

## Problem Description

A company has two factories, one each at Bristol and Leeds. The factories produce paints which are sold to five wholesalers. The wholesalers are either supplied directly from the factories or through one of the company warehouses, the transportation costs being paid by the company. The company has three warehouses, one each in London, Birmingham and Glasgow. Table 1 shows the transportation costs per ton for deliveries from the factories to the warehouses or wholesalers and also from the warehouses to the wholesalers, omitting entries when delivery from a certain supplier or warehouse is impossible for some destination.

Supplier	Warehouse			Wholesaler				
	London	Birmingham	Glasgow	1	2	3	4	5
Bristol	27	25	-	82	-	93	100	88
Leeds	32	29	33	-	72	57	-	100
London	-	-	-	38	34	-	42	45
Birmingham	-	-	-	38	42	45	42	48
Glasgow	-	-	-	48	45	32	-	38

Table 1: Transportation costs in £'s/ton delivered.

The two factories at Bristol and Leeds can produce up to 50,000 and 60,000 tons per week respectively. No more than 25,000, 20,000 and 16,000 tons can be moved each week through the warehouse in London, Birmingham and Glasgow, respectively. Wholesalers 1, 2, 3, 4 and 5 require at least 20,000, 25,000, 13,000, 19,000 and 21,000 tons per week respectively.

Answer the following three parts of the problem. Parts A and B are worth 30% each while part C is worth 40% of the overall mark for this problem.

- Formulate a linear programming model to determine the minimum cost transportation schedule. Explain clearly the variables you use and the constraints you construct. What is the minimum cost transportation schedule and what are the corresponding costs?
- Discuss the effect on the minimum transportation cost when capacity at each factory or warehouse is altered by adding or subtracting one ton. What are the minimum capacity changes at Glasgow that will alter the optimum set of routes and what will those alterations be? Explain how you arrive at each one of your answers.
- The management of the company is considering the possibility of closing down one of the warehouses as this is expected to result in substantial labour and maintenance savings. Further, the manager of the Birmingham warehouse is considering sub-letting some of the capacity of this warehouse. Such sub-lets would have to be in exact multiples of 1000 tons. It is estimated that each 1000 tons of capacity could be let for £19,000 per week. Formulate a mixed integer linear programming model – or, if necessary, different model variants – to examine and evaluate the alternative courses of action. What would you recommend the company to do, and why? Discuss the alternatives, also taking into account the solution from part (a) and explain which additional information you might need (if any) to give the company more specific advice.