Title: Aggregate Production Planning

# Problem Description:

A manufacturer “ABC Private Limited” wants to minimize operations cost of one of its manufacturing unit where 15 different products (P1 to P15) are manufactured. Irrespective of the product category, every item undergoes two sequential process steps, S1 and S2 as shown below in the flow diagram. Your task is to come up with a daily production plan for the next year which satisfies the manufacturer’s requirements.

Raw Material

WIP

Finished Good

S1

S2

1. There are 8 identical machines for S1 (M11 to M18) and 6 identical machines (M21 to M26) for S2. The machines used for S1 cannot be used for S2 and vice versa.
2. It takes 3 minutes per item to complete S1 step and 2 minutes per item to complete S2 step for any product category.
3. There is no limit on raw materials availability.
4. Scrap / defect quantity can be assumed to be zero.
5. The products do not have any expiry period.
6. Machine breakdown duration can be assumed to be zero. Hence, all machines are available for 24 hrs a day.
7. There is setup time (delay in hours) involved while switching production from one product category to another for both S1 and S2 steps. The details are given in ‘product\_details.csv’ file (‘S1\_setup\_time’ and ‘S2\_setup\_time’). Setup change at any machine can only be done once at the start of day.
8. All workers are skilled to produce any product at any machine.
9. 1 worker per machine need to be present during production as well as setup.
10. Available normal working hours per day is 240 and available over time working hours per day is 120. Over time wage is Rs. 50/hr
11. There is no inventory limit for raw materials, WIP and finished goods.
12. Inventory cost is Rs. 0.5/day/item for both WIP and finished goods. At the end of day, items in inventory is computed and one day inventory cost is charged for them.
13. Initial inventory levels for both WIP and finished goods (FG) for all product categories are provided in ‘product\_details.csv’ file (‘WIP\_initial’ and ‘FG\_initial’).
14. Production quantity of any product at process step 2 is constrained by the available WIP inventory at the end of previous day (Steps S1 and S2 cannot be performed on the same item on the same day).
15. Demand forecast for all 15 products for next 1 year (week 2 to week 53) is given in ‘demand\_forecast.csv’ file.
16. Actual demand follows triangular distribution with parameters (0.95\*f, f, 1.05\*f) (rounded to nearest integer) where f is forecasted demand of any product for any week.
17. There is zero lead time for demand fulfilment. For week-2 demand, items are dispatched at the end of 7th day, for week-3 demand, items are dispatched at the end of 14th day and so on till 364th day (for week-53 demand).
18. Non-fulfilment of demand for any product leads to lost sales (no back order). Cost of lost sales is Rs. 1000/item.
19. On the first day of production, it is assumed all the machines are available and hence setup cost will be incurred if a machine starts producing.

# Evaluation Criteria:

Solution has to be submitted in the format shown in ‘sample\_submission.csv’ file. Only a sample production plan of 3 days period is shown in the file, but your submission should have production plan from day 1 to day 364. ‘Mij\_product’ represents Product\_ID for the items getting produced at step i in machine j in each day. Similarly ‘Mij\_qnty’ represents quantity of items getting produced at step i in machine j in each day. Both the fields can be kept blank if a machine is not used in a day. The evaluation metric is total cost (details below) on actual demand data (will only be available with jury) for the 1 year period for which forecasted demand is provided. If your solution is not conforming to one or multiple constraint(s) listed in problem statement, penalty will be added to calculated total cost as mentioned below. Candidates are encouraged to solve the problem using computationally inexpensive heuristic.

**Cost Function Definition:**

**total\_cost =** IC\*inventory + EPC\*excess\_production + LSC\*lost\_sales + OTC\*overtime + EWC\*excess\_work\_hours + EMC\*excess\_machine\_hours

where,

**IC =** inventory cost = Rs. 0.5 per day per item

**EPC =** penalty for producing more finished goods than available WIP inventory at the end of previous day = Rs. 10000 per item

**LSC =** Lost sales cost = Rs. 1000 per item

**OTC =** Cost of overtime work = Rs. 50 per hour

**EWC =** Cost of excess work hours beyond the available 240 hrs of normal work and 120 hrs of overtime work per day = Rs. 100000 per hour

**EMC =** Cost of excess machine hours beyond the available 24 hrs per machine per day = Rs. 100000 per hour

**inventory =** total item days in inventory (WIP and FG combined) at the end of year. E.g. if 10 items are there in inventory at the end of every day, inventory value will be 364\*10 = 3640

**excess\_production =** total finished goods produced throughout the year without satisfying condition 14 mentioned in problem statement. E.g. if there are 300 WIP items present in inventory for product ‘P1’ at the end of day 1 and if 400 items of P1 is produced at process step S2 on day 2, then 100 (400-300) items will be added to ‘excess\_production’ variable.

**lost\_sales =** total accumulated lost sales at the end of year (due to less availability of finished goods compared to actual demand)

**overtime =** total accumulated overtime working hours at the end of year

**excess\_work\_hours =** total accumulated excess work hours (beyond 360 hours per day) at the end of year

**excess\_machine\_hours =** total accumulated excess machine hours (beyond 24 hours per machine perday) at the end of year