CHAPTER

0b

Duxbury Thomson Learning

Making Hard Decision Third Edition

Introduction to Decision Analysis for Engineering

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ENCE 627 – Decision Analysis for Engineering

Department of Civil and Environmental Engineering

University of Maryland, College Park

Computers, Software, and Spreadsheets

- Computers Evolution Era (Chapra & Canale 1988)
  - Zero Generation - Manual & Mechanical (pre 1951)
  - First Generation – Vacuum tubes (1951 – 1958)
  - Second Generation – Transistors (1958 – 1964)

Computers, Software, and Spreadsheets

- Computers Evolution Era (Chapra & Canale 1988)
  - Third Generation – Integrated circuits (1964 – 1971)
  - Fourth Generation – Very large scale integration (1971 – present)
  - Mainframes, Supercomputers
  - Personal Computers, Microcomputers, and Minicomputers

Computers, Software, and Spreadsheets

- Computers Evolution Era (Chapra & Canale 1988)
  - Fifth Generation (1990?)
  - Parallel Processing
  - Artificial intelligence

Computers, Software, and Spreadsheets

- High-level Languages
  - FORTRAN (introduced by IBM in 1957)
    - FORTRAN = *FORmula TRANslation*
    - *Developed for the IBM 704 Computer*
    - *Developed by John Backus and a team of 13 other programmers*
  - BASIC
  - Pascal
  - C+, C++, Java, and Others

Computers, Software, and Spreadsheets

- Software Packages
  - MATLAB
  - MathCad
  - Spreadsheet
    - Microsoft Excel
    - Quattro Pro
    - Lotus 123

Computers, Software, and Spreadsheets

- Spreadsheets and Engineering
  - Spreadsheet is special type software that allow the user to enter and perform calculations on rows and columns of data displayed on computer monitor
  - Advantages of Spreadsheet
    - Easy to use and understand
    - Provide organized record of user computation
    - Entire calculation can be updated easily
    - Suitable for "what if?" scenarios

Computers, Software, and Spreadsheets

- Spreadsheet Calculations

B5 = B3 + B4

	A	B	C	D	E	F	I
1							
2							
3	X =	10					
4	Y =	13.5					
5	Sum =	23.5					
6							
7							
8	u =	45					
9	v =	25					
10	$\sqrt{uv}$ =	33.54102					
11							
12							

B10 = sqrt(B8*B9)

Computers, Software, and Spreadsheets

- Spreadsheet Calculations
  - EXAMPLE: Volume of a Cylinder
    - Input
      - Diameter, *D*
      - Height, *h*
    - Computation

$$V = \left(\frac{\pi D^2}{4}\right) \times h$$

    - Output
      - Volume, *V*

Computers, Software, and Spreadsheets

- Spreadsheet (Example)

B5 = B3 + B4

	A	B	C	D	E	F	I
1							
2				Volume of Cylinder:			
3	X =	10		*D* =	20	in	
4	Y =	13.5		*h* =	76	in	
5	Sum =	23.5		Volume =	23876.1	in^2	
6							
7							
8	u =	45					
9	v =	25					
10	$\sqrt{uv}$ =	33.54102					
11							
12							

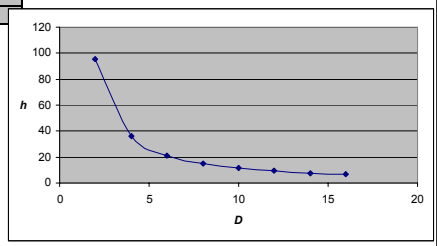
B10 = sqrt(B8*B9)

(PI()*E3^2/4)*E4

Computers, Software, and Spreadsheets

- Spreadsheet Calculations

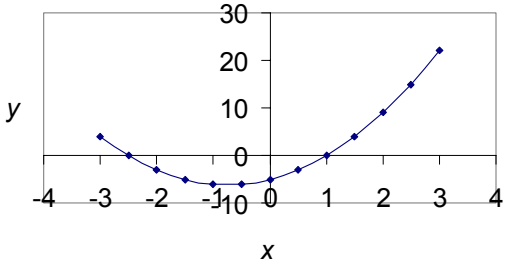
	A	B	C	D	E
1					
2		Diameter, *D*	Volume, *V*	Calculated Height, *h*	
3		2	300	*95.49296586*	
4		4	450	*35.8098622*	
5		6	600	*21.22065908*	
6		8	750	*14.92077591*	
7		10	900	*11.4591559*	
8		12	1050	*9.284038347*	
9		14	1200	*7.795344151*	
10		16	1350	*6.714349162*	
11					
12					



Computers, Software, and Spreadsheets

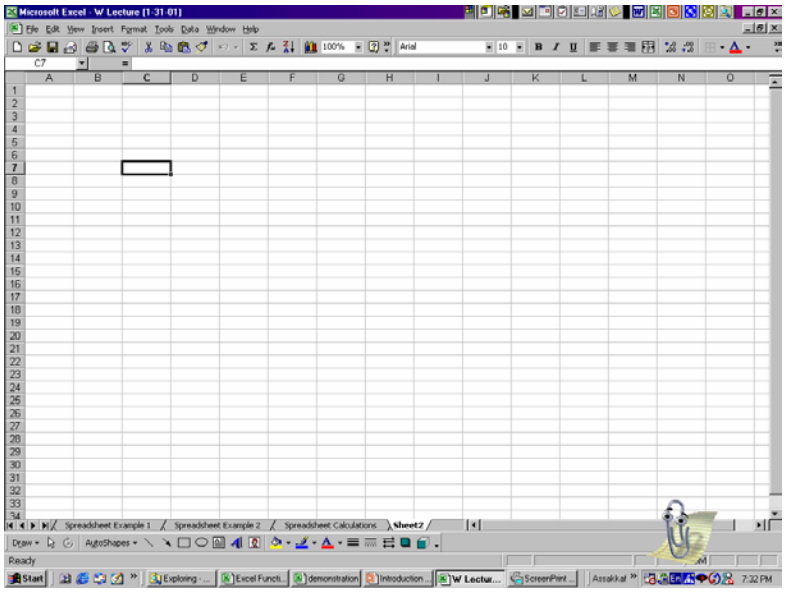
- Spreadsheet & Numerical Solutions

x	*y*
-3	4
-2.5	**0**
-2	-3
-1.5	-5
-1	-6
-0.5	-6
0	-5
0.5	-3
1	**0**
1.5	4
2	9
2.5	15
3	22



