

Assignment 2
MF5001 (Mathematical Modelling in Supply Chains)
(30%)

Problem 1.

(10 Marks)

A service firm will need to modify its staff timetable from eight-hour shifts to twelve-hour shifts. Before the change, the staff were working eight hours a day for five days per week. After the change, for the first week, the staff will be working for three days and then will be off for four days. For the following second week, they will be working for four days and will be off for four days. This means overall the company staff will be working eighty-four hours every 2 weeks.

The highest demand period is between 5A.M. – 7A.M. and between 5P.M. – 7P.M. To accommodate this peak demand, the following twelve-hour shifts must be arranged:

1. Shift: E & E [alt], Working hours: 5A.M. to 5P.M., and Payment rate per week: \$757
2. Shift: F & F [alt], Working hours: 7A.M. to 7P.M., and Payment rate per week: \$841
3. Shift: G & G [alt], Working hours: 5P.M. to 5A.M., and Payment rate per week: \$881
4. Shift: H & H [alt], Working hours: 7P.M. to 7A.M., and Payment rate per week: \$923

The least and most desired times to commence and finish work will be used as the basis for the shift pay differentials. In any one week, staff on shift E might work Sun to Tues, while staff on shift E [alt] would work at the same times, but on Wednesday to Saturday. In the following week, staff on shift E would work Sunday to Wednesday, while staff on shift E [alt] would work the corresponding Thursday to Saturday. So, this results in scheduling the same number of staff for shift E as for shift E[alt].

Table 1 shows the firm's staff requirement for the twenty-four-hour day. (1) Formulate this example as an LP model to determine the most economical schedule? (2) Use Microsoft Solver to solve the formulated LP model in (1).

Table 1. firm's staff requirement

	5A.M. to 7A.M.	7A.M. to 5P.M.	5P.M. to 7P.M.	7P.M. to 5A.M.
Staff needed	12	8	14	10

Problem 2.

(10 Marks)

A distribution company have two production facilities in Charlotte and Washington DC. These facilities act as the suppliers for two large retail shops located in San Francisco and LA. Due to COVID, the demand for their product (e-readers) has gone up and therefore, the company managers are thinking to open a new production plant either in Boston or Chicago. The data Table 2 provides related information to this supply network. Which city (Boston or Chicago) will this company need to open their new plant in, to achieve the minimum total cost?

Table 2. Data table.

Table 2: Data table.				
	Markets			
	Transportation costs			
Plants	San Francisco	LA	Capacity	Production cost per unit

Charlotte (current plant)	\$8.2	\$5.1	600	\$5.1
Washington DC (current plant)	\$4.3	\$6.9	900	\$4.9
Boston	\$4.9	\$6.2	500	\$4.1 (estimated)
Chicago	\$4.2	\$5.7	500	\$3.2 (estimated)
Forecasted demand after Covid	800	1200		

Formulate and solve this problem using the LP approach and MS Solver. Clearly present the decision variables, objective function, and constraints.

Problem 3.

(20 Marks)

A company wants to move some products (medical supplies) from Pittsburgh (Node 1) and Staunton (Node 2) to hospitals in Nodes 3 to Node 7. Figure 1 provides the details of this network. The shipping costs of all routes are provided below each arc. Please note that there is a vehicle capacity limitation of maximum 800 units for all routes. That means, for instance, no more than 800 units of products (medical supplies) can be shipped from a city to another one.

- Formulate this problem as an LP model to determine the least costly shipping plan.
- Solve the model in (a) using MS Solver.
- Reformulate the model in (a) assuming that the vehicles are now changed to a different one with more capacity up to 1000 products between any two cities.
- Solve the model in (c) using MS Solver and compare your results with (b).

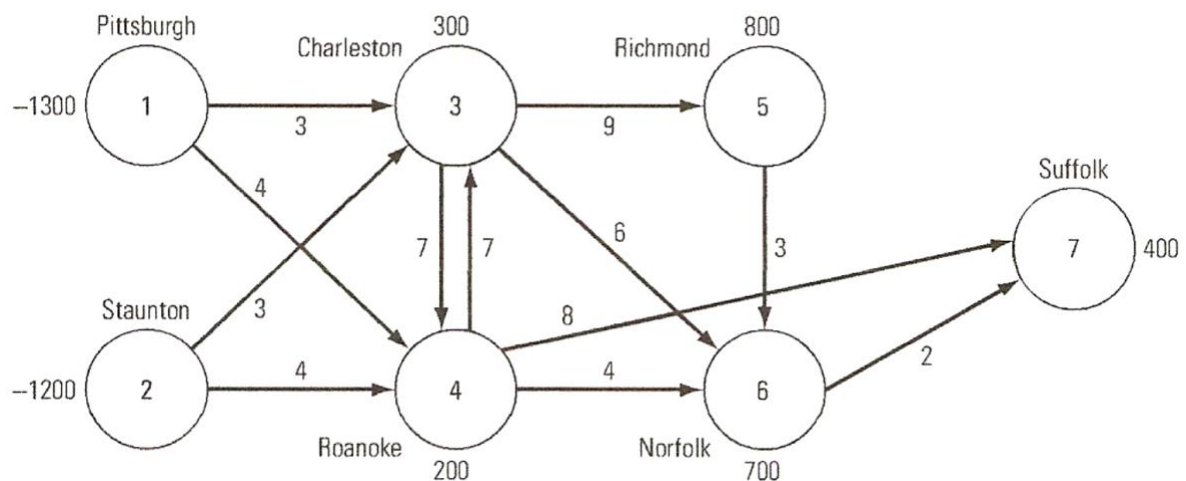


Figure 1. Medical supply network

Problem 4.**(20 Marks)**

Company 1 and Company 2 are two European producers of a demanding medical component. Company 1 has plants in Germany, France, and Italy, whereas Company 2 has plants in Ireland and UK. The markets are in North America and have four geographical zones, i.e. north, east, west, and south. Table 2 provides all required information about these plants and markets.

Table 2. Information for problem 3.

		Variable production and shipping costs (euros per unit)					Annual Fixed Cost (millions of euros per year)
		North	East	South	West	Capacity (millions of units per year)	
Company 1	Germany	€100	€110	€105	€100	50	1000
	France	€95	€105	€110	€105	50	1000
	Italy	€90	€100	€115	€110	40	850
Demand (millions of units)		30	20	20	35		
Company 2	Ireland	€105	€120	€110	€90	50	1000
	UK	€110	€105	€90	€115	60	1150
Demand (millions of units)		15	20	30	20		

- a) Company 1 and 2 are merging and will serve the markets (supply products) collectively, what is the minimum total cost if none of the plants is shut down? Formulate this problem using Integer Programming (IP) and solve using MS solver. Clearly show your model and discuss results.

(10 marks)

- b) After the merger, what is the minimum total cost if plants can be shut down (assume that a shutdown saves 100% of the annual fixed cost of the plant)? Formulate this problem using Integer Programming (IP) and solve using MS solver. Clearly show your model and discuss results.

(10 marks)

The requirement for this assignment is:

1. Submit a .PDF file containing the answers to all problems. .PDF file can be done using computer or can be a scanned hand-written one with good image quality.
2. Submit separate excel files that details the solution procedure for all problems.
3. Rename all submitted file as “your surname-your student ID-Assignment 2” e.g. “Smiths-12243543-Assignment 2”