Seoul National University
Dept. of Civil and Environmental Engineering

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457.646 Topics in Structural Reliability
In-Class Material: Class 01

I. Introduction

◎ Uncertainties in Engineering

① **( ) :** Inherent randomness (or physical fluctuation)

e.g. earthquake intensity (PGA, PGV, …), wind velocity, maximum flow rate

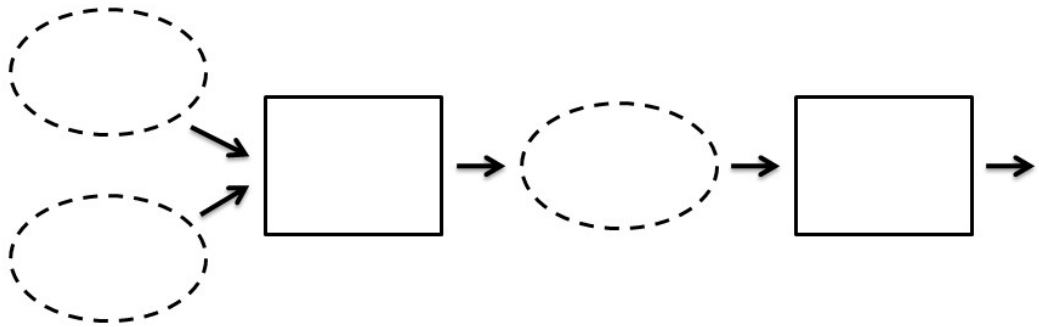
⇒ ( ) be reduced

② **( ) :** uncertainty due to insufficient ( )

- ( ) uncertainty: imperfect or simplified model (e.g. 3D→2D)
  missing variables or effects
- ( ) uncertainty: insufficient data
  e.g. "sample mean is not the true mean"

⇒ ( ) be reduced by investing more in knowledge and data

◎ Uncertainty, Risk and Decisions



Decision making under ( ) leads to ( )
Need to quantify ( ) caused by ( )

◎ 457.646 Topics in Structural Reliability (Theory)

- Focus: methods for quantifying risk & applications
- Provide overview and applications of " " reliability methods

⇒ The word " " does not refer to physical structures (buildings and bridges, …)

⇒ in an ( ) & ( ) manner

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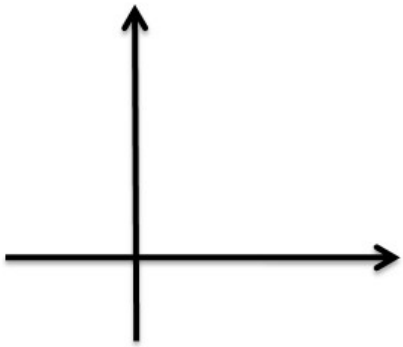
◎ Part 2: Basic theory of probability & statistics (≤ 3 weeks) (ref. A&T textbook)

◎ Part 3: Structural Reliability Analysis (SRA) - Component

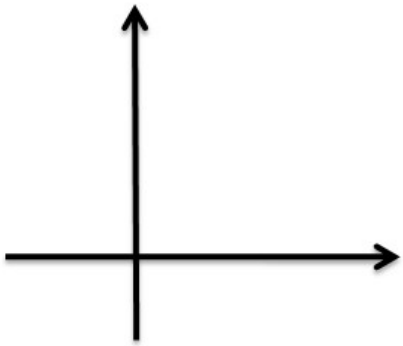


P_f =

- Reliability index: β_{MVFOSM} , β_{HL}

- Reliability methods: FORM, SORM, etc. (how to integrate ↖)

◎ Part 4: Structural Reliability Analysis (SRA) - System



P_f =

- Reliability methods developed to handle system failure domains

: “System” reliability methods

◎ Part 5: Structural Reliability under Epistemic Uncertainty

$$P_f = \int_{g(\mathbf{x};\ )\le 0} f_{\mathbf{x}}(\mathbf{x};\ )\, d\mathbf{x}$$

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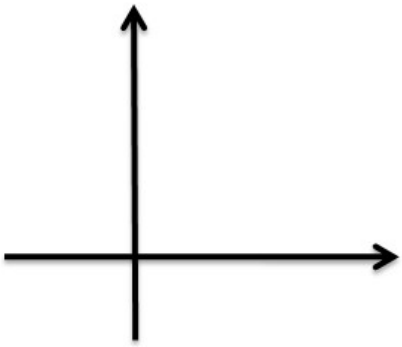
◎ Part 6 : Simulation Methods



