

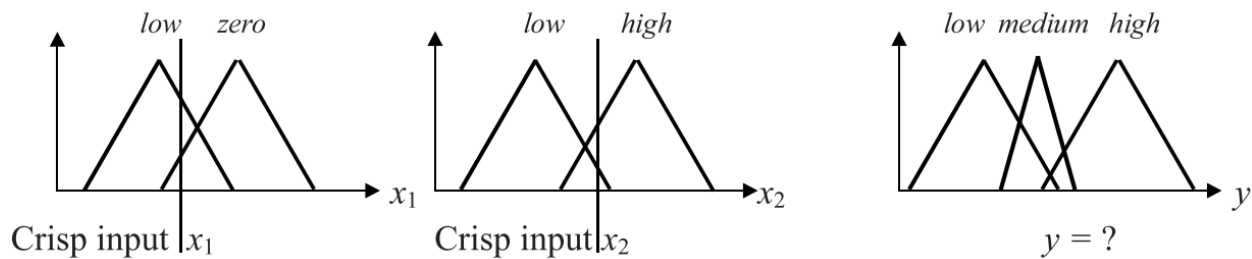
COURSE TITLE: MULTI-CRITERIA ANALYSIS IN ENGINEERING  
 DATE: 16-03-2023

TIME: 90 MINUTES  
 MAX. MARKS: 30

Note: (i) Attempt **all** questions (ii) Make necessary assumptions, if required.

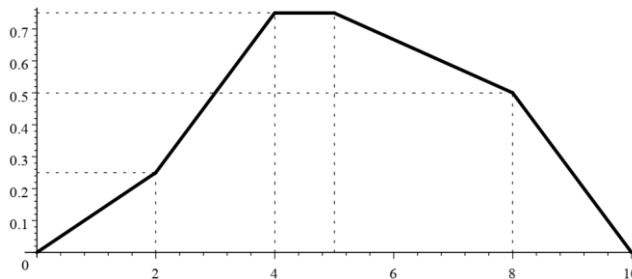
**Q.1(a)** Figure below in Q.1(a) depicts a system with two inputs (having two fuzzy sets per each input) and one output described by following four rules:

R <sub>1</sub> : IF $x_1 = \text{low}$	AND $x_2 = \text{low}$ ,	THEN $y = \text{low}$ .
R <sub>2</sub> : IF $x_1 = \text{low}$	AND $x_2 = \text{high}$ ,	THEN $y = \text{medium}$ .
R <sub>3</sub> : IF $x_1 = \text{zero}$	AND $x_2 = \text{low}$ ,	THEN $y = \text{medium}$ .
R <sub>4</sub> : IF $x_1 = \text{zero}$	OR $x_2 = \text{high}$ ,	THEN $y = \text{high}$ .



Determine and present graphically the output fuzzy set for the system by clearly showing all steps of the analysis. Also, show the approximate location of defuzzified value from the final outcome. **[7 M]**

**Q.1(b)** Defuzzify the fuzzy set expressed by following figure for Q.1(b) using centroid method. **[3 M]**



**Q2.** Water purifying machine in a city produces water for two purposes namely drinking and bathing. For drinking water production four man hours are required and for bathing water production, five man hours are required. Every week 80 man hours are available. The drinking water requires five hours of aeration tank whereas bathing water requires four hours on it. Every week 80 hours are available on aeration tank. The supply of drinking water fetches a profit of Rs.100 per litres whereas the bathing water supply fetches a profit of 60 per litres.

i. Formulate the above problem as linear programming problem. **[2 M]**

ii. The goals assigned by the decision maker and their priorities are as follows:

Priority goal 1 (P1): A profit target of Rs 1, 400; Priority goal 2 (P2): Minimum of 5 litres of bathing water needs to be produced and supplied; Priority goal 3 (P3): To avoid overtime

Formulate the above program as linear goal programming problem **[6 M]**

iii. Represent the optimal solution graphically if and only if goal 1(P1) and goal 2 (P2) is to be satisfied. Shade the feasible region in the graph. **[2 M]**

**Q.3** Himachal Pradesh State Government wishes to take advantage of the possibilities of developing tourism during all year round (snow in winter and trekking in summer, sailing, fishing, hunting, etc.) at Sholtu in Kinnaur (Himachal Pradesh), as this area is endowed with many natural features that can be exploited for tourism, as mountains, rivers, lakes and beautiful scenery. The firm is considering two types of projects (i) A project just to lodge tourists, and (ii) projects that create some additional attractions. The different projects considered are: **Project A:** Construction of hotels and entertainment facilities. This project belongs to the first type since it adds nothing; it will only try to attract people by providing lodging and entertainment opportunities, for people to rest, play, socialize and enjoy the scenery of fishing ponds, and taking advantage of already existent facilities such as walking trails, etc. **Project B:** Involves the construction of a cable car from the village to the top of a nearby mountain, which offers spectacular views, and building a restaurant at the top. This project then adds a new attraction to the area. **Project C:** Construction of a very large sporting and entertainment facility including swimming pools, climbing walls, bowling, tennis and golf courses, etc. as well as Satsang halls, and a mall. **Project D:** Construction of a Cinema complex, complemented with restaurants. **Project E:** Construction of a large mall, as well as restaurants and discos. **These projects are subject to the following conditions or criteria:**

C1: Internal Rate of Return (IRR), in percentage, which must be superior to the return that the same amount of money could yield if placed in another investment. In this respect, there were estimated scores for each project, considering the results of the respective feasibility studies and financial statements, taking into account initial investments, bank loans and interest rates, working capital, potential patronage, etc., over a 30 years' period.

C2: Net Present Value, in millions of Rupees, considering the same period; scores were obtained as above.

C3: Payback period, which is the estimate of number of years for initial disbursements recovery, with information also from financial statements.

C4: Environmental disturbance. This is a serious matter due to environmentalists' movement against the project and regulations from the Ministry of the Environment. There is an agreement about scores, which values come from consultations on the impact of each alternative, surveys and polls, and discussions with environmental authorities. However, the Ministry of the Environment demands additional work to compensate for the damage that the undertaking – whatever it might be – will produce. This additional cost is already included in the budget.

Weights assigned to each of these criteria come from the DM and his team. Table 2 reflects these initial conditions.

Table 2: Decision matrix for the evaluation

Criteria→	C <sub>1</sub>	C <sub>2</sub>	C <sub>3</sub>	C <sub>4</sub>
Criteria Weights→	1.0	1.0	1.0	1.0
Action →	Max	Max	Min	Min
Alternatives ↓				
Construction of hotel and entertainment facilities (A)	7.5	8.09	6.5	7
Construction of a cable car and a restaurant at the top of the mountain (B)	6.9	8.54	7.1	6
Construction of a large sporting facility including swimming pools, etc. (C)	8.2	9.01	6.6	6
Construction of a cinema complex (D)	7	6.9	9	8.5
Construction of large mall (E)	8.2	7.4	5	8.5

**Answer the following:**

- Based on above payoff matrix, compute the ranking pattern using Simple Additive Weighting (SAW).
- How would you analyze above problem using PROMTHEE-2 method? Explain point wise. No need of any calculation.

**[10.0 M]**

-----GOOD LUCK-----