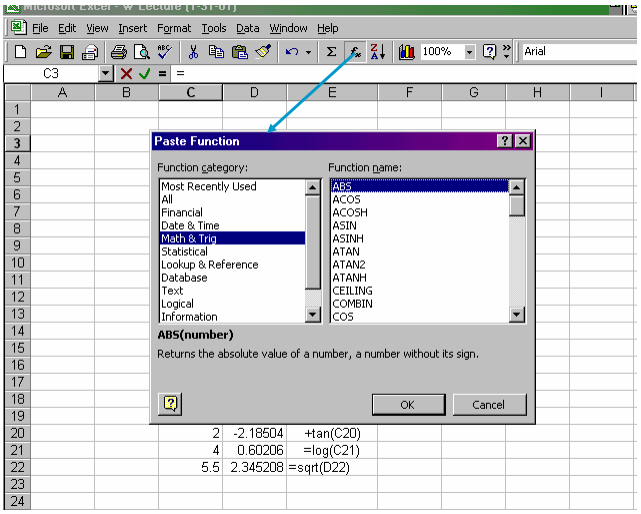
$$y = 2x^2 + 3x - 5 = 0$$

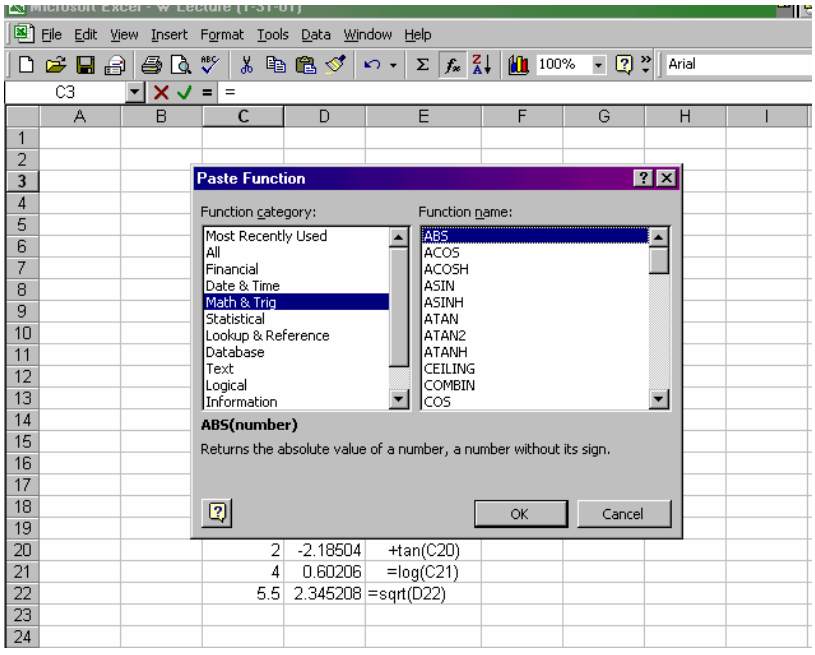
Introduction to Microsoft Excel



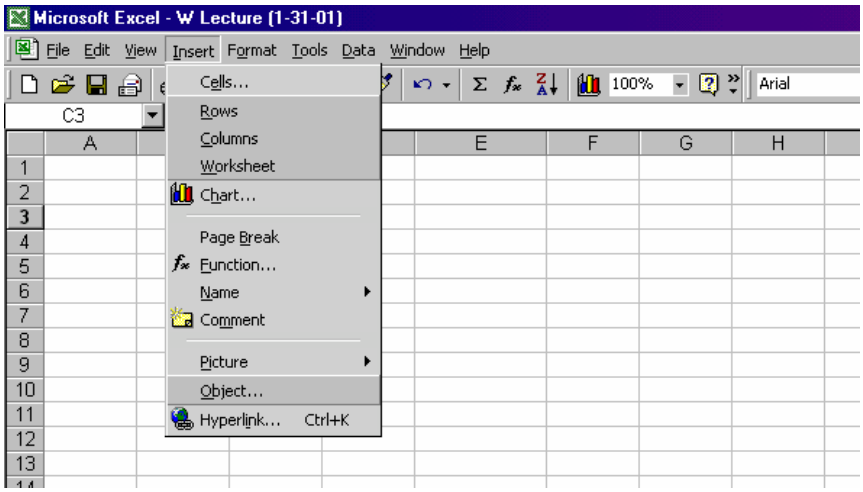
Introduction to Microsoft Excel

MS Excel Math and Trig. functions

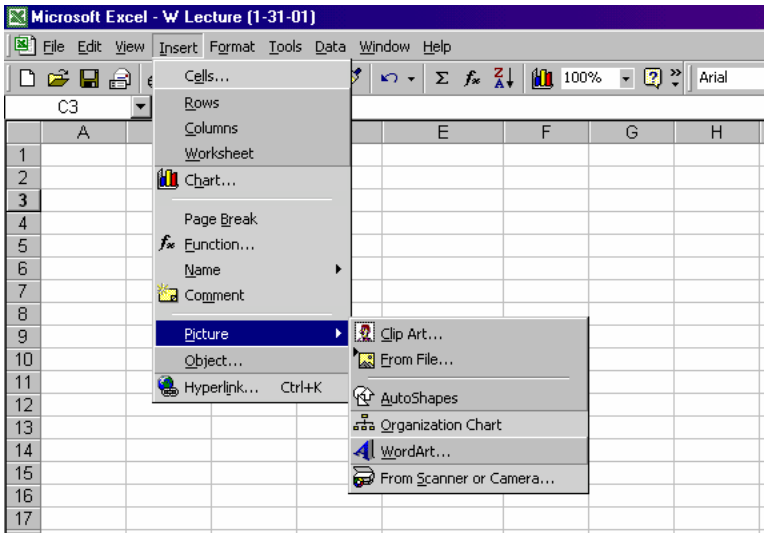




Introduction to Microsoft Excel



Introduction to Microsoft Excel



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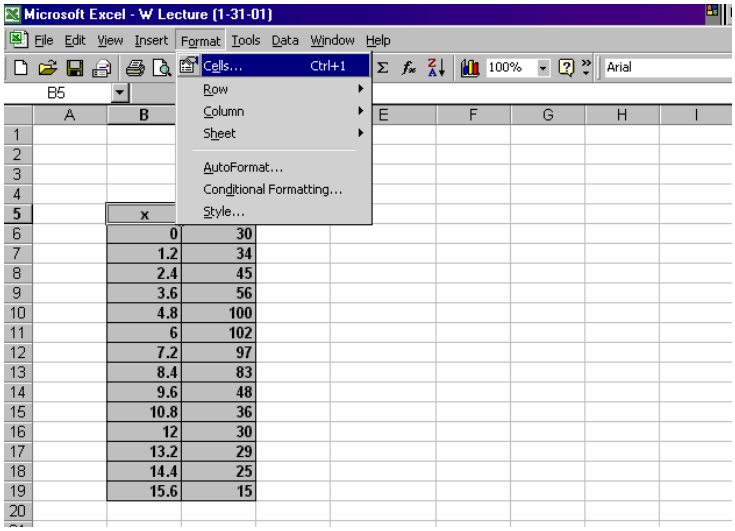
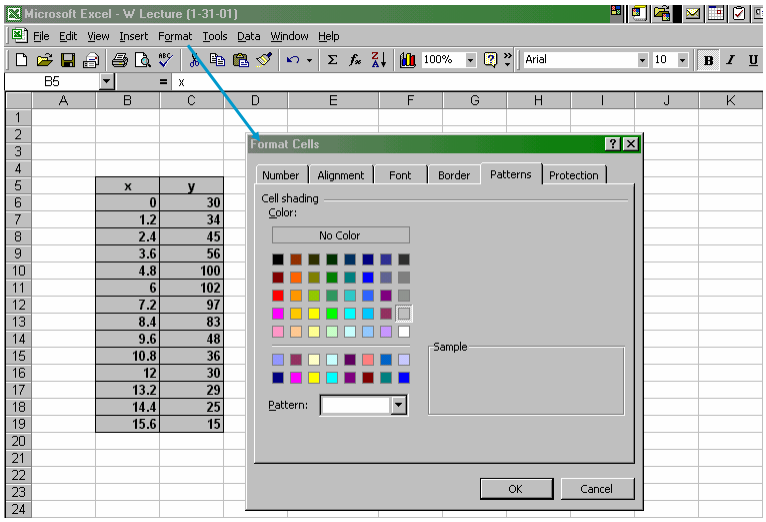
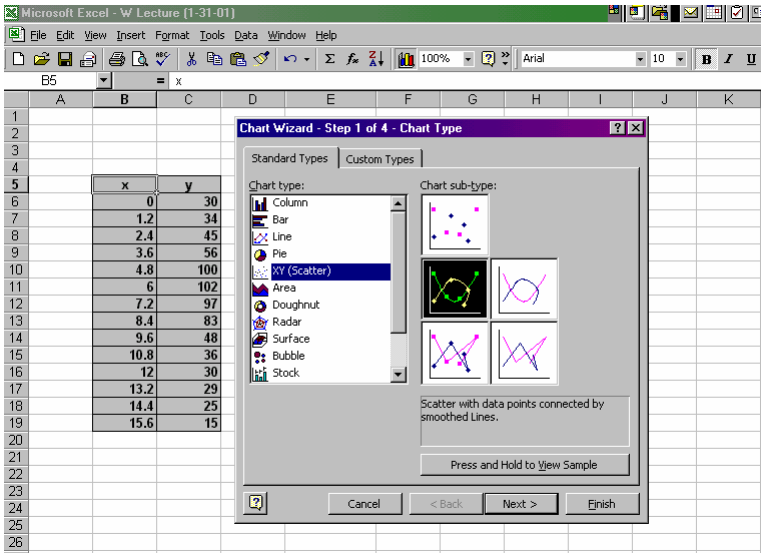


