Quantitative Risk Analysis using Monte Carlo Simulation

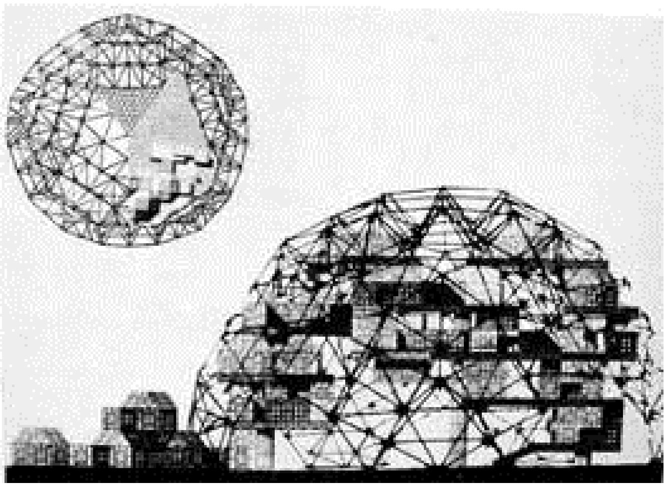
Subject Coordinator:

Dr Lihai Zhang

CONTACT:

Department of Infrastructure Engineering (Room B307)

lihzhang@unimelb.edu.au



Codified Design – How safe is safe enough?

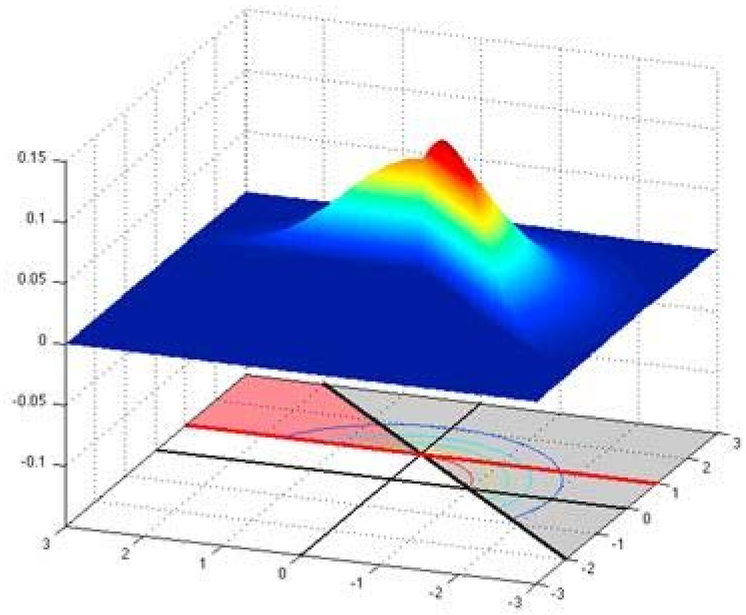
- This judgement must be made by code writers when
  - Identifying those natural and artificial forces that must be considered to ensure adequate safety and serviceability.
  - Providing criteria for achieving minimum required levels of structural resistance to these forces.

What has this judgement been based on?

