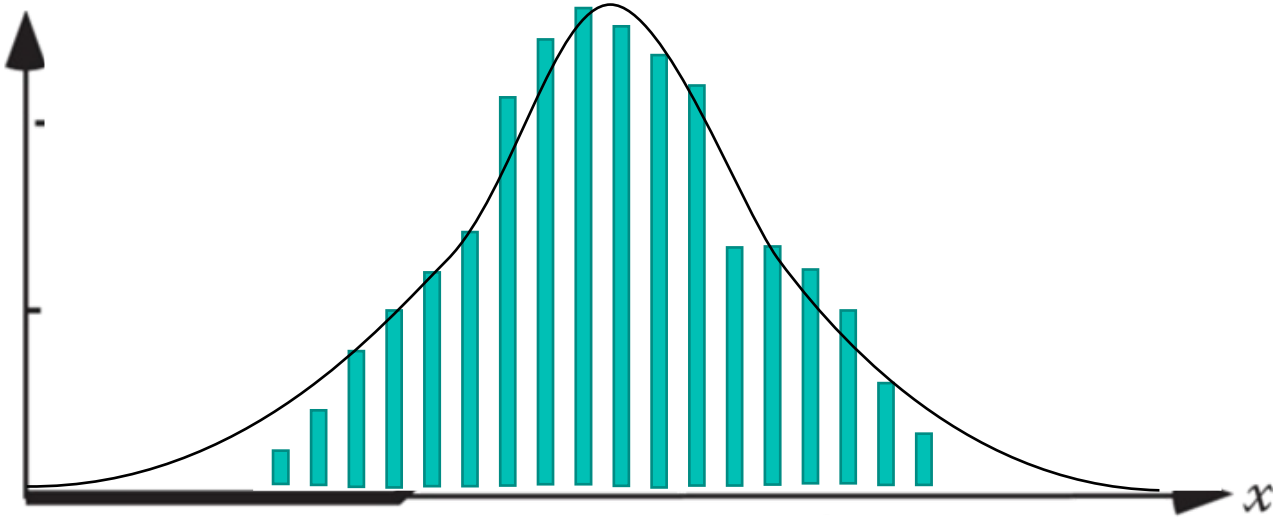
Monte Carlo simulation

pdf normal distribution



Be careful…

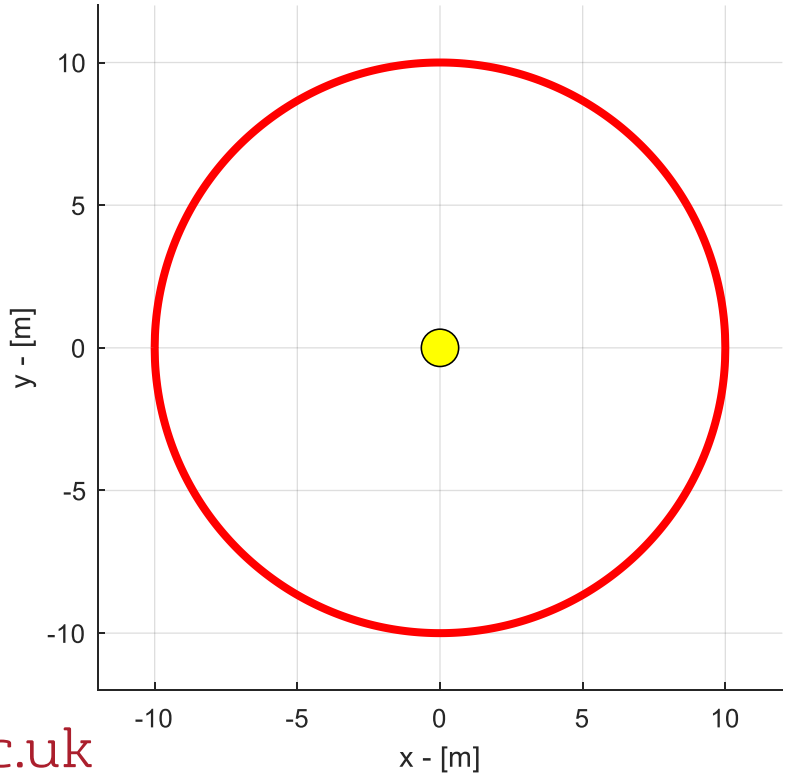
Important:

- random number generator is not completely 'random'.
- The sequence of random numbers depends on the seed number.
- Control this number so that you can reproduce the results by starting Monte Carlo simulations from the same seed number.

A simple example

R = 10 m

Area = ?

