Technological Institute of the Philippines
CPE 300-CPE22S2 - Optimization Techniques

Final Project:
Production & Profit Calculator

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Production Cost and Profit Analysis Report

1. Statement of the Problem and Assumptions

This report analyzes a program designed to calculate the maximum production capacity, cost of goods sold, revenue, profit, and break-even point for a given product based on its bill of materials, raw material availability, selling price, and fixed overhead costs. The core problem the program addresses is to provide businesses with a tool to understand the financial viability of producing a certain quantity of a product, considering resource constraints and cost factors.

Assumptions Made:

1. **Linear Consumption:** The program assumes a linear relationship between the number of product units produced and the quantity of each ingredient required. For example, producing twice the number of energy drinks will require exactly twice the amount of water, sugar, etc.
2. **No Spoilage or Waste:** The calculations do not account for any potential spoilage of raw materials or waste during the production process. The program assumes that all used ingredients contribute directly to the finished product.
3. **Consistent Unit Costs:** The cost per unit of each ingredient is assumed to be constant regardless of the quantity purchased or used.
4. **Fixed Overhead is Truly Fixed:** The fixed overhead cost is assumed to remain constant within the production volume considered.
5. **Single Product Analysis:** The current program is designed for analyzing the production of a single product at a time.
6. **Availability Limits Production:** The maximum number of units producible is solely limited by the availability of the raw materials. Other potential production constraints (e.g., labor, machine capacity) are not considered.
7. **Instantaneous Production and Sales:** The model does not consider inventory holding costs or the time value of money. It assumes that produced units are sold instantaneously.

2. Description of the Algorithm and Program's Design Approach

The program, implemented in Python using the Flask framework, follows these key steps:

2.1. Algorithm:

1. **Input Collection:** The program takes the following inputs:
    - Product Name
    - Selling Price per Unit
    - Fixed Overhead Cost
    - A list of ingredients, each with:
        - Name
        - Available Quantity
        - Available Unit of Measurement
        - Required Quantity per Product Unit
        - Required Unit of Measurement
        - Cost per Unit

2. **Maximum Producible Units Calculation:** The program iterates through each ingredient and calculates the maximum number of product units that can be produced based on the available quantity of that specific ingredient. This is done by dividing the available quantity (after conversion, if necessary) by the required quantity per unit: Max Units for Ingredient =[Required per Unit Available Quantity] The overall maximum producible units for the product is then the minimum of the maximum units calculated for each individual ingredient. This ensures that production is limited by the ingredient with the least available quantity relative to its requirement.

3. **Cost Calculation:** For the determined maximum producible units:
    - For each ingredient, the total quantity used is calculated: **Total Used Quantity** = Required per Unit × Maximum Producible Units
    - The total cost for each ingredient is calculated: **Total Ingredient Cost** = Cost per Unit × Total Used Quantity
    - The total raw cost is the sum of the total costs of all ingredients: **Total Raw Cost** = $\sum$ Total Ingredient Cost
    - The total overall cost (or total cost of goods sold) is the sum of the total raw cost and the fixed overhead cost: **Total Overall Cost** = Total Raw Cost + Fixed Overhead Cost
    - The cost per unit is calculated by dividing the total overall cost by the maximum producible units: **Cost per Unit** = Total Overall Cost / Maximum Producible Units (if Maximum Producible Units>0)

4. **Revenue and Profit Calculation:**

    - The total revenue is calculated by multiplying the selling price per unit by the maximum producible units: **Total Revenue** = Selling Price per Unit × Maximum Producible Units
    - The total profit is the difference between the total revenue and the total overall cost: **Total Profit** = Total Revenue − Total Overall Cost
5. **Break-Even Point Calculation:**

    - The contribution margin per unit is the selling price per unit minus the cost per unit: **Contribution Margin per Unit** = Selling Price per Unit − Cost per Unit
    - The break-even point in units is calculated by dividing the fixed overhead cost by the contribution margin per unit and rounding up to the nearest whole number: **Break-Even Units** = [Fixed Overhead Cost / Contribution Margin per Unit] (if Contribution Margin per Unit>0)
    - If the contribution margin is not greater than zero, the break-even point is considered infinite.
6. **Output Display:** The program displays the calculated results, including the maximum producible units, total raw cost, total overall cost, cost per unit, revenue, profit, break-even units, and a detailed breakdown of ingredient usage and costs.