Deterministic and Probabilistic Approaches

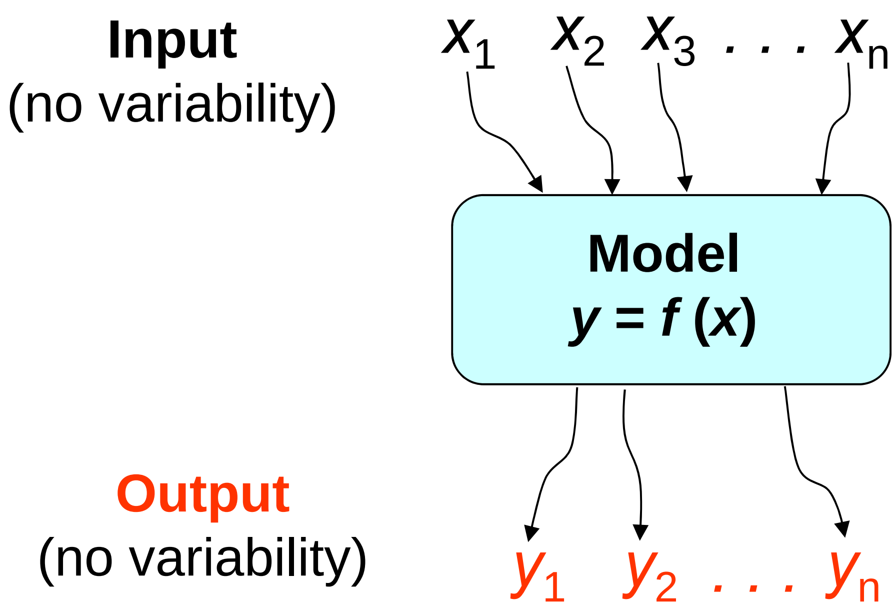
- The deterministic approach

- Probabilistic approach



Deterministic Approaches

- DETERMINISTIC Approaches
  - Deterministic calculations always give same answers (y_1,y_2) if input values (x_1,x_2,x_3) do not change



Calculations might be

$y_1 = x_1 + 3 * x_2^2 - 0.07 * \ln(x_3)$

$y_2 = 2 * x_1 - 3 * x_2^2$

. . . . . .

Probabilistic Approaches

- When **inputs** (x_1,x_2,x_3) are random variables then **outputs** (y_1,y_2) are also random variables.

