# Operations Research, Spring 2017

# Pre-lecture Problems for Lecture 7: Applications of Integer Programming

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**Note.** The deadline of submitting the pre-lecture problem is ***9:20am, April 13, 2017***. Please submit a hard copy of your work in class. Late submissions will not be accepted. Each student must submit her/his individual work. Submit ONLY the problem that counts for grades.

1. (0 point) Six towns locate at the following six points on a Cartesian plane: $(0, 60)$, $(20, 50)$, $(30, 20)$, $(40, 80)$, $(50, 50)$, and $(90, 60)$ (in km). Currently a company owns six retail stores, one in each town. The weekly sales of a product in these stores are 10000, 15000, 12000, 8000, 20000, and 3000. The company currently has one distribution center (DC) in town 3. It plans to build some more DCs for the retail stores to replenish from. The construction costs of building a DC in these towns are \$200000, \$180000, \$160000, \$190000, \$150000, and \$200000. A truck can carry 500 units of this product. The shipping cost for a truck to move 1 km is \$1. The existing DC and any newly built DC can be used for 5 years. There is no capacity limit for a DC. Transportation between two locations can be done by traveling through the straight line connecting them.

   (a) Formulate the problem of minimizing the 5-year total construction and shipping costs as an integer program if DCs can only be built in towns.

   (b) Suppose DCs may also be built in the following locations: $(0, 20)$, $(20, 40)$, $(40, 30)$, and $(60, 40)$. Do Part (a) again.

2. (0 point) Ten jobs should be scheduled on one single machine. The processing times for these jobs are 6, 9, 3, 5, 10, 6, 3, 9, 7, and 10 (in hours) The due times for these jobs are 50, 53, 55, 56, 59, 60, 62, 67, 68, and 70 (in hours).

   (a) Formulate the scheduling problem of minimizing total tardiness as an integer program.

   (b) Suppose that some precedence rules must be followed: Job 1 must be finished before job 5 can start, job 3 must be finished before job 4 can start, jobs 5 and 6 must be finished before job 7 can start, and job 6 must be finished before jobs 9 and 10 can start. Do Part (a) again.

3. (10 points; 5 points each) Ten jobs should be scheduled on one single machine. The processing times for these jobs are 6, 9, 3, 5, 10, 6, 3, 9, 7, and 10 (in hours) The due times for these jobs are 50, 53, 55, 56, 59, 60, 62, 67, 68, and 70 (in hours).

   (a) Suppose that job $j$ has its release time $r_j$, i.e., one may not start to process job $j$ prior than time $r_j$. The release times for the ten jobs are 8, 0, 2, 14, 12, 4, 20, 22, 18, and 15. Formulate the scheduling problem of minimizing total tardiness as an integer program.

   (b) In AMPL, we may append the keyword `integer` or `binary` at the end of the declaration statement of a (set of) variables to declare integer or binary variables. Continue from Part (a) and write AMPL programs to find an optimal solution. Submit ONLY an optimal schedule and the associated total tardiness. Make sure that your schedule is easy to read and interpret. DO NOT submit your AMPL programs.