Introduction to Microsoft Excel



x	y
0	30
1.2	34
2.4	45
3.6	56
4.8	100
6	102
7.2	97
8.4	83
9.6	48
10.8	36
12	30
13.2	29
14.4	25
15.6	15

Introduction to Microsoft Excel



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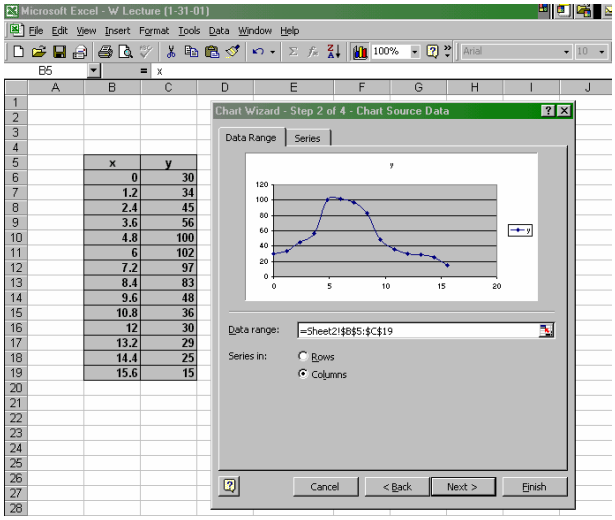

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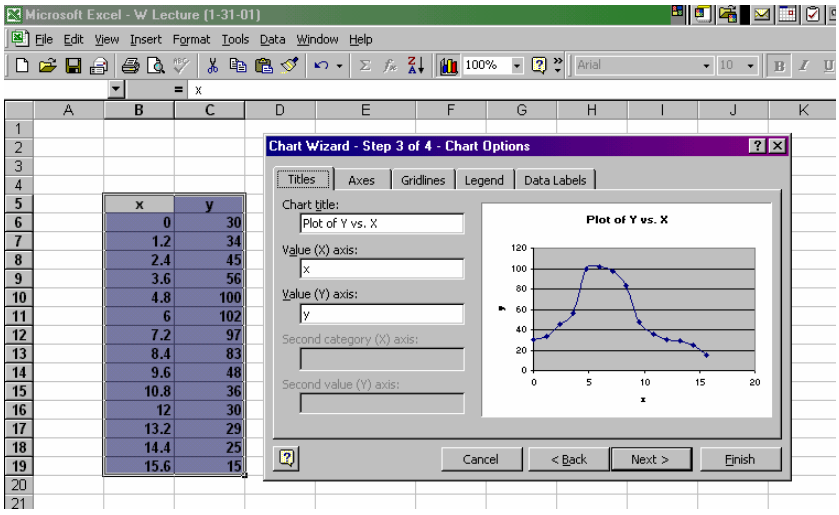

x	y
0	30
1.2	34
2.4	45
3.6	56
4.8	100
6	102
7.2	97
8.4	83
9.6	48
10.8	36
12	30
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14.4	25
15.6	15