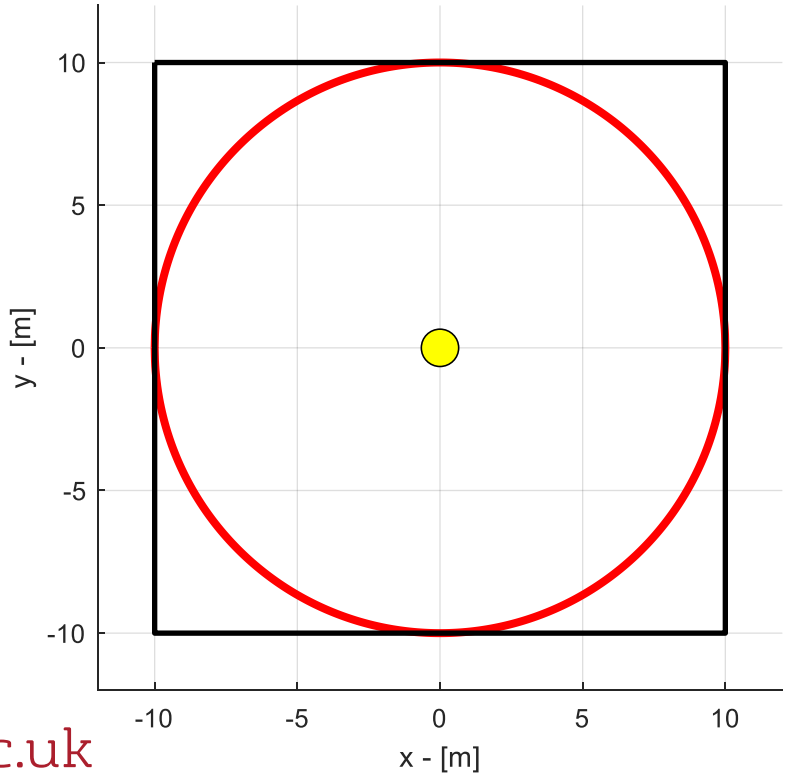


A simple example

R = 10 m

Area = ?

Square Area = 400 m^2



A simple example

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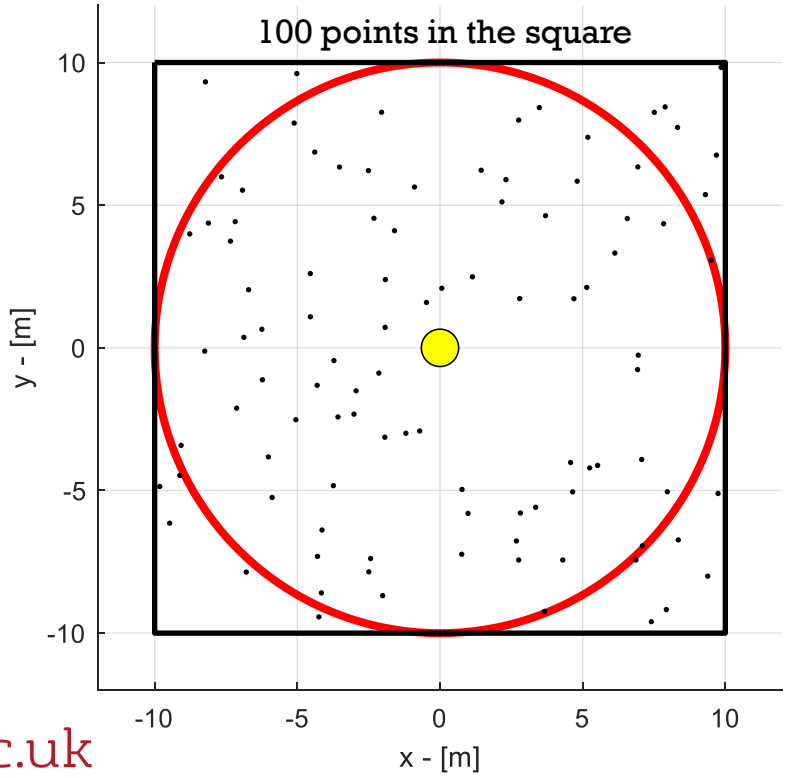

