# Coordinating Advertising and Production

The Future Bright Company manufactures four types of lamps at its factory including table lamps, floor lamps, ceiling lamps, and pendant lamps.

Each product is made in one of two production processes by purchasing components, assembling and testing the product, and finally packaging it for shipping. Table lamps and floor lamps go through the assembly and finishing process in Department 1, while ceiling fixtures and pendant lamps go through the process in Department 2. Variable production costs and capacities are shown in the table below. The capacities are measured in units of product. Note that there are regular and overtime possibilities for each department.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Mineral** | **Regular Time** | | **Overtime** | |
| **Unit Cost** | **Capacity (000)** | **Unit Cost** | **Capacity (000)** |
| **Department 1** | $16 | 100 | $18 | 25 |
| **Department 2** | $12 | 90 | $15 | 24 |

The materials costs are shown in the table below. Additionally, average selling prices for the four products are known, and estimates have been made of the market demand for each product at these prices. Sales levels can also be affected by advertising expenditures. Starting with the demand levels in the table, an increase of up to $10,000 in advertising for a product raises the demand by the percentage shown in the last row. An expenditure of less than $10,000 in advertising will lead to a proportional effect on demand. For example, an increase in advertising of $5,000 for table lamps would raise demand by 6 percent, or 3,600 units. However, there is a budget limit of $18,000 on the total amount to be spent on advertising among all four products.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Product** | **Table** | **Floor** | **Ceiling** | **Pendant** |
| **Materials Cost/Unit** | $66 | $85 | $50 | $80 |
| **Selling price/Unit** | $120 | $150 | $100 | $160 |
| **Predicted sales quantity before**  **Ad (000)** | 60 | 20 | 100 | 35 |
| **Ad effect on demand** | 12% | 10% | 8% | 15% |

For each of the following parts, answer the question as specifically and completely as possible without solving the problem again with Solver. Note: Each part is independent (i.e., any change made to the model in one part does not apply to any other parts). For (a) write 1–2-line description explaining your thinking behind each equation. For (b), organize and label the spreadsheet so that objective, constraints, and solutions are clear. For (c) -(d) write your reasoning referring to what you find in the spreadsheet.

1. Formulate this decision question as a Linear Programming Model. Define the variables, write down the constraints and the objective function in mathematical (algebraic) terms (variables, inequalities, etc.)
2. Find the optimal solution using SOLVER and generate the sensitivity report. What is an optimal output for the company?

Show us clearly how you answer the question below **without rerunning** solver. Use the information provided by the solver answer reports above.

1. For each department, what is the marginal value of additional overtime capacity?
2. If the company cut the total budget of advertising by $6,000, how would you expect this to impact the overall profit, assuming all other conditions remain the same?

# Optimize purchase plan and cost schedule

The facilities manager at Oxbridege University is planning to apply fertilizer to the grass in the quadrangle area in the spring. The grass needs nitrogen, phosphorus, and potash in at least the amounts give in the following table:

|  |  |
| --- | --- |
| **Mineral** | **Minimum Weight (lb)** |
| **Nitrogen** | 1.2 |
| **Phosphorus** | 1.4 |
| **Potash** | 1.8 |

Three kinds of commercial fertilizer (A, B, and C) are available, with mineral content and prices per pound as given in the following table. There is virtually unlimited supply of each kind of fertilizer.

|  |  |  |  |
| --- | --- | --- | --- |
| **Fertilizer** | **A** | **B** | **C** |
| **Nitrogen Content (lb)** | 0.02 | 0.01 | 0.015 |
| **Phosphorus Content (lb)** | 0.01 | 0.005 | 0.01 |
| **Potash Content (lb)** | 0.005 | 0.015 | 0.005 |
| **Prices ($)** | 0.01 | 0.008 | 0.007 |

1. Formulate this model algebraically.
2. How much of each fertilizer should be purchased to satisfy the above requirements at minimum cost? Formulate and solve this problem using Solver on a spreadsheet.
3. Solve this problem using Python and either Gurobipy or Pyomo package. If you’d like to use a different python package, first check with the instructor.