

Concordia University
Department of Building, Civil and Environmental Engineering
Civil Engineering Systems (CIVI-341) Winter – 2011

FINAL

[50 marks in total]

Instructor: Dr. L. Amador

NAME: _____

ID#: _____

Due: Monday, April 18th, 2011

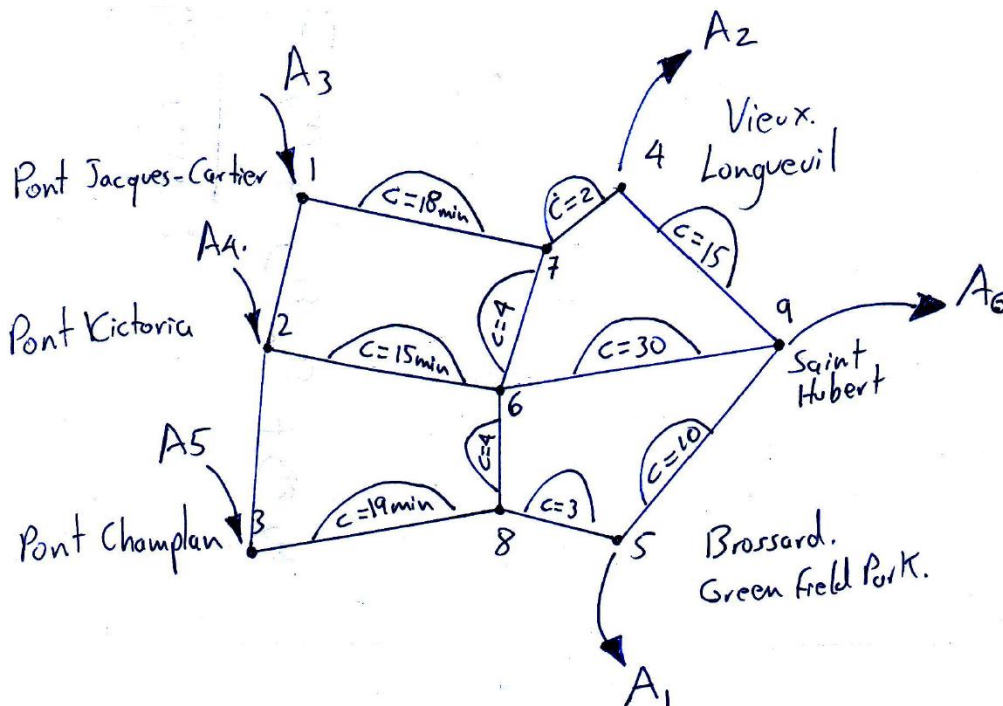
Start 2:00 am. - End 5:00 am

1. Which one of the following problems can you solve using linear programming [4 marks]

- a) MAX $3x + 2y$, Subject to $x + y \leq 12$ and $2x - 5y \geq 0$ YES X NO ___
- b) MIN $3x_1 + 2x_2 + (5x_2)(3x_1)$, Subject to $x_1 + x_2 \leq 1$, $x_1 - 2x_2 \geq 0$ YES ___ NO X
- c) MAX $3w + 2y - 3x_1 + 2x_2$, Subject to $2x - 5y \geq 10$, $x_1 + x_2 \leq 1$ YES X NO ___
- d) MIN $(3x_1)^2 + 2x_2$, Subject to $2x - 5y \geq 10$, $x + y \leq 1$ YES ___ NO X

2. Afternoon commuters heading from Montreal Island to Vieux Longueuil, Saint Hubert or Greenfield Park (Brossard) are expected to experience congestion given by travel times (semi-circles, units in minutes). Consider all links having: bi-directional flow, 1 lane per sense (2 lanes in total), maximum capacity given by 1,200 vehicles per lane per sense.

a. Prepare a mathematical formulation that achieves optimal flows (vehicles/hour) on the bridges and that alleviates travel time [16 marks]



Obj 1

Minimize Total Travel Time in the Network.

Node 1

Node 2

$$Z = C_{17}x_{17} + C_{12}x_{12} + C_{21}x_{21} + C_{23}x_{23} + C_{26}x_{26}$$

Node 3

$$C_{32}x_{32} + C_{38}x_{38}$$

Node 7

$$C_{71}x_{71} + C_{76}x_{76} + C_{74}x_{74}$$

Node 6

$$+ C_{67}x_{67} + C_{62}x_{62} + C_{69}x_{69} + C_{68}x_{68}$$

Node 8

$$+ C_{83}x_{83} + C_{86}x_{86} + C_{85}x_{85}$$

Node 5

$$+ C_{58}x_{58} + C_{59}x_{59}$$

Node 4

$$+ C_{47}x_{47} + C_{49}x_{49}$$

Obj 2 Maximize Total Flow through bridges.

