TIE4203 Decision Analysis in Industrial & Operations Management
Tutorial #9

Question 1 (P9.1)

Your department wants to purchase a new personal computer. Three objectives are important in determining which computer should be purchased: Cost, user-friendliness, and software availability. The pairwise comparison matrix for these objectives is as follows:

	Cost	User-friendliness	Software availability
Cost	1	1/4	1/5
User-friendliness		1	1/2
Software availability			1

Three computers are being considered for purchase. The performance of each computer with regard to each objective is indicated by the following pairwise comparison matrices.

For Cost:

	Computer 1	Computer 2	Computer 3
Computer 1	1	3	5
Computer 2		1	2
Computer 3			1

For user-friendliness:

	Computer 1	Computer 2	Computer 3
Computer 1	1	1/3	1/2
Computer 2		1	5
Computer 3			1

For software availability:

	Computer 1	Computer 2	Computer 3
Computer 1	1	1/3	1/7
Computer 2		1	1/5
Computer 3			1

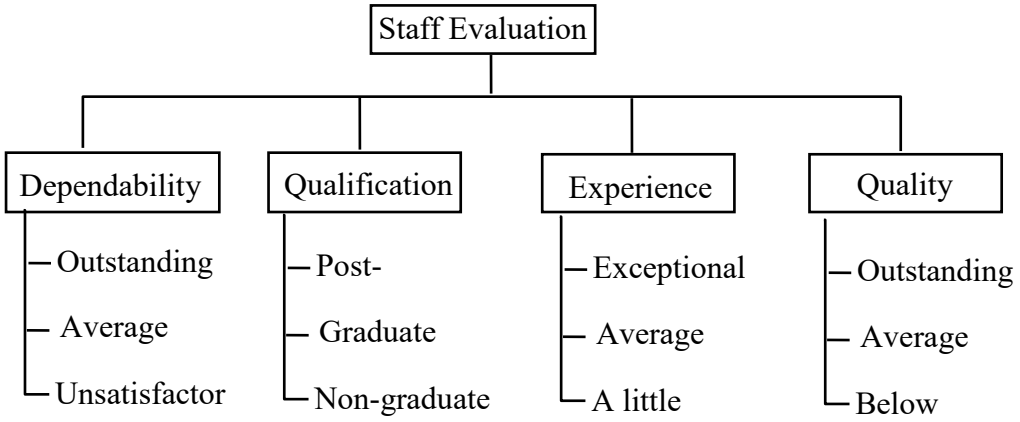
(*a*) If the AHP method is followed, which computer should be purchased?

(*b*) Check the pairwise comparison matrices for consistency.

(*c*) Does all preference relations in the pairwise matrices satisfy the transitivity property?

Question 2 (P9.2)

A company is evaluating its employees for raises and has decided on the four main criteria: Dependability, Qualification, Experience, and Quality (of work). Employees will be evaluated under each criterion using the ratings or standards as shown in the hierarchy below:



The prioritization pairwise comparison matrix for the main criteria is as follows:

	Dependability	Qualification	Experience	Quality
Dependability	1	2	3	4
Qualification		1	2	3
Experience			1	2
Quality				1

For each of the criteria, the pairwise comparison matrix for its intensities or ratings is as follows:

Dependability:

	Outstanding	Average	Unsatisfactory
Outstanding	1	3	7
Average		1	3
Unsatisfactory			1

Qualification:

	Postgraduate	Graduate	Non-graduate
Postgraduate	1	3	5
Graduate		1	3
Non-graduate			1

Experience:

	Exceptional	Average	Little
Exceptional	1	5	9
Average		1	3
Little			1

Quality:

	Outstanding	Average	Below average
Outstanding	1	5	9
Average		1	3
Below average			1

(*a*) Set up a staff evaluation system for the company using the Rating Method of AHP.

(*b*) John and Bill have been assessed by their supervisors as follows:

Employee	**Assessment for Criterion**			
	Dependability	**Qualification**	**Experience**	**Quality**
John Chen	Average	Graduate	Average	Outstanding
Bill Zhang	Outstanding	Non-graduate	Exceptional	Average

Should John be given a higher pay rise than Bill? Why?

Question 3 (P9.3)

In determining where to invest some money, two criteria – expected rate of return and degree of risk – are being considered equally important. Two investments (1 and 2) have the following pairwise comparison matrices:

Expected Return:

	Investment 1	Investment 2
Investment 1	1	1/2
Investment 2	2	1

Degree of Risk:

	Investment 1	Investment 2
Investment 1	1	3
Investment 2	1/3	1

(*a*) How should the two investments be ranked?

(*b*) Now suppose another investment (investment 3) is available. Suppose the pairwise comparison matrices for these investments are as follows:

Expected Return:

	Investment 1	Investment 2	Investment 3
Investment 1	1	1/2	4
Investment 2	2	1	8
Investment 3	1/4	1/8	1

Degree of Risk:

	Investment 1	Investment 2	Investment 3
Investment 1	1	3	1/2
Investment 2		1	1/6
Investment 3			1

How should the three investments be ranked now?

