

Department of Civil Engineering  
CEL 886: Environmental Systems Analysis (1<sup>st</sup> Semester 2006-07)  
Major Exam      Max Marks- 25      Time – 2 hrs  
Note: Assume missing data (if any) and mention the same.

1. A fertilizer industry has conducted a study of its manufacturing operations with the goal of reducing liquid and solid waste production. The plant produces Urea, Di-Ammonium Phosphate (DAP) and NPK. The selling cost are Rs 4830.00, Rs 9350.00 and Rs 8360.00 for per ton of Urea, DAP and NPK respectively. These three products produce the varying amount of waste

Product	Liquid Waste (m <sup>3</sup> /ton)	Solid Waste (kg/ton)
Urea	2.0	5.0
DAP	1.5	6.0
NPK	2.6	4.8

The minimum target for production of these products are 5000, 4000 and 4350 tons per day for urea, DAP and NPK respectively. However, under pollution control strategy the management decides to limit the discharges of 70000m<sup>3</sup>/day for liquid waste and 30000kg/day for solid waste. Formulate a LP for optimal production and also write it's dual. [6]

2. An industrial development corporation wishes to zone 60 ha of currently vacant land. Zoning is to be done in 10 ha units. Concerned with both possible tax revenues and costs of providing services, the corporation has hired a consultant to determine net tax revenues (tax payments minus costs of municipal services) from three possible development options: commercial, heavy industries and software park. Net tax revenues from these options are in Rs 1000 /year as follows

Commercial	Heavy industries	Software park
$6A^{0.6}$	$A^{1.1}$	$50[1-\exp(-A/15)]$

Where in each case A is the area of land (ha) devoted to the land use. How should the municipality zone the 60 ha in order to maximize the tax revenues? It is suggested to use Dynamic Programming to find the solution. [12]

3. Three alternative plans have been developed for the expansion of a city's water supply system over the next 15 years. Plan A has an initial cost of Rs 14 crore and O&M costs of Rs 12 lakh /year. There is no salvage value at the end of 15<sup>th</sup> year. Plan B involves a phased capacity expansion. The initial cost is Rs 10 crore and O&M cost Rs 1.2 crore /year in 10 years. A subsequent Rs 10 crore expansion is made at the end of year 10, and total O&M costs for year 11 to 15 are Rs 2.00 crore. Plan B produces a salvage value of Rs 30 lakh at the end of year 15. Plan C is the most complicated of the three alternatives. Initial cost is Rs 7.00 crore and subsequent expansion costing Rs 9.00 crore and Rs 8.00 crore are made at the end of years 5 and 10, respectively. Annual O&M costs are Rs 5.00 lakh, Rs 9.00 lakh and Rs 25 lakh in years 1 to 5, 6 to 10, and 11 to 15, respectively. Salvage value at the end of year 15 is Rs 40.00 lakh. Compute the present value costs and equivalent annual costs for these three plans using 5 % interest rate. Show that interest rates of 10 and 15 % will change the relative ranking of three plans. [7]