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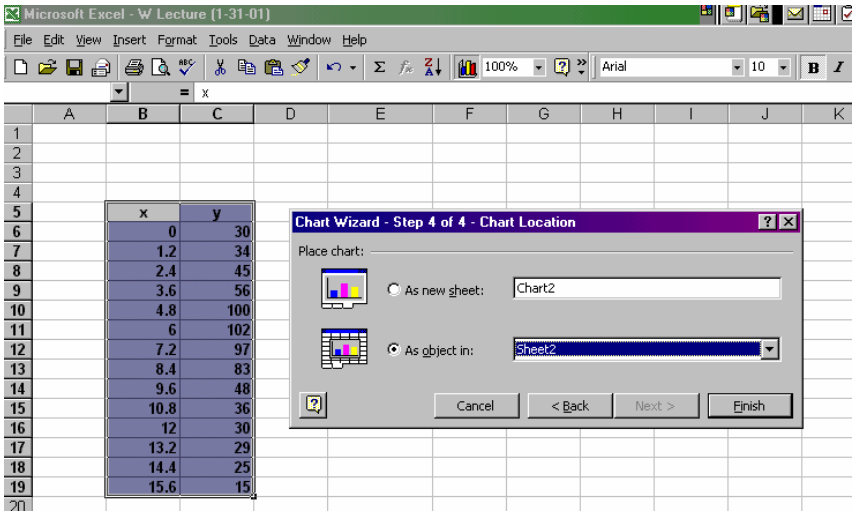
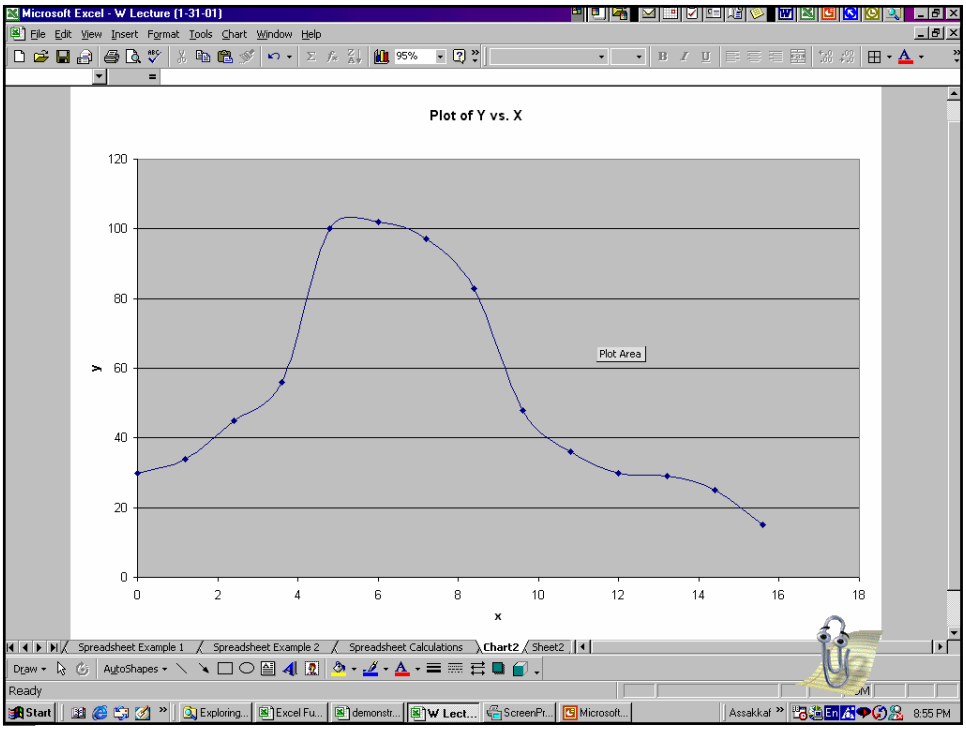




Introduction to Microsoft Excel

Microsoft Excel - W Lecture (1-31-01)

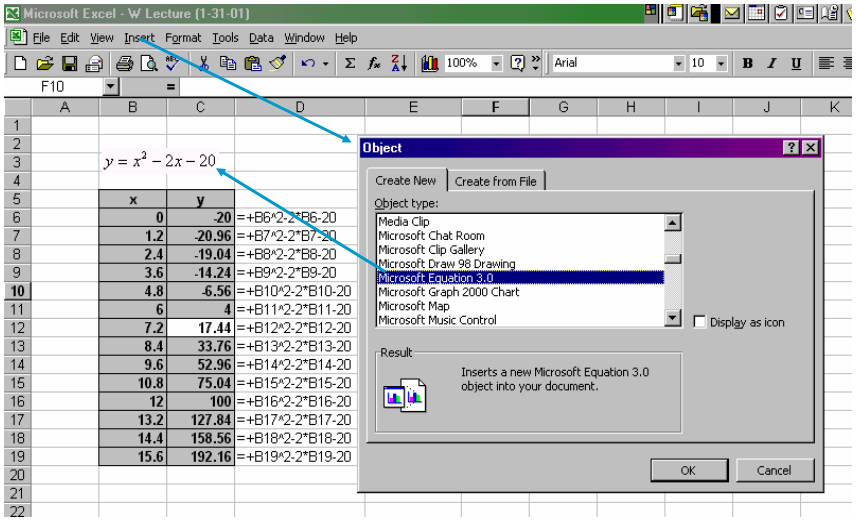
File Edit View Insert Format Tools Data Window Help

C12 = =+B12^2-2*B12-20

$y = x^2 - 2x - 20$

	x	y	
6	0	-20	=+B6^2-2*B6-20
7	1.2	-20.96	=+B7^2-2*B7-20
8	2.4	-19.04	=+B8^2-2*B8-20
9	3.6	-14.24	=+B9^2-2*B9-20
10	4.8	-6.56	=+B10^2-2*B10-20
11	6	4	=+B11^2-2*B11-20
12	7.2	17.44	=+B12^2-2*B12-20
13	8.4	33.76	=+B13^2-2*B13-20
14	9.6	52.96	=+B14^2-2*B14-20
15	10.8	75.04	=+B15^2-2*B15-20
16	12	100	=+B16^2-2*B16-20
17	13.2	127.84	=+B17^2-2*B17-20
18	14.4	158.56	=+B18^2-2*B18-20
19	15.6	192.16	=+B19^2-2*B19-20