(*c*) Comment on the pairwise comparison matrices and the rankings found in Part (*a*) and Part (*b*).

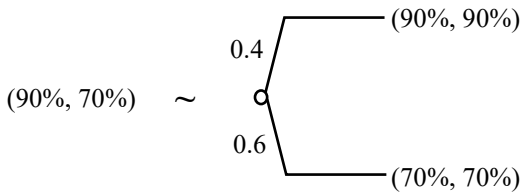
(*d*) Try the Ideal Mode of AHP and observe if rank reversal can be prevented for this problem.

Question Q4 (P10.1)

Mathematics & Science have been identified as the most important knowledge for workers in a knowledge-based economy. To give school graduates a good foundation in the two subjects, the Education Ministry is revising its method of teaching the two subjects in their primary schools. It has to make a choice between two teaching techniques and will use a two-attribute additive utility function of the form $u(x_1,x_2) = k_1\, u_1(x_1) + (1 - k_1)\, u_2(x_2)$, where $u_1(x_1)$ and $u_2(x_2)$ are single-attribute utility function for two attributes defined as follows:

- Attribute x_1: Average score of students on a Mathematics test where $70\% \le x_1 \le 90\%$.
- Attribute x_2: Average score of students on a Science test where $70\% \le x_1 \le 90\%$.

(*a*) If the Ministry is indifferent between the following deals, determine its two-attribute utility function.

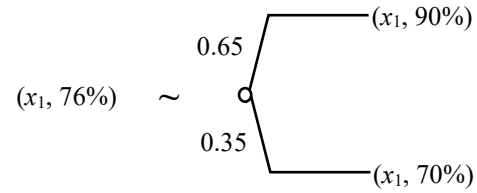


(*b*) The two alternative teaching techniques have uncertain outcomes:

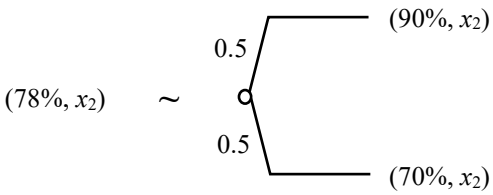
1. Teaching technique 1 is equally likely to produce either average test scores of 78% and 76% for mathematics and science respectively, or average test scores of 70% and 90% for mathematics and science respectively.

2. Teaching technique 2 has a 60% chance of achieving average test scores of 90% for both mathematics and science, and a 40% chance of achieving average test scores of 70% for both subjects.

For any value x_1 of Attribute 1, the Ministry is indifferent between



For any value x_2 of Attribute 2, the Ministry is indifferent between



Which is the best teaching technique for the Education Ministry?

Question Q5 (P10.2)

A field hospital set up for a relief operation in a remote area must determine at the beginning of each week how many pints of blood should be ordered from its home base. Any blood left over at the end of the week will be outdated and cannot be used. The field hospital considers the following two attributes of be important:

1. *Weekly blood shortage* (x_1): This is the number of pints of blood by which ordered blood falls short of the week's demand. This quantity is known to be always between 0 and 10 pints.

2. *Weekly blood outdated* (x_2): This is the number of pints of blood that are outdated. This quantity is known to be always between 0 and 10 pints.

The hospital's utility function is $u(x_1, x_2) = 0.4\,u_1(x_1) + 0.5\,u_2(x_2) + 0.1\,u_1(x_1)\,u_2(x_2)$

where $u_1(x_1) = 0.582\left[\exp(1 - \frac{x_1}{10}) - 1\right]$ and $u_2(x_2) = 1 - \frac{x_2^2}{100}$.

Suppose that each week there is a 0.5 chance that the demand for blood will be 25 pints and a 0.5 chance it will be 35 pints. Would the blood bank be better off ordering 28 pints, 30 pints, or 32 pints?

Question 6 (P10.4)

A project manager is faced with the problem of evaluating a number of alternative system designs. He has determined that the four main criteria that determine his choice are human productivity, economics, design, and operations. The pairwise comparison matrix for these four criteria is as follows:

	Human Productivity	Economics	Design	Operations
Human productivity	1	3	3	7
Economics		1	2	5
Design			1	7
Operations				1

Three alternatives are being considered. The pairwise comparison for the three alternatives with respect to each of the evaluation criteria is as follows:

For human productivity:

	System A	System B	System C
System A	1	3	5
System B		1	2
System C			1

For Economics:

	System A	System B	System C
System A	1	1/3	1/2
System B		1	3
System C			1

For Design:

	System A	System B	System C
System A	1	1/2	1/7
System B		1	1/5
System C			1

For Operation:

	System A	System B	System C
System A	1	3	1/5
System B		1	1/9
System C			1

(*a*) Use the AHP method to determine the best system based on the four criteria. Approximate computational methods may be used.

(*b*) If the equivalent uniform annual costs (EUAC) of the three alternatives over the life cycle are as given below, determine the set of efficient cost-effective alternatives. Illustrate your answers with a graphical plot.

Alternative	EUAC ($)
System A	100,000
System B	80,000
System C	110,000