1.      Take the simple goal program

$$Max \begin{bmatrix} 3X_1 & + 3X_2 \\ 4X_1 & + X_2 \end{bmatrix}$$
$$X_1 + X_2 \leq 1$$
$$X_1 , X_2 \geq 0$$

a)      Develop a weighted trade-off type objective function without targets.
b)      Assume some targets and make it lexicographic

2.      Suppose you have been hired by an international development agency to do an analysis of the effects of new technology on farming conditions in Jalava. Suppose that you have chosen to use a mathematical program to do this and have the following data:

Farms grow 4 crops: rice, maize, cassava and legumes. The year is divided into two seasons. Rice may be grown in three versions: year-long, wet season, and dry season; maize in the dry season, cassava in the dry season or year-long, and legumes in the dry season. The crops produce output, use land, labor, and miscellaneous outputs, and have prices as follows:

| Crop | | Wet Rice | Dry Rice | Year Long Rice | Maize | Dry Casava | Year Long Casava | Legume |
|---|---|---|---|---|---|---|---|---|
| Yield (Kg.) | | 4000 | 3500 | 4500 | 2800 | 12000 | 22000 | 1000 |
| Labor Use (hours) | Wet Season | 50 | 0 | 30 | 0 | 0 | 15 | 0 |
| | Dry Season | 0 | 50 | 25 | 30 | 20 | 10 | 18 |
| Land Use (Hectares) | Wet Season | 1 | 0 | 1 | 0 | 0 | 1 | 0 |
| | Dry Season | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| Miscellaneous Input Use (rp/hectare) | | 4000 | 3800 | 4100 | 2000 | 100 | 150 | 1000 |
| Price (rp/kg) | | 70 | 73 | 73 | 45 | 8 | 8 | 125 |
| Calories/kg | | 3360 | 3360 | 3360 | 3490 | 1050 | 1050 | 4520 |

Assume the farm has 2 hectares and 75 man-days of labor in each period.
However, in addition to profits, the family is concerned about its diet. The family has 5 members. Assume that family members have a goal of consuming at least 1575 calories per day, with at least 210 from legumes, and no more than 400 calories from cassava. Further, assume the family would prefer to have at least 120 kg. annually of rice per member.

Formulate this as a multiple objective programming problem using a lexicographic for the diet and a profit max objective.

3. Give optimality conditions and tell whether (or how to find out whether) you have a maximum or a minimum, for the following problems:

a) $Z = 4X - 2X^2$

b) $Z = (8-X)^2 - 6X$

c) $Z = 6X^2 + 12Y^2 - 8XY$

d) opt $Z = 3X^2 + 2Y^2 - 2XY$

   $X + Y = 6$

e) opt $Z = 3X^2 + 2Y^2 - 2XY$

   $X + Y \leq 10$

   $X, Y \geq 0$

4 Take your earlier GAMS formulation
   1. Add multiple objectives and solve for a lexicographic and 3 different weight settings