Introduction to Microsoft Excel



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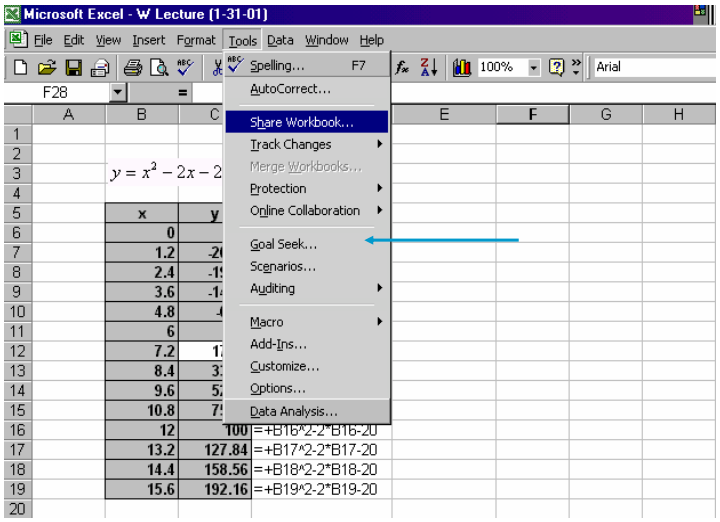

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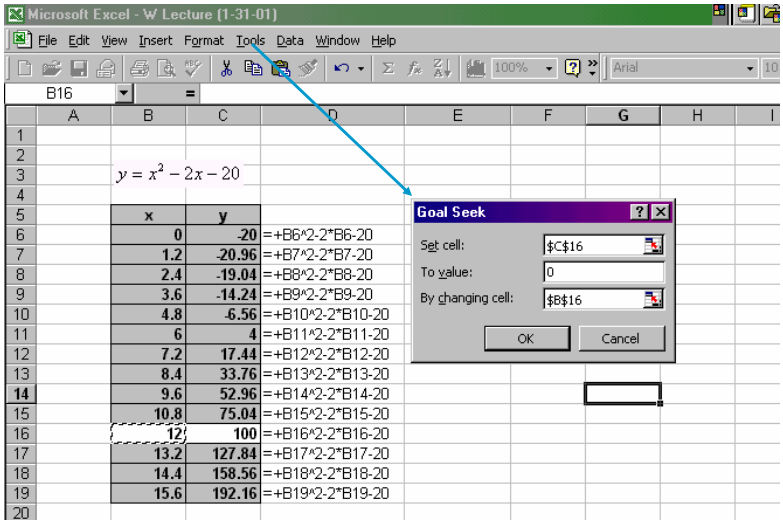

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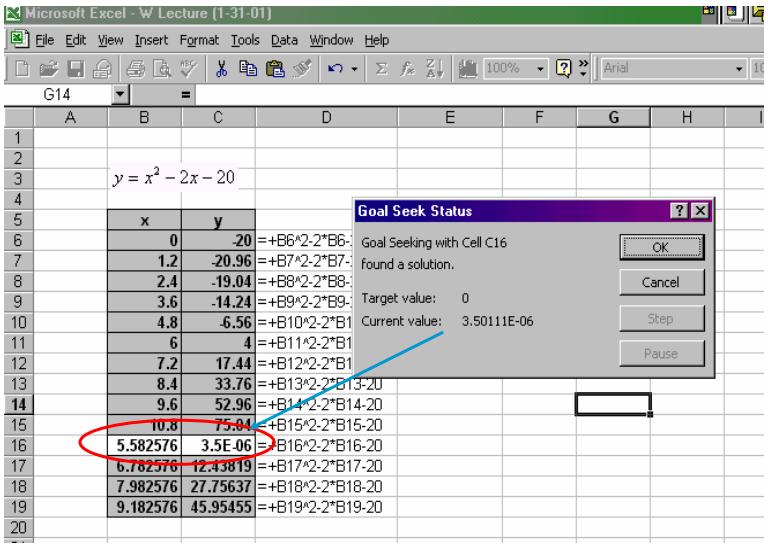
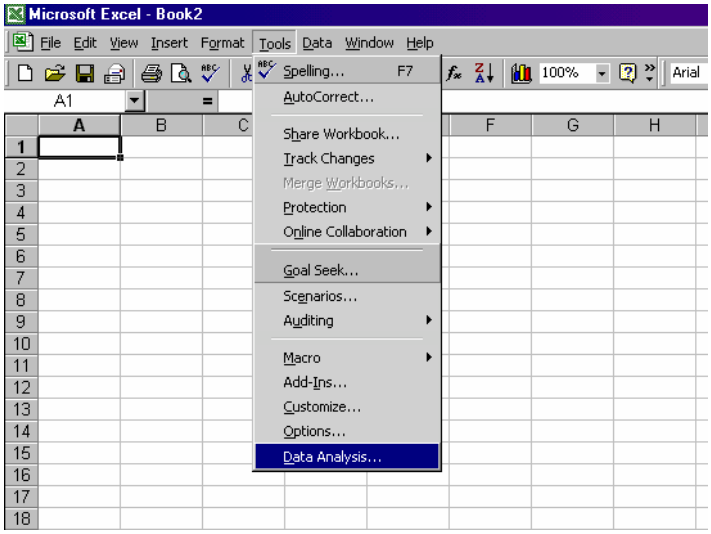
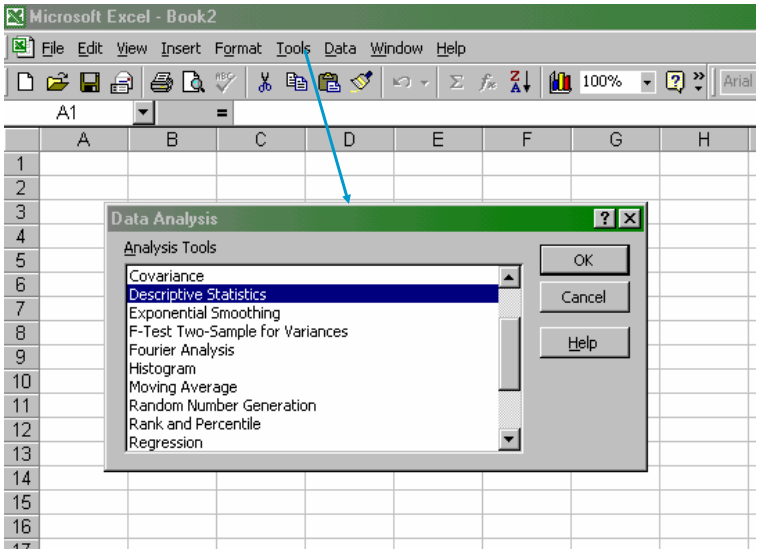


Data Analysis Tools in Excel



Data Analysis Tools in Excel



Data Analysis Tools in Excel

A. Data Analysis Tools

If the Data Analysis Tools is not already installed, you have to install as follows:

1. Place the cursor on "Tools", and click
2. Select "Adds-In", you'll be prompted with a set of available tools (see Figure 1)
3. Check the "Analysis ToolPak" box
4. Hit "OK"
5. The "Data Analysis" Pak will be installed automatically.
6. To verify that the "Data Analysis" has been installed", move the cursor to "Tools"

If you see "Data Analysis" in the menu, this means that the ToolPak has been successfully installed.

