UNIT 5
MECHANICAL SYSTEM DESIGN

- *Chapter 9- Decision Analysis*
- *Chapter10-System Simulation*

CHAPTER 9

Decision Analysis

Decision Analysis

After having selected various alternatives for solution of a design, designer faces the task of taking decision for suitable feasible alternatives. The designer has to make assessment of the available solutions in stages and then the promising ones should be examined in detail.

Technical feasibility is the most vital aspect that the designer has to take into account. Following this process; he can eliminate a few solutions, so that the remaining alternatives can be examined more intensely. The evaluation thus starts at a superficial level and more and more detailed study is conducted with the increase of elimination process.

With each round of technical assessment of feasible alternatives the designer must make their economic assessment. It has been observed that systematic techno economic investigation goes a long way in providing rapid convergence towards the final decision.

Importance of Decision Making

- To select the optimum solution.
- Stress on better performance due to increased competition.

Elements of Decision Problem

- Strategies available to decision maker
- State of nature.
- Payoffs or outcomes
- Objectives
- Utility
- State of knowledge

Utility Matrix

- If the utility has been expressed on a scale of losses, following is the loss table for this material selection of gains and table would be called PAYOFF MATRIX.

Courses of action	State of Nature			
	θ_1	θ_2	θ_3	θ_4
a_1	1	4	10	15
a_2	3	2	4	6
a_3	5	4	3	2

Decision Making under Multiple Criteria

- **Multiple-criteria decision-making** or **multiple-criteria decision analysis** (MCDA) is a sub-discipline of operations research that explicitly considers multiple criteria in decision-making environments.
- Whether in our daily lives or in professional settings, there are typically multiple conflicting criteria that need to be evaluated in making decisions. Cost or price is usually one of the main criteria. Some measure of quality is typically another criterion that is in conflict with the cost.
- In purchasing a car, cost, comfort, safety, and fuel economy may be some of the main criteria we consider.
- It is unusual that the cheapest car is the most comfortable and the safest one.
- In portfolio management, we are interested in getting high returns but at the same time reducing our risks..

Types of decisions

- Decision problems under certainty
- Decision problems under risk
- Decision problems under uncertainty
- Decision problems under conflict

Decision tree

- A **decision tree** is a decision support tool that uses a tree-like graph or model of decisions and their possible consequences, including chance event outcomes, resource costs, and utility. It is one way to display an algorithm.
- Decision trees are commonly used in operations research, specifically in decision analysis, to help identify a strategy most likely to reach a goal.

Decision model by Herbert Simon

- It has three phases

1. Intelligence
2. Design
3. Choice

Expected Monetary value

Steps to Calculate Expected Monetary Value (EMV)

- To calculate the Expected Monetary Value in project risk management, you need to:

1. Assign a probability of occurrence for the risk.
2. Assign monetary value of the impact of the risk when it occurs.
3. Multiply Step 1 and Step 2.
4. The value you get after performing Step 3 is the Expected Monetary Value. This value is positive for opportunities (positive risks) and negative for threats (negative risks). Project risk management requires you to address both types of project risk.