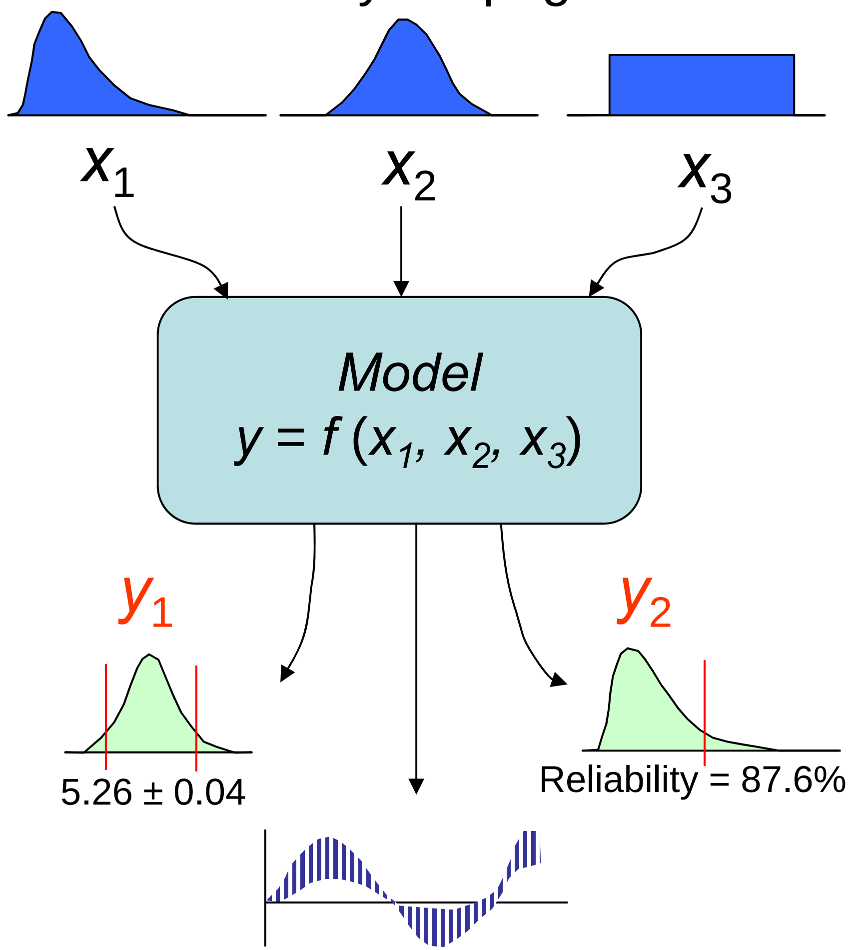
x_1 has a right skewed distribution,

x_2 …

y_1 has a Normal distribution,

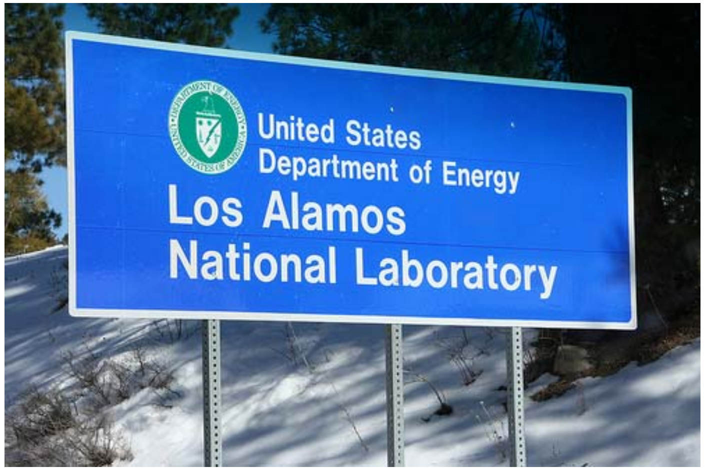
y_2 …

Uncertainly Propagation



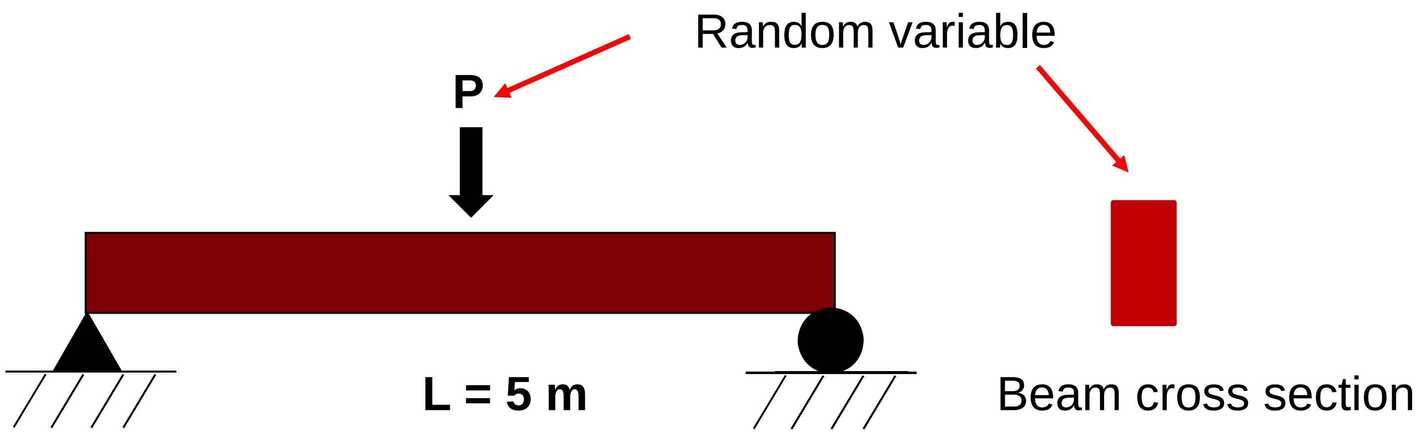
Monte Carlo Simulations

A **Monte Carlo method** is a broad class of computational algorithms that rely on repeated random sampling to obtain numerical results .