$$Z = A_3 + A_4 + A_5$$

Subject to:

In

Out.

$$\text{Node 1} \rightarrow x_{21} + x_{71} + A_3 = x_{12} + x_{17}$$

$$\text{Node 2} \rightarrow x_{12} + x_{32} + x_{62} + A_4 = x_{21} + x_{23} + x_{26}$$

$$\text{Node 3} \rightarrow x_{23} + x_{83} + A_5 = x_{32} + x_{38}$$

$$\text{Node 7} \rightarrow x_{17} + x_{67} + x_{47} = x_{71} + x_{76} + x_{74}$$

$$\text{Node 6} \rightarrow x_{26} + x_{76} + x_{86} + x_{96} = x_{62} + x_{67} + x_{68} + x_{69}$$

$$\text{Node 8} \rightarrow x_{38} + x_{68} + x_{58} = x_{83} + x_{86} + x_{85}$$

$$\text{Node 5} \rightarrow x_{85} + x_{95} = x_{58} + x_{59} + A_1$$

$$\text{Node 4} \rightarrow x_{74} + x_{94} = x_{47} + x_{49} + A_2$$

$$\text{Node 9} \rightarrow x_{94} + x_{69} + x_{59} = A_6$$

3. In your new position as manager of engineering services for a large construction company you have been given \$200,000 budget to renew the old concrete mixing equipment you currently have. The

local vendors are accepting your old equipment to be trade in for new one as follows: (a) small concrete mixers at 5000\$ each (ideal on small contracts), (b) large mobile plants at \$100,000 each (large contracts) or (c) medium concrete mixers at 30,000 each (medium sized contracts). Based on the historical record of contracts awarded during the last 5 years, you have determined that the likelihood of getting small, medium and large contracts and the profit derived from them is as given in the following table. **[13 marks in total]**

Type of contract	Maximum Expected Number of Contracts happening in parallel	Historical profit (in thousands)
Small	16	5 contracts → from \$5 to \$10 10 contracts → from \$10 to \$15 5 contracts → from \$15 to \$20
Medium	7	1 → \$25 2 → from \$26 to \$29 2 → from \$29 to \$35
Large	2	1 → +\$220,000 (positive) 1 → -\$28,000 (negative)

- Make a decision tree showing your purchase alternatives and potential profit [3marks].
Do not consider the number of projects happening in parallel
- Obtain mean expected profit for each mixer type (use the historical profit to obtain it) [3 marks]
- Prepare a benefit / cost ratio for each type of mixer (simply divide the mean expected profit over the unitary cost) [3 marks]
- Select which equipment would you buy and justify why? [4 marks]
At this stage consider the expected number of projects happening in parallel



Decision = buy	Total profit	No Projects	B/C	Expected profit			
80000	200	16	2.5	12.5	small	0.25	7.5
						0.5	12.5
						0.25	17.5
210000	201.6	7	0.96	28.8	medium	0.2	25
						0.4	27.5
						0.4	32
	192	2	0.96	96	large	0.5	220
						0.5	-28

solution d)	given	sol c)	sol b)	Solution a)
-------------	-------	--------	--------	-------------

SOL= Buy 7 medium (\$210,000) and 16 small (\$80,000)

- Solve the following problem using the Simplex method (**tableau OR equations**). Please solve in the examinations booklet or in a separate sheet **[10 marks]**

$$\text{MINIMIZE } Z = 3x_1 + 2x_2 + x_3$$

$$\text{Subject to: } x_1 + x_2 + x_3 \leq 4$$

$$x_1 - 2x_2 + \frac{1}{2}x_3 \geq 0$$

$$2x_1 + 2x_2 + 2x_3 \leq 8$$

$$x_1, x_2, x_3 \geq 0$$

Solution is 0, 0, 0 because you cannot improve any further (coefficients on objective in equation format are positive). All slack basis is feasible

5. The construction of a sewage lagoon will cost \$100 million and \$20 million every 20 years for expansion in order to cover demand. How much is the required budget today in order to have enough money to build the project and maintain it at perpetuity (use a rate of 5%) without having to incur in any additional cost ever (apart from the amount of money you need to get today). [5 marks]

$$A = F(A/F, i, n) = 20,000,000 \left(\frac{i}{(1+i)^n - 1} \right)$$

$$A = 20,000,000 \left(\frac{0.05}{(1.05)^{20} - 1} \right) = 20,000,000 (0.03024)$$

$$A = 604851.74$$

$$P = \frac{604851.74}{0.05} \quad \left(P = \frac{A}{i} \right)$$

$$P = 12097034 + 100000000$$

$$P = 112097034$$

Proof

$$12097034 \cdot (1.05)^2 = 32097034$$

$$- 20000000$$

$$\hline 12097034$$