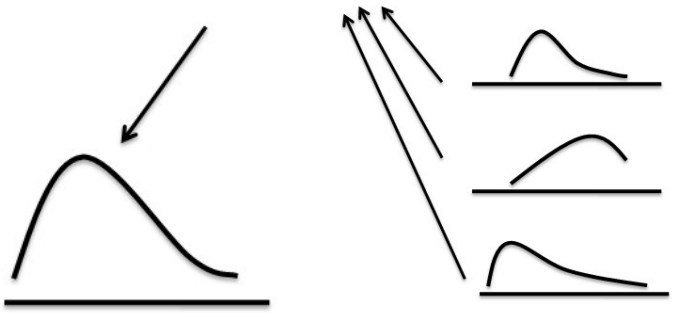
$P_f =$

⇒ Monte Carlo simulations

⇒ Efficient Sampling methods

◎ Part 7: Uncertainty Quantification

$$Y = g(\mathbf{x})$$



input distributions

Find distributions of output

◎ Part 8: Applications

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II. Basic theory of Probability and Statistics

1. Set Theory

Why do we need 'set theory' in uncertainty analysis?

- **Uncertainty:** a ( ) of possible ( )

  e.g. toss a coin

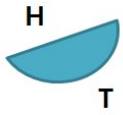
  roll a dice

  weight of a car

- **Probability:** numerical measure of the ( ) of an event (i.e. a group of outcomes) of interest ( ) the other possible outcomes

e.g. "unfair coin"

H:T= P(H)=



- Uncertainty analysis starts with ( ) the collection of all possible outcomes
- Principles of set theory are essential tool for this task.

2. Definitions

(a) **Sample space** ( ): the set of ( ) possible outcomes

Sample point ( ): an ( ) outcome

e.g.

Criteria	Sample space	Examples
Continuous?	"Discrete": ( ) quantities	# of typhoons at city A in a year S={ }
	"Continuous": ( ) quantities	% of congested traffic in Seoul S={ }
Can count sample points?	"Finite" : ( ) ( ) and ( )	S = { }
	"Infinite" : ( ) ( ) or ( )	S = { } S = { }

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(b) **Event** ( ): any collection of sample ( ) or any ( ) of sample space

e.g. Baseball: outcomes of each "at-bat"

S=

discrete or continuous?

infinite or finite?

"A hitter reaches a base"

E=

(c) Some notable events

- ( ) event: E=

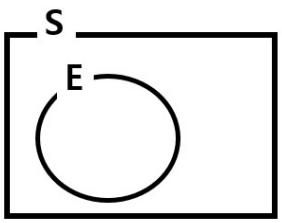
  - Occurs with certainty

- ( ) event: E=

  - cannot occur

- **Complementary** event of E : ( ) or ( )

  - An event that contains ( ) the sample points that are ( ) in E



- e.g. "at-bat" outcomes

  E: "a hitter reaches a base"

  $\overline{E}$ =

- e.g. $\overline{S}$ = , $\overline{\phi}$ =

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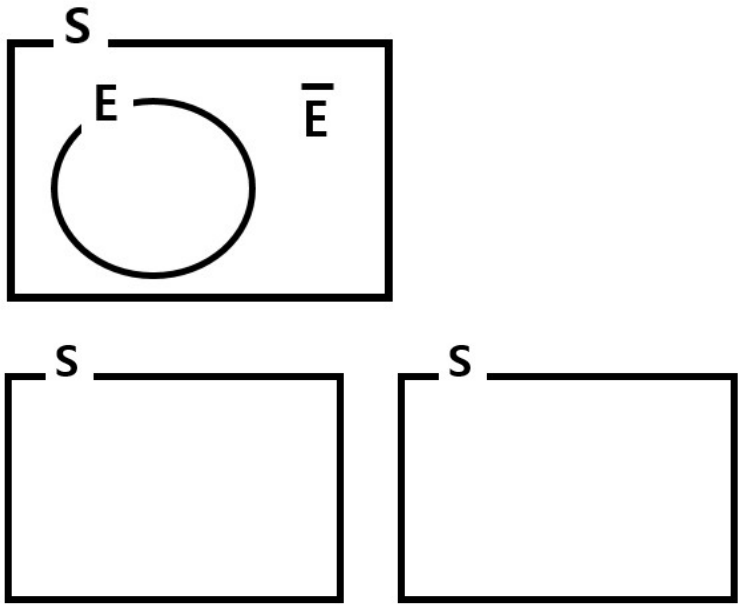
(d) **Venn diagram**: ( ) & ( ) representation of the sample space, sample points and events



* GUI-based interactive learning tools for Venn diagrams (and other statistical concepts) are available at http://www.stat.berkeley.edu/~stark/Java/Html/