Data Analysis Tools in Excel

B. Descriptive Measures (i.e., mean, COV, etc.)

1. Input your data either column-wise or row-wise.
2. Go to "Tools".
3. Choose "Data Analysis", you'll be prompted with a set of tools.
4. Check the "Descriptive Statistics" box, you'll be prompted with a dialogue box as shown in Figure 2.
5. In the "Input range" Entry box, provide the range of your data (e.g., A3:A89).
6. In the "New Worksheet Ply" entry box, provide a descriptive name of your sheet that will contain your output.
7. Check the "Summary Statistics" box.
8. Click "OK".

Your statistical output will be given in a new worksheet under the name you have provided.

Data Analysis Tools in Excel

C. Histograms

1. First you have to input your data in two columns, one for the actual or measured data, and the other for the "Bin" (intervals). You need to know the range of your data, number of intervals, and interval width to construct your Bin column as explained in class (i.e., $k = 1+3.3\log_{10}(n)$).
2. Go to "Tools" and click "Data Analysis", you'll be prompted with a set of tools.
3. Check the "Histogram" box. You'll be prompted with a dialogue box as shown in Figure 3.

Data Analysis Tools in Excel

Microsoft Excel - Lecture 3

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G9

	A	B	C	D	E	F	G	H	I	J
1	**Example: how to compute descriptive statistics using excel functions**									
2		**"Commute times from home to work"**								
3	**Commute Times (in hours)**									
4	0.5	0.6	0.9	0.4						
5	0.9	0.4	1	1.3						
6	0.2	0.8	0.7	0.7						
7	0.4	1.1	0.3	0.6						
8	0.7	0.9	0.6	1						
9	1.2	0.3	1.1	0.8						
10	1.1	0.4	0.7	0.4						
11	0.7	1	1.1	0.9						
12										
13	**Central Tendency Measures:**				**Excel Function**					
14		Mean =	0.740625		=AVERAGE(A4:D11)					
15		Median =	0.7		=MEDIAN(A4:D11					
16		Mode =	0.4		=MODE(A4:D11)					
17	**Dispersion Measures:**									
18		Variance =	0.088296		=VAR(A4:D11)					
19		Standard Deviation =	0.297147		=STDEV(A4:D11)					
20		COV =	0.401211		=C19/C14					
21	**Others:**									
22		Minimum =	0.2		=MIN(A4:D11)					
23		Maximum =	1.3		=MAX(A4:D11)					
24		Count =	32		=COUNT(A4:D11)					
25		Sum =	23.7		=SUM(A4:D11)					
26		Range =	1.1		=C23-C22					
27										

Data Analysis Tools in Excel

Microsoft Excel - Lecture 3

File Edit View Insert Format Tools Data Window Help

G6

	A	B	C	D	E	F	G	H	I	J	K	L
1	**Example: how to compute descriptive statistics using Excel Data Analysis Tools**											
2		**"Commute times from home to work"**										
3	**Commute Times (in hours)**											
4	0.5	0.6	0.9	0.4								
5	0.9	0.4	1	1.3								
6	0.2	0.8	0.7	0.7								
7	0.4	1.1	0.3	0.6								
8	0.7	0.9	0.6	1								
9	1.2	0.3	1.1	0.8								
10	1.1	0.4	0.7	0.4								
11	0.7	1	1.1	0.9								
12												
13	**Central Tendency Measures:**											
14		Mean =	0.740625									
15		Median =	0.7									
16		Mode =	0.4									
17	**Dispersion Measures:**											
18		Variance =	0.088296									
19		Standard Deviation =	0.297147									
20		COV =	0.401211									
21	**Others:**											
22		Minimum =	0.2									
23		Maximum =	1.3									
24		Count =	32		=COUNT(A4:D11)							
25		Sum =	23.7		=SUM(A4:D11)							
26		Range =	1.1		=C23-C22							
27												

Descriptive Statistics

Input

Input Range: $A$4:$D$11

Grouped By: Columns / Rows

Labels in First Row

OK

Cancel

Help

Output options

Output Range:

New Worksheet Ply: Statistics

New Workbook

Summary statistics

Confidence Level for Mean: 95 %

Kth Largest: 1

Kth Smallest: 1

Data Analysis Tools in Excel

Microsoft Excel - Lecture 3

File Edit View Insert Format Tools Data Window Help

A1 = Column1

	A	B	C	D	E	F	G	H	I	J
1	*Column1*		*Column2*		*Column3*		*Column4*			
2										
3	Mean	0.7125	Mean	0.6875	Mean	0.8	Mean	0.7625		
4	Standard E	0.121652	Standard E	0.107633	Standard E	0.098198	Standard E	0.1084592		
5	Median	0.7	Median	0.7	Median	0.8	Median	0.75		
6	Mode	0.7	Mode	0.4	Mode	0.7	Mode	0.4		
7	Standard D	0.344083	Standard D	0.304432	Standard D	0.277746	Standard D	0.3067689		
8	Sample Va	0.118393	Sample Va	0.092679	Sample Va	0.077143	Sample Va	0.0941071		
9	Kurtosis	-0.96611	Kurtosis	-1.82806	Kurtosis	-0.1642	Kurtosis	-0.1669944		
10	Skewness	0.027616	Skewness	0.036076	Skewness	-0.64007	Skewness	0.4719572		
11	Range	1	Range	0.8	Range	0.8	Range	0.9		
12	Minimum	0.2	Minimum	0.3	Minimum	0.3	Minimum	0.4		
13	Maximum	1.2	Maximum	1.1	Maximum	1.1	Maximum	1.3		
14	Sum	5.7	Sum	5.5	Sum	6.4	Sum	6.1		
15	Count	8	Count	8	Count	8	Count	8		
16										
17										
18										
19										
20										

Palisade's DecisionTools

- Will see in this course, a variety of techniques and applications relevant to decision making in engineering and financial settings.
- Palisade DecisionTools work as one program within Microsoft Excel.
- To help us with Decision Analysis, we have the following software packages:

Palisade's DecisionTools

Decision Tools Program	Where used in the Decision Process	Where in the Text
Precision Tree	Structuring the decision Solving the decision Sensitivity analysis Value of information Modeling preferences	Chapter 3 Chapter 4 Chapter 5 Chapter 12 Chapter 13
Top Rank	Sensitivity analysis	Chapter 5
Risk View	Modeling uncertainty	Chapter 8 & 9
Best Fit	Using data to model uncertainty	Chapter 10
@Risk	Simulation Modeling	Chapter 11

Central Questions

- What is decision analysis?
- What makes a decision hard?
- Why is it useful?
- How can I apply it?

