**Nazmul Hasan Rabbi report for Task 1:** **Production Planning**

**Task 1.1** **Formulate a linear programming model for production planning** [10 Points]

Parameters:

* is the demand (number of units required) for product type .
* is the cost (in dollars) to produce each unit of product type *in-house*.
* is the price (in dollars) to purchase each unit of product type from *out-sourcing partner*.
* is the average machining time (minutes) required to produce each unit of product type .
* is the average assembly time (minutes) required to produce each unit of product type .
* is the average finishing time (minutes) required to produce each unit of product type .
* is the machining time (in minutes) available for in-house production.
* is the assembly time (in minutes) available for in-house production.
* is the finishing time (in minutes) available for in-house production.

LP formulation:

*Decision variables*:

* is the number of units required of product type produced,
* is the number of units required of product type purchased,

*Objective function*:

Minimize Total Cost =

*Subject to constraints*:

*Demand constraints:*  for

*Machining time availability*:

*Assembly time availability*:

*Finishing time availability*:

All decision variables are *non-negative*.

**Task 1.2**. **Obtain data for the LP model parameters** [5 Points]

Obtain product data from the CSV file ‘production\_planning.product.csv’ and specify the parameter values for the LP model in following table:

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Product type** | **P1** | **P2** | **P3** | **P4** | **P5** |
| Demand () | 3000 | 5000 | 6000 | 8000 | 7000 |
| Production Cost () | 113 | 99 | 63 | 53 | 63 |
| Purchase Price () | 146 | 108 | 76 | 86 | 86 |
| Machining time () | 4 | 1 | 2 | 4 | 4 |
| Assembly time () | 4 | 1 | 1 | 4 | 2 |
| Finishing time () | 3 | 1 | 2 | 3 | 3 |

Obtain resource data from the CSV file ‘production\_planning.resource.csv’ and specify the parameter values for the LP model in following table:

|  |  |  |
| --- | --- | --- |
| **Resource** | **Available hours** | **Hourly cost** |
| Machining time | 1186 | 60 |
| Assembly time | 920 | 300 |
| Finishing time | 946 | 180 |

Substituting the LP parameter values, we get:

Minimize Cost = 113 x\_1 + 99 x\_2 + 63 x\_3 + 53 x\_4 + 63 x\_5 + 146 y\_1 + 108 y\_2 + 76 y\_3 + 86 y\_4 + 86 y\_5

Subject to constraints:

Demand\_for\_P1: x\_1 + y\_1 >= 3000

Demand\_for\_P2: x\_2 + y\_2 >= 5000

Demand\_for\_P3: x\_3 + y\_3 >= 6000

Demand\_for\_P4: x\_4 + y\_4 >= 8000

Demand\_for\_P5: x\_5 + y\_5 >= 7000

machine\_time\_availability: 4 x\_1 + x\_2 + 2 x\_3 + 4 x\_4 + 4 x\_5 <= 71160

assembly\_time\_availability: 4 x\_1 + x\_2 + x\_3 + 4 x\_4 + 2 x\_5 <= 55200

finishing\_time\_availability: 3 x\_1 + x\_2 + 2 x\_3 + 3 x\_4 + 3 x\_5 <= 56760

All decision variables are non-negative.

**Task 1.3** Solve the linear programming model [10 Points].

Solve the LP model formulated in Task 1.1 using parameters obtained in Tasks 1.2 and report the following:

Minimum cost attainable: **$ 2,206,560.00**

Optimal production plan (round quantities to the nearest integer):

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Quantity** | **P1** | **P2** | **P3** | **P4** | **P5** |
| **In-house production** | 1420 | 1560 | 6000 | 8000 | 4980 |
| **Outsourced** | 1580 | 3440 | 0 | 0 | 2020 |

Resources:

|  |  |  |
| --- | --- | --- |
| **Resources** | **Used (minutes)** | **Available (minutes)** |
| **Machine Time** | 71160 | 71160 |
| **Assembly time** | 55200 | 55200 |
| **Finishing time** | 56760 | 56760 |

**Task 1.4 Sensitivity analysis**. [10 Points].

Perform sensitivity analysis and determine at most how much the company should be willing to pay to increase the availability of each resource by 1 hour (over its current availability). Consider one resource at a time; all other parameter values remain fixed at the values used in Task 1.3.

*Explain your reasoning*.

|  |  |
| --- | --- |
| Resource | Maximum amount the company should be willing to pay to increase the availability of the resource by 1 hour |
| Machining time | $ 120 |
| Assembly time | $ 600 |
| Finishing time | $ 360 |

*Reasoning*: We increase the availability of each resource by 1 hour and record the resulting decrease in cost (specified under the column ‘**Savings**’ in the table below). We should be willing to pay up to this amount *over its current cost* (specified under the column ‘**Hourly cost**’ in the table below) for each additional hour of the resource; the column ‘**Maximum amount**’ specifies the sum of ‘cost per hour’ and ‘savings per hour’.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Resource** | **Available hours** | **Hourly cost** | **Savings** | **Maximum amount** |
| Machining time | 1186 | 60 | 60 | 120 |
| Assembly time | 920 | 300 | 300 | 600 |
| Finishing time | 946 | 180 | 180 | 360 |