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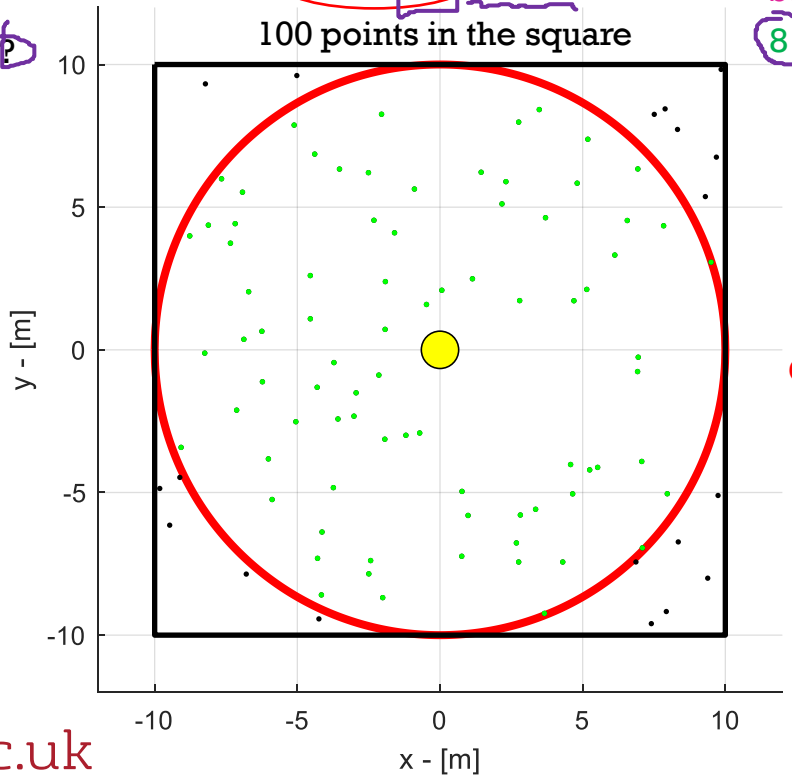
A simple example

$$\frac{\text{Square Area}}{\text{Circle Area}} = \frac{\text{Points in the square}}{\text{Points in the Circle}}$$

R = 10 m

Circle Area = ?

Area = 324 / 100 = 3.24



Square Area = 400 m^2

81 points in the circle

πR^2

Circle Area = 314 m^2

$$\pi = \frac{A}{R^2}$$

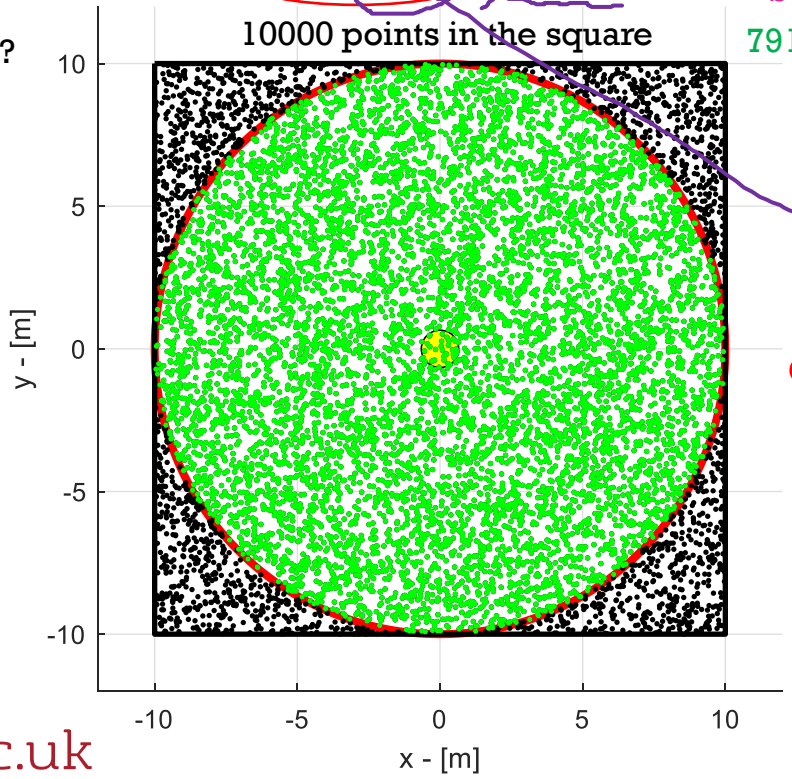
A simple example

$$\frac{\text{Square Area}}{\text{Circle Area}} = \frac{\text{Points in the square}}{\text{Points in the Circle}}$$

R = 10 m

Circle Area = ?