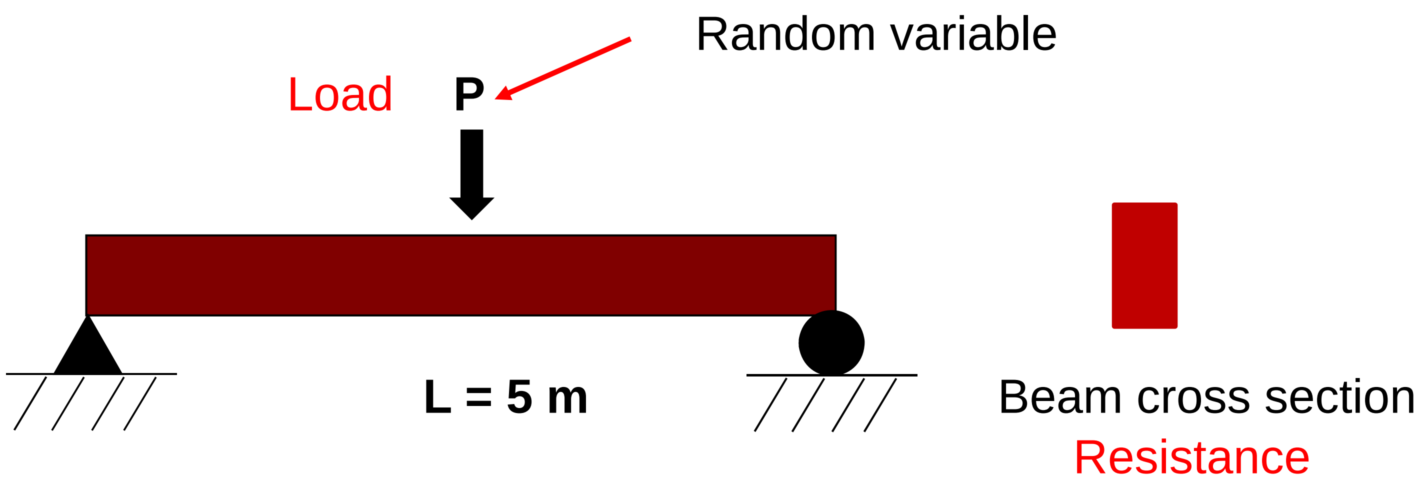
The term **Monte Carlo** was coined in the 1940s by physicists working on nuclear weapon projects in the Los Alamos National Laboratory.

- Monte Carlo Simulation
  1. Defining all the random variables (continued)



- Monte Carlo Simulation
  2. Quantifying the probabilistic characteristics of the random variables.

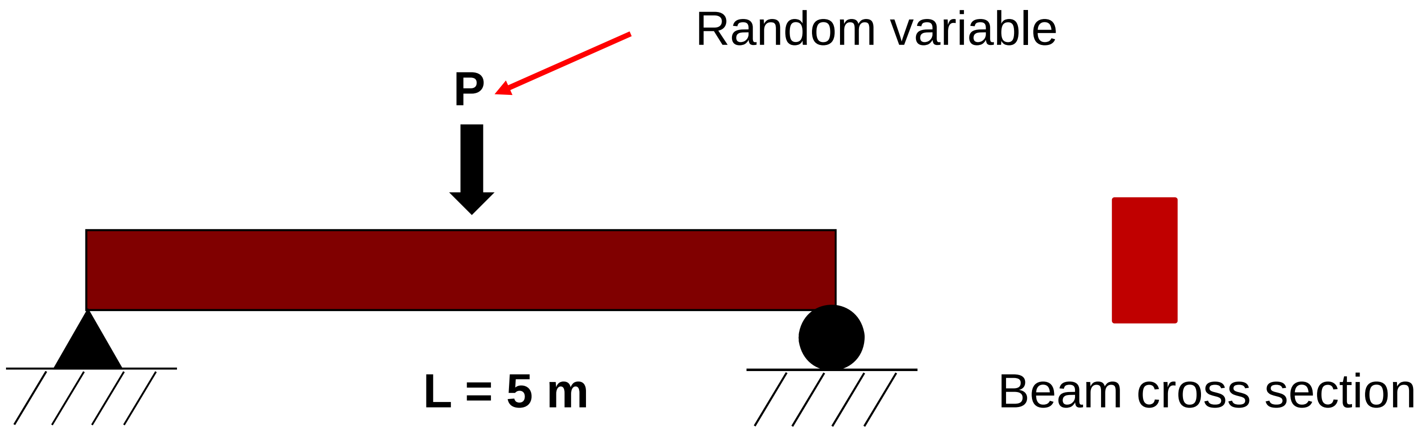
A simply supported timber beam of length 5 m is loaded with a central load P with μ_S = 3 kN and σ_S = 1 kN. The bending strength of similar beams has been found to have a allowable load of 5 kN. Determine the probability of failure.