2.2. Program's Design Approach:

The program adopts a web-based approach using the Flask microframework. This allows users to interact with the calculator through a web browser. The design can be broken down into the following components:

- **Frontend** (HTML Templates - index.html and result.html):

    - **index.html:** Provides a user interface for inputting product details, ingredient information (with dynamic addition of ingredient fields using JavaScript), selling price, and fixed costs.
    - **result.html:** Displays the calculated results in a structured and readable format, using Jinja templating to dynamically insert the data passed from the Flask backend. It uses Bootstrap for styling to ensure a consistent and responsive presentation.
- **Backend (Python Flask Application - app.py):**

    - **Routing:** Defines different URL endpoints (/, /save_ingredients, /get_saved_ingredients, /load_ingredients/<name>, /remove_ingredients/<name>) and associates them with specific Python functions to handle different user actions (e.g., submitting data, saving/loading ingredients).

    - **Logic:** Contains the core logic for calculating maximum producible units, costs, revenue, profit, and break-even point. It also handles saving and retrieving ingredient data from a JSON file (**saved_ingredients.json**).
    - **Data Handling:** Uses Python dictionaries and lists to manage ingredient data and calculation results. The **json** module is used to serialize and deserialize ingredient lists to and from the **saved_ingredients.json** file.
    - **Session Management:** Utilizes Flask's session object to temporarily store the calculated **report_data** before rendering the **result.html** template.
    - **Error Handling:** Includes basic **try-except** blocks to catch potential **ValueError** (for non-numeric inputs) and other exceptions.
- **Data Storage (saved_ingredients.json):**
    - A JSON file is used for persistent storage of saved ingredient lists, allowing users to reuse previously defined sets of ingredients.
- **Client-Side Scripting (JavaScript in index.html):**
    - Handles dynamic UI elements like adding and removing ingredient input fields.
    - Uses the fetch API to make asynchronous requests to the Flask backend for saving, loading, and removing ingredient lists, improving the user experience by avoiding full page reloads.

3. Sample Calculations

Let's perform sample calculations using the provided **saved_ingredients.json** data for the "Energy Drink" and assuming a selling price of ₱15 per unit and a fixed overhead cost of ₱1000.

Input Data (from saved_ingredients.json and assumed values):

- **Product Name:** Energy Drink
- **Selling Price per Unit:** ₱50
- **Fixed Overhead Cost:** ₱8000

Ingredients			
Name	**Available Qty**	**Required per Product Unit**	**Cost Per Unit (₱)**
Water	**500L**	**0.3L**	**5**
Sugar	**30kg**	**0.04kg**	**20**
Caffeine Powder	**500g**	**0.2g**	**2.5**
Citric Acid	**2000g**	**2g**	**0.3**
Flavoring Syrup	**2000mL**	**5mL**	**1**
Bottle and Cap	**1000pcs**	**1pc**	**5**
Label Sticker	**2000pcs**	**1pc**	**2**

3.1. Hand Calculations:

1. **Maximum Producible Units:**
    - Water: [500/0.3] = **1666 units**
    - Sugar: [30/0.04] = **750 units**
    - Caffeine Powder: [500/0.2] = **2500 units**
    - Citric Acid: [2000/2] = **1000 units**
    - Flavoring Syrup: [2000/5] = **400 units**
    - Bottle and Cap: [1000/1] = **1000 units**
    - Label Stickers: [2000/1] = **2000 units**
    - **Maximum Producible Units =** min(1666, 750, 2500, 1000, 400, 1000, 2000) **= 400 max units**

2. **Total Raw Cost:**

    - Water: 0.3 × 400 × 5 = **₱600**
    - Sugar: 0.04 × 400 × 20 = **₱320**
    - Caffeine Powder: 0.2 × 400 × 2.5 = **₱200**
    - Citric Acid: 2 × 400 × 0.3 = **₱240**
    - Flavoring Syrup: 5 × 400 × 1 = **₱2000**
    - Bottle and Cap: 1 × 400 × 5 = **₱2000**
    - Label Stickers: 1 × 400 × 2 = **₱800**
    - **Total Raw Cost = 600 + 320 + 200 + 240 + 2000 + 2000 + 800 = ₱6160**