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck

	Sample 1	Sample 2
	3250	3650
	3610	3360
	3460	3328
	3380	3420
	3510	3260
Mean	**3442**	**3404**
StDev	**135.9**	**149.3**

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck

  Assume that the building code requires a mean compressive strength of **3500 psi**.

  Since the mean of 3442 psi of Sample1 is less than 3500 psi

  Should we conclude that the garage deck does not meet the specifications?

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck
  - Unfortunately, decision making is not that simple.
  - If a third sample of 5 measurements had been randomly collected from other locations on the garage deck, the following values as just likely to have been obtained:

    3720, 3440, 3590, 3270, and 3610 psi.
  - This sample would have different mean and different standard deviation as shown next.

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck

	Sample 1	Sample 2	Sample 3
	3250	3650	3720
	3610	3360	3440
	3460	3328	3590
	3380	3420	3270
	3510	3260	2610
Mean	**3442**	**3404**	**3526**
StDev	**135.9**	**149.3**	**174.4**

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck
  - The third sample (Sample 3) produces a mean of 3526 psi and standard deviation of 174.4 psi.
  - In this case, the mean value is greater than the specified value. The question now arises:
  - **Can we conclude that the concrete is of adequate strength?**
  - **Unfortunately**, we cannot conclude with certainty that the strength is adequate.

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck
  - " The fact that different samples lead to different means is an indication that we cannot conclude that the design specification is not met just because the sample mean is less than the design standard."

Motivation: Making Hard Decision

- Example: Strength of Concrete (psi) in a Parking Garage Deck
  - A systematic decision process is needed to take into account the variation that can be expected from one sample to another.
  - The decision process must also capable to reflect the ***risk*** of making incorrect decision.
  - This decision making can be made using techniques used in this course.

Quick Review on Decision-Analysis & Decision-Making

- What is Decision Analysis?
- Areas of Application in Real Life
- Nature of Project/Organizational Problems
- Problem Solving & Decision-Making and their Relationship
- Definition of Decision-Making
- Structuring & Analyzing The Decision Problem
- The Decision Analysis Flow Chart

What is Decision Analysis?

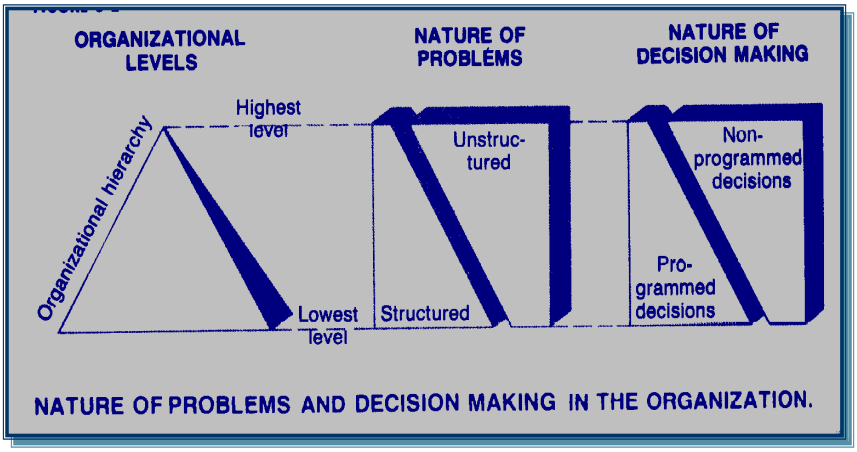
- Definition

  "Decision Analysis is an analytic and systematic approach to studying decision making."

Areas of Application in Real Life

- Decision analysis can be used in many various applications in real life.
- It is used to determine optimal strategies when a decision maker is faced with several decision alternatives and an uncertain or risk-filled pattern of future events.

Nature of Project/Organizational Problems



Types of Organization Decisions and Management Levels

Problem Solving and Decision-Making

- Problem Solving can be defined as

"The process of identifying a difference between some actual and some desired state of affairs and then taking action to resolve the difference."

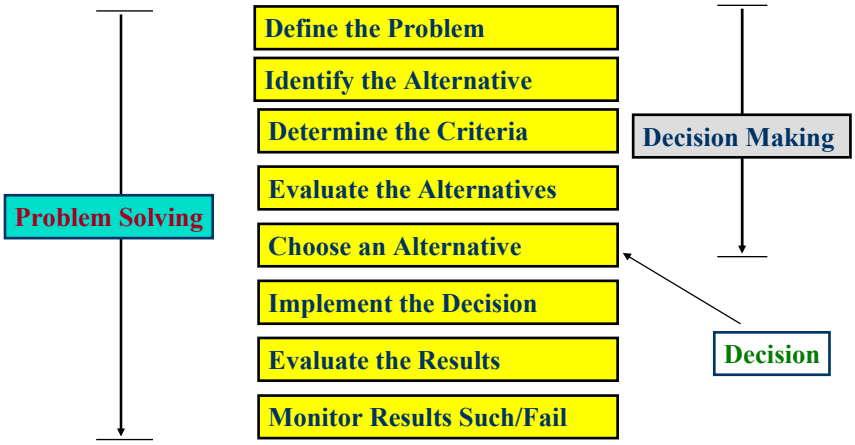
Problem Solving and Decision-Making

- The Problem-solving process involves the following eight steps:
  1. Define the Problem
  2. Identify the Alternatives
  3. Determine the Decision Criteria
  4. Evaluate the Alternatives

Problem Solving and Decision-Making

5. Choose the Alternative
6. Implement the Decision
7. Evaluate the Results
8. Monitor the success or failure of the chosen alternative

The Relationship between Problem Solving and Decision Making



Decision Making

- Definition

  "***Decision-making is defined as the Selection of a Course of Action from among Alternatives or Ventures***."