- Monte Carlo Simulation

  3. Generating values of these random variables.

Load P with μ_S = 3 kN and σ_S = 1 kN



- Monte Carlo Simulation

  3. Generating 1000 values of these random variables.

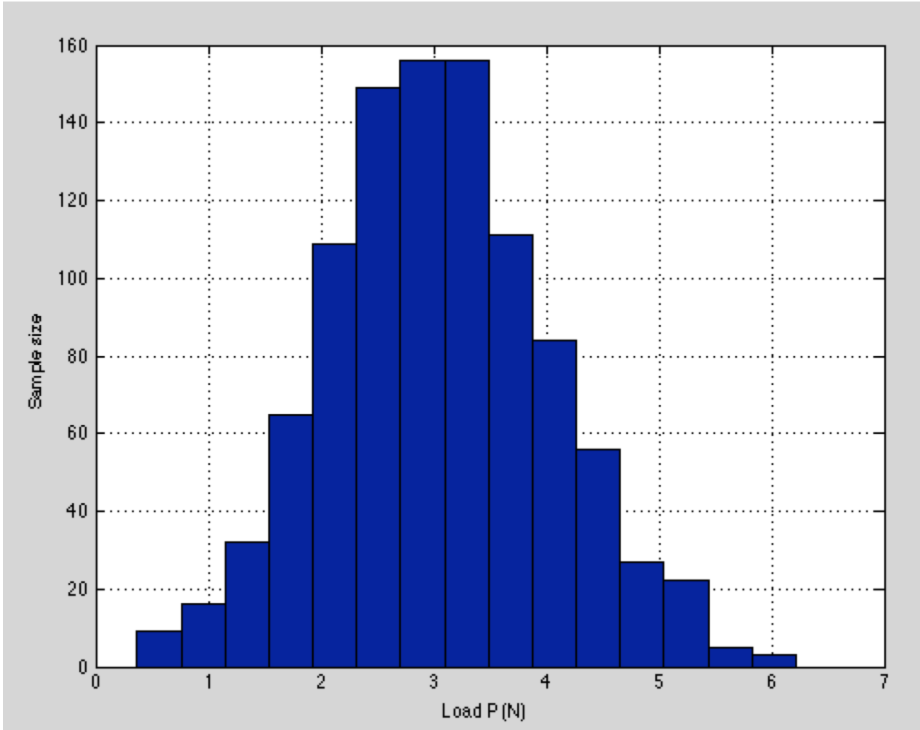
Load P with μ_S = 3 kN and σ_S = 1 kN

```
%Monte Carlo simulation with histogram

clear all;
close all;
clc;

% generate sample
rng(123456);      %specifiy random seed
mu = 3;           %mean
sigma = 1;        %standard deviation
size = 1000;      %sample size

r = mu + sigma.*randn(size,1);    %generate sample mu and sigma

```

Monte Carlo Simulation

- Monte Carlo Simulation
  3. Generate histogram of 1000 samples with 15 bins

```
% generate histogram
hist(r,15);
xlabel('Load P (N)');
ylabel('Sample size');
grid on;
```



- Monte Carlo Simulation
  4. Determine the probability of failure if the allowable load = 5 kN

```
%calculate probability of failure

n = length(r);
allowable_load = 5;
counter = 0;

for i = 1:n
    if r(i) > allowable_load
        counter = counter+1;
    end
end

probability_failure = counter/size*100;
display(probability_failure);
```

Command Window

```
probability_failure =

    3.1000
```

Probability of failure: 3.1%