Area = 316.72 π = 3.1672



Square Area = 400 m^2

7918 points in the circle

π R^2

Circle Area = 314 m^2

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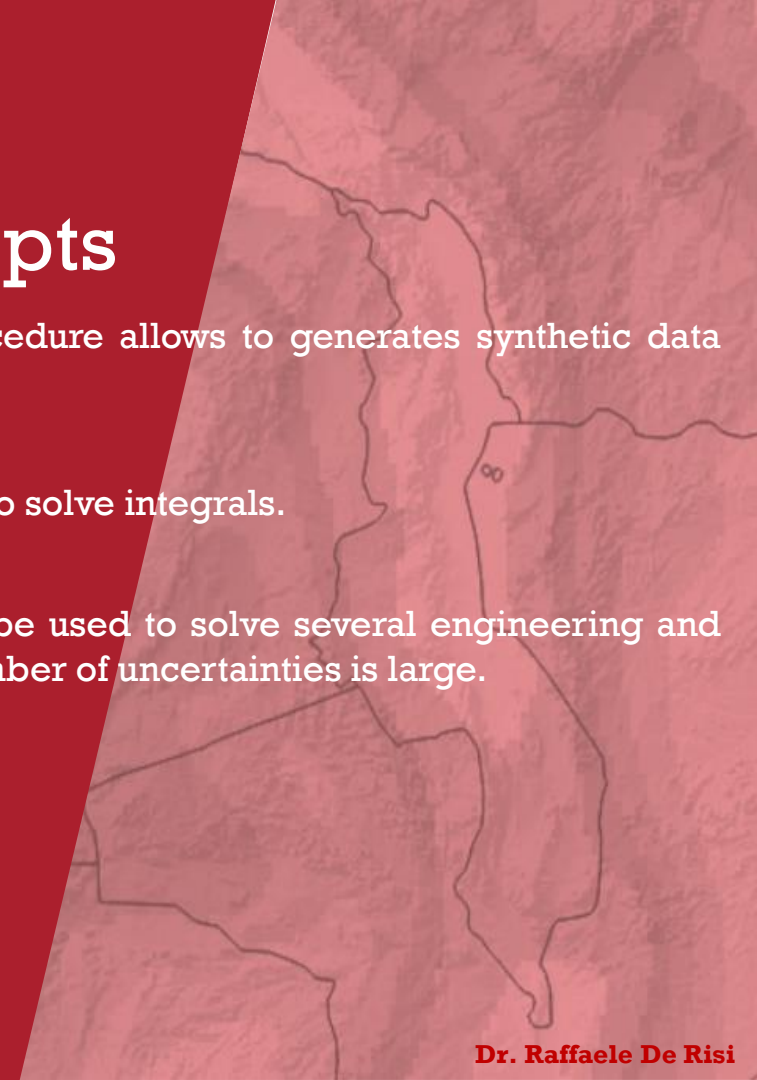
Takeaway concepts

- The Monte Carlo simulation procedure allows to generates synthetic data from a distribution.
- The method was initially created to solve integrals.
- The Monte Carlo simulation can be used to solve several engineering and reliability problems when the number of uncertainties is large.



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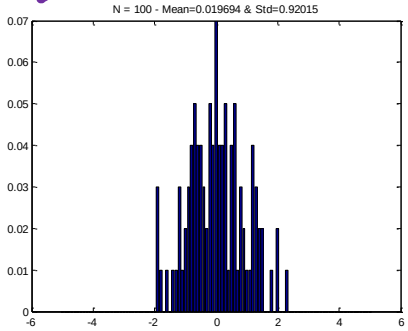
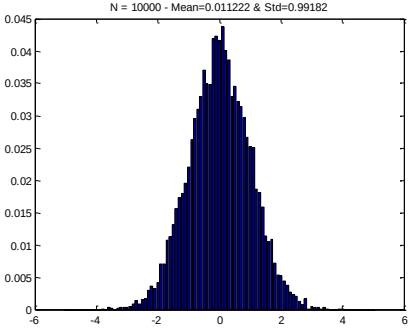
Exercise

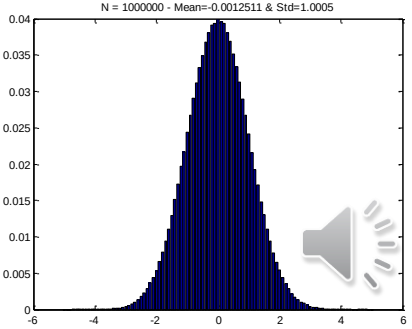
- Generate 100, 10000, 1000000 samples of z from u.
- Check the histograms and calculate mean and statistics to examine whether the inverse method is implemented correctly.

Matlab codes

- N = 1000000; Range = -5:0.1:5
- U = *rand*(N,1);
- Z = *norminv*(U,0,1) ;
- C = *hist*(Z,Range);
- *bar*(Range,C/N);
- MeanZ = *mean*(Z); StdZ = *std*(Z);







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Thank you !

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