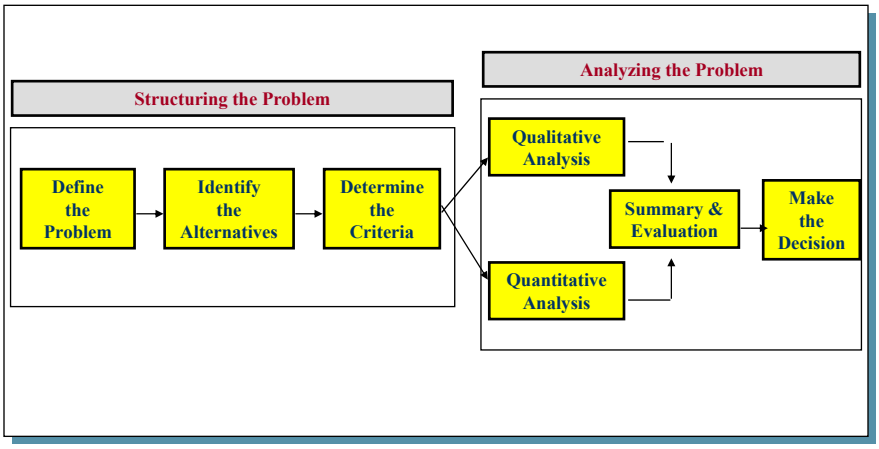
Decision Making Process

- The Decision-Making process involves the following five steps:
  - Define the Problem
  - Identify the Alternatives
  - Determine the Decision Criteria
  - Evaluate the Alternatives
  - Choose the Alternative

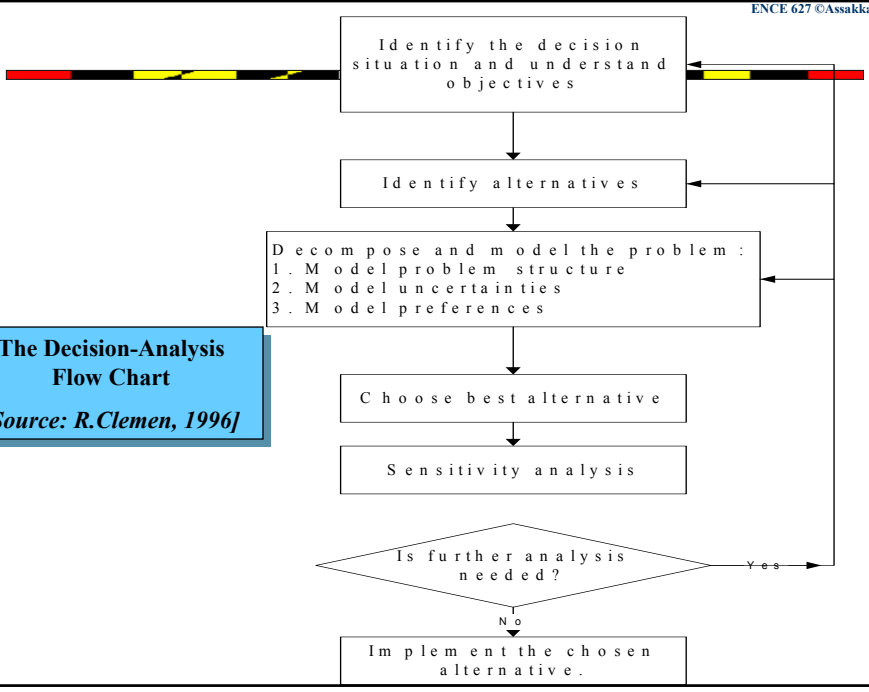
Decision-Making Types

- Decision Making
  - Simple choice between two or more alternatives
  - Statistical decision making
  - Decisions under uncertainty
  - Consequences
  - Past, present and future >> forecasting
- Decision Maker >> subjectivity

Structuring and Analyzing the Decision Problem

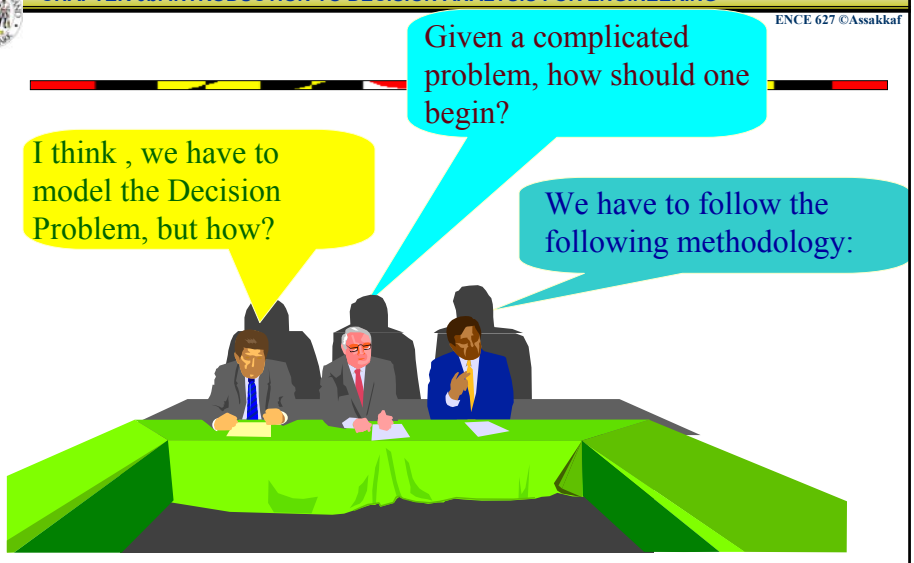


The Role of Qualitative and Quantitative Analysis



The Decision-Analysis Flow Chart

[Source: R.Clemen, 1996]



Methodology for Modeling Uncertainties

The Methodology of Modeling Uncertainty is described in five chapters that mainly concentrating on how to model uncertainty using probabilities and information as follows:

- Probability Basics: reviews fundamental probability concepts.
- Subjective probability: translates beliefs & feelings about uncertainty in probability for use in decision modeling.
- Theoretical Probability Models: helps with representing uncertainty in decision modeling
- Using Data: uses historical data for developing probability distributions
- Monte Carlo Simulation**:** to give the decision-maker a fair idea about the probabilities associated with various outcomes.
- *Value of Information***:**explores the value of information within the decision-analysis framework.

Detailed Steps

- ***Chapter 7***
- ***Chapter 8***
- ***Chapter 9***
- ***Chapter 10***
- ***Chapter 11***
- ***Chapter 12***

Methodology for Modeling Decision

The Methodology of Modeling Decisions is to:

- **Understand the problem under study**
- **Introduce quantitative modeling**
- **Discuss the elements of a decision.**
  - **Values and Objectives**
  - **Decisions to be made**
  - **Upcoming uncertain events, and**
  - **Consequences**
- **Build the decision Model and identify a set of feasible alternatives.**
- **Evaluate the alternatives and make a choice of a feasible alternative.**
- **Re-evaluate the alternatives using sensitivity analysis to refine the solution.**