Baye’s theorem

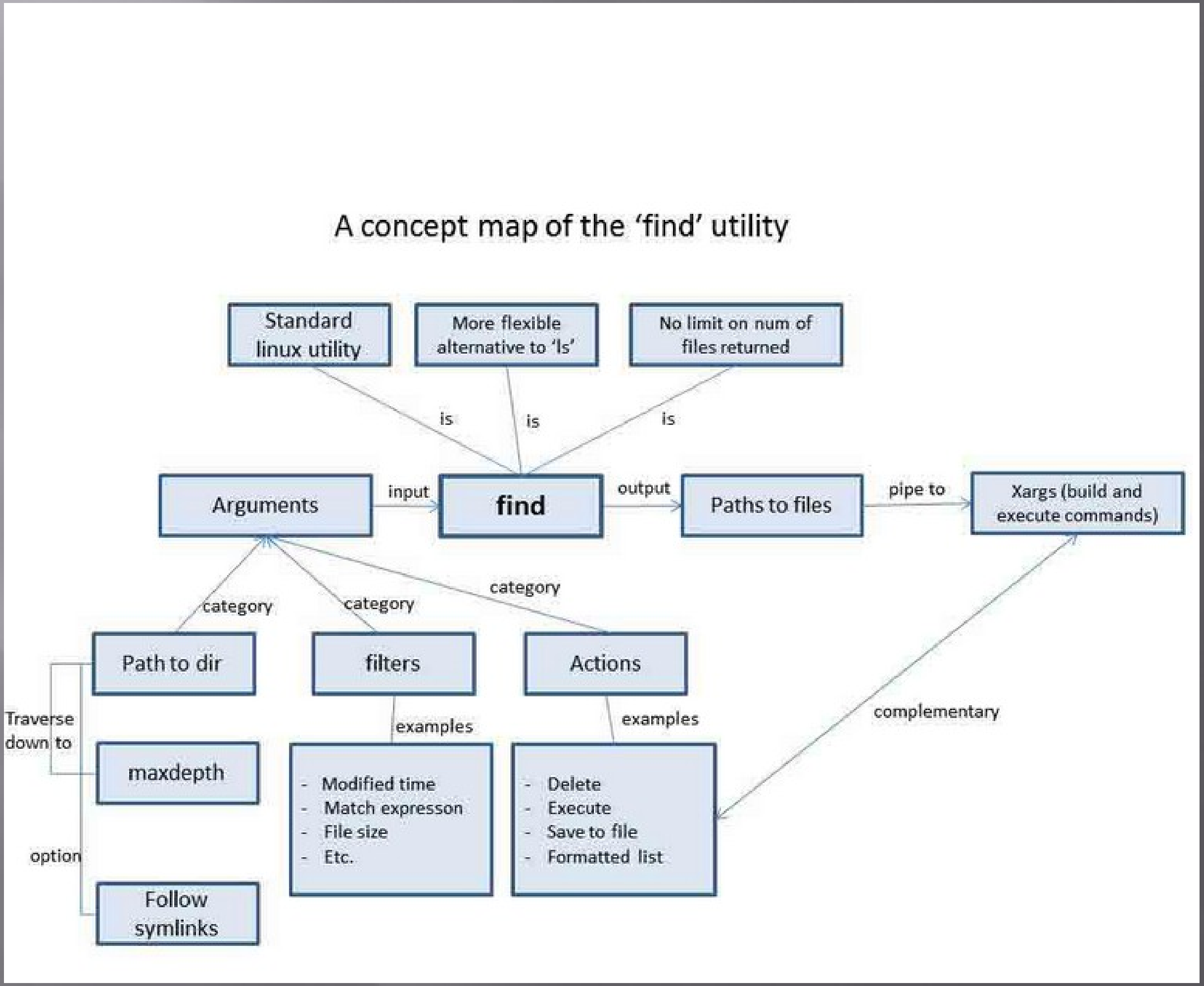
- **ayes' theorem.** Let A_1, A_2, ... , A_n be a set of mutually exclusive events that together form the sample space S. Let B be any event from the same sample space, such that P(B) > 0. Then,

  $P(A_k | B) = P(A_k \cap B) P(A_1 \cap B) + P(A_2 \cap B) + . . . + P(A_n \cap B)$

  <u>Note:</u> Invoking the fact that $P(A_k \cap B) = P(A_k)P(B | A_k)$, Baye's theorem can also be expressed as

  $P(A_k | B) = P(A_k) P(B | A_k) P(A_1) P(B | A_1) + P(A_2) P(B | A_2) + . . . + P(A_n) P(B | A_n)$

Utility concept



Meaning of Utility

- Utility refers to want satisfying power of a commodity. It is the satisfaction, actual or expected, derived from the consumption of a commodity. Utility differs from person- to-person, place-to-place and time-to-time. In the words of Prof. Hobson, "Utility is the ability of a good to satisfy a want".
- In short, when a commodity is capable of satisfying human wants, we can conclude that the commodity has utility.