3. **Total Overall Cost:**
    - **Total Overall Cost =** Total Raw Cost + Fixed Overhead Cost = ₱6160 + ₱8000 **= ₱14,160** - *Total overall Cost*
4. **Cost per Unit:**
    - **Cost per Unit =** Total Overall Cost / Maximum Producible Units = ₱14,160 / 400 **= ₱35.40 -** *Cost per Unit*
5. **Total Revenue:**
    - **Total Revenue = S**elling Price per Unit × Maximum Producible Units = ₱60 × 400 **= ₱24,000 -** *Total Revenue*
6. **Total Profit:**
    - **Total Profit =** Total Revenue - Total Overall Cost = ₱24,000 - ₱14,160 **= ₱9,840 -***Total Profit*
7. **Break-Even Units:**
    - Contribution Margin per Unit = Selling Price per Unit - Cost per Unit = ₱60 - ₱35.40 = **₱24.60**
    - Break-Even Units = [Fixed Overhead Cost / Contribution Margin per Unit] = [8,000 / 24.60] = [325.20] = **326 units**

3.2. Program Calculations:

Production Report for Energy Drink

Max producible units	400
Total raw cost	₱6160.0
Total Overall Cost	₱14160.0
Cost per unit	₱35.4
Revenue	₱24000.0
Profit	₱9840.0
Break-even units	326

Ingredient Usage Summary

Ingredient	Required per Product Unit	Cost Per Unit	Total Quantity Used	Total Remaining Unit	Total Cost
Water	0.3 l	₱5.0	120.0 l	380.0 l	₱600.0
Sugar	0.04 kg	₱20.0	16.0 kg	14.0 kg	₱320.0
Caffeine Powder	0.2 g	₱2.5	80.0 g	420.0 g	₱200.0
Citric Acid	2.0 g	₱0.3	800.0 g	1200.0 g	₱240.0
Flavoring Syrup	5.0 ml	₱1.0	2000.0 ml	0.0 ml	₱2000.0
Bottle and Cap	1.0 pcs	₱5.0	400.0 pcs	600.0 pcs	₱2000.0
Label Stickers	1.0 pcs	₱2.0	400.0 pcs	1600.0 pcs	₱800.0
			Total Raw Cost	**₱6160.0**	
			Total Overhead Cost	**₱8000.0**	
			Total Overall Cost	**₱14160.0**	

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4. Discussion of the Results

The cost-profit analysis of the "Energy Drink" production reveals key insights into the feasibility, profitability, and production constraints of the example business.

Maximum Production Capacity

From the available inventory, the most limiting ingredient was **Flavoring Syrup**, allowing for a **maximum of 400 units** to be produced. This shows that even if most ingredients are available in large amounts, the one with the smallest supply controls how many products you can make.

Cost Structure

The total **raw material cost** for 400 units is **₱6,160**, while the **fixed overhead cost** (e.g., utilities, labor, rent) is ₱8,000. This leads to a total cost of **₱14,160** for the 400-unit batch. The **cost per unit** was computed as **₱35.40**, making it a mid-range cost product depending on market benchmarks.

Revenue and Profit

At a **selling price of ₱60 per unit**, the total revenue from 400 units would be **₱24,000**, generating a **net profit of ₱9,840**. This is a **profit margin of about 41%**, showing that the product has a healthy markup over its cost.

Break-Even Analysis

The break-even point was calculated to be **326 units**, meaning that at least 326 units must be sold to cover all fixed and variable costs. This corresponds to **81.5% of total production capacity** (326 out of 400 units). It implies that a relatively high proportion of units must be sold before the business becomes profitable. However, since this is within the maximum production limit, the product is considered **financially viable**.

Key Observations

- The **Flavoring Syrup** acts as a limiting resource. If demand is high, sourcing more of it would directly increase profit potential.
- The **break-even threshold is high**, but manageable, provided sales can consistently meet or exceed that volume.
- The product remains **profitable even at partial capacity**, offering some flexibility in scaling production.

In conclusion, the production and cost analysis of the Energy Drink product demonstrates that profitability is achievable with proper cost management and inventory planning. Although most ingredients are available in large quantities, the ingredient with the smallest supply flavoring syrup limits how many units can be produced. With a total production capacity of 400 units and a break-even point of 326 units, the product can generate a good profit if sales targets are met. To improve profitability, it’s important to monitor inventory levels and ensure that critical ingredients are always in stock.

Conclusion of the Program

The Production Cost and Profit Calculator is a helpful tool for businesses that make products. It helps you figure out how many items you can make with the ingredients you have, how much it will cost, how much money you can earn, and how many items you need to sell to break even.

The program is easy to use. You just enter your product details, the ingredient amounts, prices, and overhead cost, and it does the math for you. It shows where your limits are. For example, if one ingredient runs out first, that sets the limit on how many products you can make. It also helps you see if making the product will give you profit or loss. This can guide you in setting a good selling price, managing your inventory, and planning your production.

In short, the calculator helps business owners make smart decisions by giving a clear picture of their production and profit potential.