IE 313
Supply Chain Management
Assignment 1

Q&H is a major detergent manufacturer with a monthly demand forecast for the coming year as shown in the following table (in tons).

Month	*Demand*	*Month*	*Demand*
January	280	July	291
February	301	August	220
March	277	September	304
April	310	October	295
May	285	November	302
June	278	December	297

Capacity at Q&H is governed by the number of hours the line runs. The production line requires a team of 100 employees. Employees are paid $10 per hour for regular time and $15 per hour for overtime. Each ton of detergent requires one hour of operation of the line. The plant works 20 days a month, two shifts a day, and eight hours a shift of regular time. Overtime is restricted to a maximum of 20 hours per employee per month. Q&H uses a constant workforce plan.

Each ton of detergent uses $1,000 wotrth of material. Carrying a ton of detergent in inventory from one month to the next costs $100. Q&H starts with 150 tons in inventory and wants to end with the same level. During intermediate months, Q&H wants at least 100 tons of inventory and wants to consider only plans without any stockouts.

1. Formulate a mathematical programming problem for Q&H's aggregate production planning problem with the objective of minimizing total costs for the next 12 months. Interpret the optimal production plan.

Detergent is currently sold to retailers for $2,600 per ton. The price is fixed and will not change throughout the upcoming year.

2. Re-solve your model from part (1) with the objective of maximizing profit (revenue minus cost). Interpret the optimal production plan.

Q&H wants to **plan a promotion** for its detergent. One promotion option is to drop the sale price by $260 per ton (from $2,600 to $2,340) for one month in the year. There are **two effects** of this action: (i) the demand in the month of promotion increases by 50%, **and on top of that** (ii) 20% of the demand from the next two months are attracted to the month of promotion (called *forward buying*). For example, if Q&H makes the promotion in the first month, the demand (forecast) of first three months (280,301,277) becomes (535,6, 240,8, 221,6).

3. What is the optimal production plan and optimal profit if Q&H promotes in April?
4. What is the optimal production plan and optimal profit if Q&H promotes in August?

The detergent market is shared between Q&H and its competitor, Unilock. When Q&H plans its own promotion, the outcome of this action is **influenced by the action taken by Unilock**.

If **neither firm promotes**, the forecast demand for Q&H is as shown in the above table. If **Q&H promotes** in a given month but Unilock does not, Q&H sees consumption (does not include forward buying) in that month increase by 50 percent and forward buying of 20 percent from each of the two following months. If **Unilock promotes** in a given month but Q&H does not, Q&H sees consumption in the month drop by 50 percent. If **both companies promote** in a given month, neither sees an increase in consumption but both see forward buying of 25 percent from each of the two following months.

The debate within Q&H is whether to promote, and if so, whether to do it in April or August. For the following questions, assume that demand forecast for Unilock is like that of Q&H.

5. What are the profits for Q&H if Unilock promotes in April but Q&H does not promote throughout the year (it uses everyday low pricing)?
6. What are the profits for Q&H if it promotes in April but Unilock does not promote throughout the year? Comment on the benefit from promoting versus the loss from not promoting if the competitor does.
7. What are the optimal production plan and profits if both firms promote in April?
8. What are the optimal production plan and profits if both firms promote in August?
9. What are the optimal production plan and profits if Q&H promotes in April but Unilock in August?
10. What are the optimal production plan and profits if Q&H promotes in August but Unilock in April?
11. What is the best decision for Q&H if it can coordinate its decision with Unilock?
12. What is the best decision for Q&H if it wants to maximize its minimum profits no matter what Unilock does?
13. Assume that Q&H has a third-party subcontractor willing to manufacture detergent as needed for $2,300 per ton. Repeat the analysis for all questions (5) through (13).