Group Members: _____

Instructions: All solutions should be prepared carefully and neatly. For each part of this project, you will mathematically formulate the LP and solve it using the Excel Solver. Provide a summary of the computer results as well as a clear interpretation and write a report in Word or LaTeX that includes your recommendations to the management. The use of graphs, flow charts, and tables as appropriate is encouraged and should be used to sell management on your recommendation. Submitted work that does not demonstrate clearly the process by which one arrived at the answer will not receive credit of any kind. Academic dishonesty will not be tolerated. Upload both your write-up and Excel file to D2L by the due date below.

Project I

Distribution and Location

Due: Friday, March 8 by 11:59 PM on D2L

Project Statement: This project is split into two parts: a standard operation problem and a possible expansion problem. To successfully complete the project, please submit a report in LaTeX or Word in the following format:

1. *Introduction:* Give a brief introduction to the problem, how you will solved both parts, the goal of each part, and a brief description of the results. Introduce the layout of the rest of the report.

2. *Formulations:* For each part of the problem, provide a mathematical formulation of the problem, separated in subsections. Explicitly state constraints and describe how you formulated them. If some constraints for Part 2 are repeated from Part 1, there is no need to reformulate them. Explicitly state the objective function(s) in terms of the variables and describe how you formulated them. Note: you may use tables, graphs, flow charts, etc. to organize your variables. Any visual aid to help the reader understand is helpful.

3. *Interpretations/Conclusions:* Provide an interpretation of the results of your formulations and optimized solution of all LP problems that you solve. The report should include your recommendations to management and should explicitly answer the additional questions regarding customer preference (in Part 1) and which, if any, new depots should be built/closed down/expanded (in Part 2).

4. *Program Files:* An Excel file with a clear representation of each problem and a solution produced by the Excel Solver. When submitted, the file should have the optimal solution displayed. *Note: Create a single Excel file and assign an Excel sheet for each problem that you solve.*

Part Number	Available Points	Your Points
Introduction	5	
Formulations	20	
Conclusions	8	
Program Files	7	
Total	40	

Part 1 – Standard Operations

A company has two factories, one at Liverpool and one at Brighton. In addition, it has four depots with storage facilities at Newcastle, Birmingham, London, and Exeter. The company sells its product to six customers. Customers can be supplied from either a depot or from a factory directly.

The distribution costs (which are paid by the company) are known and are given in the tables below in \$/ton. Certain customers have expressed preferences for being supplied from factories or depots. The preferred suppliers for each customer are marked with an asterisk. Not all customers have preferred suppliers.

	Suppliers	
Depots	*Liverpool Factory*	*Brighton Factory*
Newcastle	0.5	N/A
Birmingham	0.5	0.3
London	1.0	0.5
Exeter	0.2	0.2

Table 1: Distribution costs in \$/ton from the factories to the depots.

	Factory Supplier		Depot Supplier			
Customers	*Liverpool*	*Brighton*	*Newcastle*	*Birmingham*	*London*	*Exeter*
C1	1.0*	2.0	N/A	1.0	N/A	N/A
C2	N/A	N/A	1.5*	0.5	1.5	N/A
C3	1.5	N/A	0.5	0.5	2.0	0.2
C4	2.0	N/A	1.5	1.0	N/A	1.5
C5	N/A	N/A	N/A	0.5*	0.5	0.5
C6	1.0	N/A	1.0	N/A	1.5*	1.5*

Table 2: Distribution costs in \$/ton from the factories and depots to each customer. An asterisk indicates a customer's preferred supplier.

Factory and Depot Capacities: Each factory has a monthly capacity that cannot be exceeded:

- Liverpool has a capacity of 150,000 tons.
- Brighton has a capacity of 200,000 tons.

Each depot has a maximum monthly throughput given below which cannot be exceeded:

- Newcastle has a 70,000 ton maximum throughput.
- Birmingham has a 50,000 ton maximum throughput.
- London has a 100,000 ton maximum throughput.
- Exeter has a 40,000 ton maximum throughput.

Each customer has a monthly requirement given below which must be met:

- C1 has a 50,000 ton requirement.
- C2 has a 10,000 ton requirement.

- C3 has a 40,000 ton requirement.
- C4 has a 35,000 ton requirement.
- C5 has a 60,000 ton requirement.
- C6 has a 20,000 ton requirement.

Goal for Part 1: Formulate a model that will determine a distribution pattern that minimizes overall cost. Is it possible to meet all customer preferences, and if so, what would the extra cost of doing this be? (Your Excel file should have two tabs: one for minimized cost and one for satisfying customer preference.)

Part 2 – Expansion

Now suppose there is the possibility of opening new depots at Bristol and Northampton as well as of enlarging the Birmingham depot. It is not desirable to have more than four depots and if necessary, the Newcastle or Exeter (or both) depots can be closed down. If the Newcastle depot is shut down, the company will lose $10,000 monthly. If the Exeter depot is closed, they'll save $5,000 monthly. The monthly costs (in interest charges) of the possible new depots and Birmingham expansion are given below together with the potential monthly throughputs.

	Cost ($)	Throughput (tons)
Bristol	12,000	30,000
Northampton	4,000	25,000
Birmingham (expansion)	3,000	+20,000

Table 3: Monthly costs and throughput for potential depots and expansion.

The distribution costs from the factories to the new depots and from the new depots to the customers are given in the following table.

	Suppliers	
Depots	*Liverpool Factory*	*Brighton Factory*
Bristol	0.6	0.4
Northampton	0.4	0.3
	New Depot Supplier	
Customer	*Bristol*	*Northampton*
C1	1.2	N/A
C2	0.6	0.4
C3	0.5	N/A
C4	N/A	0.5
C5	0.3	0.6
C6	0.8	0.9

Table 4: Distribution costs in $/ton from the factories to the new depots and from the new depots to the customers.

Goal for Part 2: Formulate a mixed-integer LP that will determine a distribution pattern that minimizes overall cost. Your model should also determine which new depots should be built, if the Birmingham depot should be expanded, and whether or not the Exeter or Newcastle depots should be closed down.