Measuring Utility

- After understanding the meaning of utility, the next big question is: How to measure utility? According to classical economists, utility can be measured, in the same way, as weight or height is measured. For this, economists assumed that utility can be measured in cardinal (numerical) terms. By using cardinal measure of utility, it is possible to numerically estimate utility, which a person derives from consumption of goods and services. But, there was no standard unit for measuring utility. So, the economists derived an imaginary measure, known as 'Util'.
- Utils are imaginary and psychological units which are used to measure satisfaction (utility) obtained from consumption of a certain quantity of a commodity.

SYSTEM SIMULATION

Chapter 10

Introduction

- Simulation is a very powerful and widely used management science technique for the analysis and study of complex systems.

- Simulation may be defined as a technique that imitates the operation of a real-world system as it evolves over time. This is normally done by developing a simulation model. A simulation model usually takes the form of a set of assumptions about the operation of the system, expressed as mathematical or logical relations between the objects of interest in the system.

Definition of simulation

- **Simulation** is the imitation of the operation of a real-world process or system over time. The act of simulating something first requires that a model be developed; this model represents the key characteristics or behaviors of the selected physical or abstract system or process. The model represents the system itself, whereas the simulation represents the operation of the system over time.

Simulation models

- **Simulation modeling** is the process of creating and analyzing a digital prototype of a physical model to predict its performance in the real world. Simulation modeling is used to help designers and engineers understand whether, under what conditions, and in which ways a part could fail and what loads it can withstand. Simulation modeling can also help predict fluid flow and heat transfer patterns.

Iconic Models

- Look like real things.
- Four type of iconic models:
  - Proof of concept model
  - Scale model
  - Experimental model
  - Prototype model

Analog model

- **Analogical models** are a method of representing a phenomenon of the world, often called the "target system" by another, more understandable or analyzable system. They are also called **dynamical analogies**.
- They are based on symbols manipulation and algebraic techniques.

Simulation process

- It contains:
  - Model development
  - Model execution
  - Model output
    - A model is created to represent a manufacturing system. Creation of model will need:
      - Define nature of purpose
      - Specification of constraints.

Different type of simulation

- Statistical simulation
- Continuous simulation
- Discrete event simulation
- Combined simulation

Simulation Methodology

- Developing a dedicated model
- Using simulation software

Terms used in simulation

- Time
- Entities and resources
- Events
- States and queues
- Activities
- Executives

Computer simulation

- A **computer simulation** run on a single computer, or a network of computers, to reproduce behavior of a system.
- The simulation uses an abstract model (a **computer model**, or a **computational model**) to simulate the system. Computer simulations have become a useful part of mathematical modeling of many natural systems in physics (computational physics), astrophysics, climatology , chemistry and biology, human systems in economics, psychology, social science, and engineering.
- Simulation of a system is represented as the running of the system's model. It can be used to explore and gain new insights into new technology and to estimate the performance of systems too complex for analytical solutions.

Monte Carlo Methods

- A Monte Carlo simulation creates samples from a known distribution
- For example, if you know that a coin is weighted so that heads will occur 90% of the time, then you might assign the following values:

X	0	1
$f_X(x)$	0.10	0.90

Monte Carlo Methods

- Define problem
- Construct appropriate model
- Specify value to variables
- Collect info required
- Define starting
- Define a coding system that correlate factors indentified in problem defining
- Select random no. generator and no.
- Correlate the generated random no. with factor indentified in step 1 to 6.
- Summarize result
- Evaluate
- Formulate proposal to management

Waiting line simulation

- This module simulates client/server relationships. The random events for customer arrivals are generated according to Poisson distribution whose parameter **l** can be chosen from the pull-down menu "Arrival Rate"; the random events for server services are generated according to negative exponential distribution whose parameter **m** can be chosen from the pull-down menu "Service Rate".

Structure of waiting line simulation

- SCSP
- MCSP
- SCMP
- MCMP

Advantages of waiting line theory

- Good service to customer
- Optimization
- Better understanding of queues
- Better models

Limitations

- Complex
- Discipline may be an issue
- Distributions may not fit
- Difficult analyzing