Question1. Maximize $Z = 3.6x_1 - 0.4x_1^2 + 1.6x_2 - 0.2x_2^2$

Subject to the constraint

$2x_1 + x_2 \leq 10$ and both x_1 and x_2 are ≥ 0.   [10]

Question2. Solve the following integer programming problem using branch & bound method:

$Minimize \;\; Z = 2x + 3y$

Subject to the constraint:

$x + 3y \geq 5$

$2x + y \geq 6$

$x, y \; \geq 0 \; and \; integer$ [20]

Question3.a. The manager of the only record shop in a college town is not concerned with market competition. Instead, his major decision problem is the sales effort allocation to achieve the maximum profit. The record shop employs five full-time and four part-time salesmen. The average regular working time is 160 hours a month for the full-time salesmen and 80 hours for the part-time salesmen. The average sale of records per hour has been five for the full-time salesmen and two for the part-time salesmen. The average hourly wage rates are $3.00 for the full-time and $2.00 for the part-time salesmen.

   The average profit from the sale of a record is $1.50. In view of the past sales records and the increased enrollment at the college, the manager feels that the sales goal for September should be 5,500 records. Since the shop is open six days a week, overtime is often required of salesmen. The manager believes that a good employer-employee relationship is an essential factor of business success. Therefore, he decided that a stable employment level with occasional overtime requirement is a better practice than an unstable employment level with no overtime. However, he also feels that overtime of more than 100 hours for the full-time salesmen should be avoided because of the resulting fatigue.

   The relative importances of these goals are as follows: the manager gives the first priority to achievement of the sales goal of 5,500 records in September. Then he wants to limit the overtime of full-time salesmen to 100 hours. The third goal in line is to provide job security to salesmen. The manager feels that full utilization is an important factor for a good employer- employee relationship. However, he is twice as concerned with the full utilization of full-time salesmen as with the utilization of part-time salesmen. The fourth and last concern is to minimize the sum of overtime for both full-time and part-time salesmen. However, differential weights should be assigned to the minimization of overtime for the full-time and part-time salesmen. Between the full-time and part-time salesmen, the sales efficiency ratio is 5 to 2, while the hourly wage rate is $4.50 (overtime pay) and $2.00.

   The marginal profit per hour of overtime is $3.00 for the full-time salesmen and $1.00 for the part-time salesmen. The relative cost of an hour of overtime for the part-time salesmen is three times that of the full-time salesmen.

Set up the goal programming model to solve this problem.   [10]

Question3.b. Consider the model: $Minimize \;\;\;\; f = d_1^- + d_2^- + d_3^-$
$$\text{Subject to}$$
$$7.5x_1 + 10x_2 + d_1^- - d_1^+ = 1000$$
$$x_1 + d_2^- - d_2^+ = 10$$
$$x_2 + d_3^- - d_3^+ = 10$$
$$x_1 + 2x_2 \leq 60$$
$$1.5x_1 + 1.5x_2 \leq 60$$
$$x_1, x_2, d_1^-, d_1^+, d_2^-, d_2^+, d_3^-, d_3^+ \geq 0$$

Find the graphical solution to this goal programming problem. [15]

Question4. M/S Godrej & Boyee and Hindustan Lever Ltd have been selling competing products Cinthol and Liril, respectively. The brand manager of Cinthol raised the following questions:
What should be the firms's strategy in terms advertising for Cinthol? The market research group of Godrej & Boyee developed data for varying degrees of advertising by Liril and Cinthol:
1. No advertising, medium advertising and high advertising by both the firms will result in equal marketing share for Liril and Cinthol.
2. No advertising by Cinthol will result in a market share of 40% and 28% if medium level of advertising and heavy level of advertising respectively is adopted by Liril.
3. If Cinthol adopts medium level of advertising it will achieve a market share of 70% with no advertising by Liril and 45% market share with heavy advertisement by Liril.
4. If Cinthol resorts to heavy advertising it would achieve a market share of 75% with no advertising by Liril and get a 47.5% market share with medium advertising by Liril.

Based upon the foregoing information, what strategy should the brand manager of Cinthol adopt? [10]

Question5. Given that a project involves activities A, B, C, ….. I; each requiring completion time, in days, as per the following details: [5+5+5+5 =20]

Activity	A	B	C	D	E	F	G	H	I
Time	23	8	20	16	24	18	19	4	10

Given that activity A precedes activities D and E; activities B and D precede activity F; activity C precedes activity G; activities B and G precede H and activities F and G precede activity I, draw the network and calculate
a. Total Float
b. Critical Path
c. Project Completion Time

Question6. In intermodal transportation, loaded truck trailers are shipped between railroad terminals on special flatbed carts. The below figure shows the location of the main railroad terminals in the United States and the existing railroad tracks. The objective is to decide which tracks should be "revitalized" to handle the intermodal traffic. In particular, the Los Angeles (LA) terminal must be linked directly to Chicago (CH) to accommodate expected heavy traffic. Other than that, all the remaining terminals can be linked, directly or indirectly, such that the total length (in miles) of the selected tracks is minimized. Determine the segments of the railroad tracks that must be included in the revitalization program. [15]
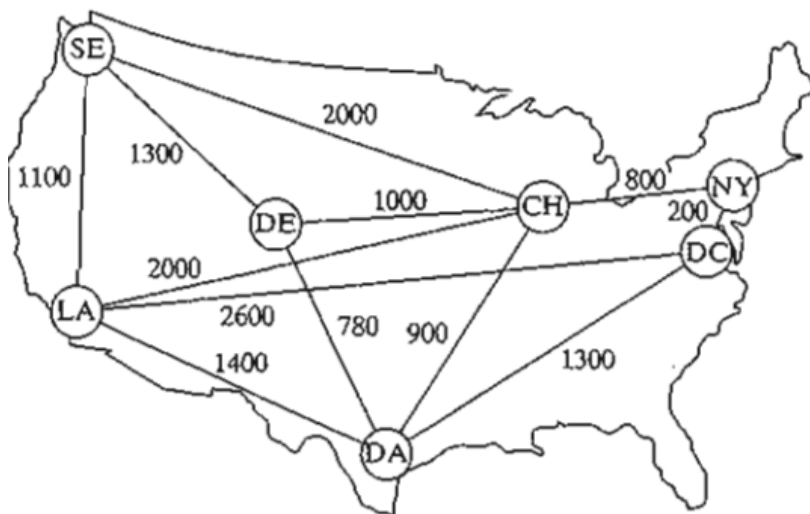

Figure: Location of the main railroad terminals