BIRLA INSTITUTE OF TECHNOLOGY AND SCIENCE, PILANI-PILANI CAMPUS
SECOND SEMESTER 2022-2023
COMPREHENSIVE EXAMINATION (OPEN BOOK/NOTES)

COURSE NO.: CE G516 TIME: 3 Hours
COURSE TITLE: Multi-Criteria Analysis in Engineering
DATE: 15/05/2023 MAX. MARKS: 40%

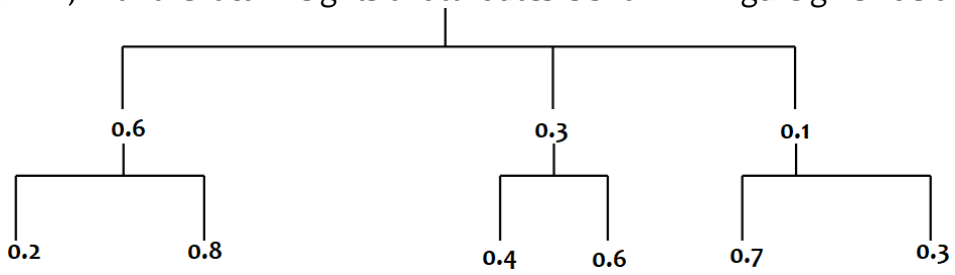
Note: (i) Attempt **any 5 questions**.
(ii) Make necessary assumptions, if required.
(iii) **Laptop is allowed but you must not access internet.**

Q.1 A construction company has four large bulldozers located at four different garages. The bulldozers are to be moved to four different construction sites. The distances in kilometers between the bulldozers and construction sites are given in Table below.

Contractor	Construction site			
	I	II	III	IV
Bulldozer 1	90	75	75	80
Bulldozer 2	35	85	55	65
Bulldozer 3	125	95	90	105
Bulldozer 4	45	110	95	115

To ensure that each Bulldozer should be deployed for only one of the construction sites, the construction company must assign only one Bulldozer to one of the construction sites. How should the bulldozers be moved to the construction sites in order to minimize the total distance traveled? [8.0 M]

Q.2 A hierarchy (containing only the attributes for this problem, not the alternative solutions) for the AHP, with the local weights of attributes is shown in Figure given below:



Also assume that two alternatives are being considered, and that the local weights for each of these alternatives for each of the six lowest level attributes, from left to right, are given by:

Alternative 1	0.7	0.4	0.8	0.4	0.2	0.2
Alternative 2	0.3	0.6	0.2	0.6	0.8	0.8

Rank the two alternatives by computing their respective global scores. [5.0 M]

(b) What do you understand by the Principal Component analysis? What would be your methodology to get solution using this approach? [3.0 M]

Q.3 A maximization function is given as $y = f(x) = \sqrt{x}$ where x is permitted to vary between 1 and 16, i.e., $1 \le x \le 16$. If following binary-strings are the members of initial population (of size 6) are created at random as given below, answer the following:

Sr. No.	*x* (Binary)
1	100101
2	011010
3	010110
4	111010
5	101100
6	001101

(a) Write down the standard fitness function and calculate the Fitness of each population member

(b) How would you select mating pool for the above problem using Roulette wheel selection method?

(c) Perform crossover operation with single-point cross over to produce new offsting of the above example by assuming cross-over probability as 1.0. Assume any other data, if required.

(d) Perform mutation operation by assuming mutation probability as 0.03.

(Note: Please perform only one generation of the GA-run. Assume any other data suitably, if required.). [8.0 M]

Q.4 An organisation has four Decision Making Units (DMUs) producing a single product using two inputs. The table below shows the number of units of each input used per unit of output by each DMU.

Units of Input per unit of output

Description	A	B	C	D
DMU	1	2	3	4
Input 1	2	4	2	1
Input 2	3	1	2	4

The DMUs operate in a technology in which if Xl and X2 denote respectively the amount of input I and 2 used then one unit of output can be secured so long as a minimum of one unit of each input is used and the input levels satisfY the expression 1.2X1 + X2 ≥ 3. Answer the following by showing necessary calculations using above data:

(a) Draw the space of feasible input levels for securing a unit of output. Identify the boundary of the space and comment on the boundary's peculiarities, if any.

(b) Using the graph compute the technical input efficiencies of the DMUs.

(c) Inputs I and 2 cost $6 and $4 per unit respectively. Compute the input allocative and the input overall efficiency of DMU 3. **[8.0 M]**

Q.5 The Civil Engineering Department of BITS Pilani has interviewed five doctoral candidates for a faculty position and has rated them on a scale of 1–10 (with 10 being the best and 1 being the worst) on three key criteria research contribution, teaching ability, and service length. The criteria values of the candidates are given in Table below.

	Criteria		
	Research Contribution (R)	Teaching Ability (T)	Service length Experience (S)
Candidate 1	8	4	3
Candidate 2	4	5	3
Candidate 3	6	6	5
Candidate 4	2	8	4
Candidate 5	7	3	2

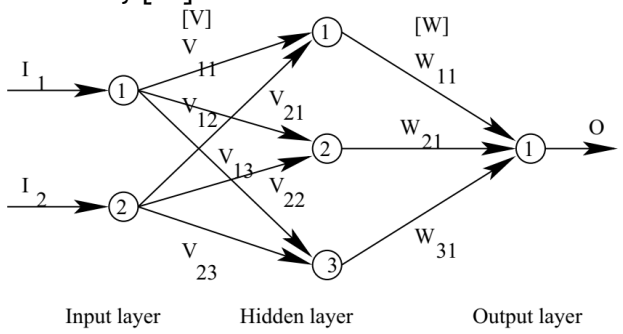
Answer the following by showing necessary calculations using above data:

(a) Determine the ideal solution to this problem. Is the ideal solution achievable? Discuss.

(b) Identify the dominated and non-dominated candidates.

(c) If the weights for research contribution, teaching ability, and service length are 0.45, 0.35 and 0.20, respectively, determine the best candidate(s) using different social choice methods viz. (i) Plurality voting (ii) Borda Count (iii) Hare System.

Q.6 Figure shows the schematic view of an neural networks consisting of three layers, such as input, hidden and output layers. The neurons lying on the input, hidden and output layers have the transfer functions represented by y = x, $y = \frac{1}{1+e^{-x}}$, $y = \frac{e^{x}- e^{-x}}{e^{x}+e^{-x}}$, respectively. There are two inputs, namely I1 and I2 and one output, that is, O. The connecting weights between the input and hidden layers are represented by [V] and those between the hidden and output layers are denoted by [W].



The initial values of the weights are assumed to be as follows:

Weights	V_{11}	V_{12}	V_{13}	V_{21}	V_{22}	V_{23}	W_{11}	W_{21}	W_{31}
Initial values	0.2	0.4	0.3	0.1	0.6	0.5	0.1	0.2	0.1

Using an incremental mode of training for the case shown in Table below, calculate the changes in V (that is, ΔV) and W (that is, ΔW) values during back-propagation of error, The learning rate η is assumed to be equal to 0.2. Show only one iteration.

S. No.	I_1	I_2	T_o
1	0.5	-0.4	0.15
2	-	-	-
⋮	⋮	⋮	⋮

---WISH YOU ALL THE BEST---