Case Summary:

- A company has developed a new Blender that will be produced on an assembly line.
- The assembly of this product includes 20 tasks.
- Each station that is going to be built will include a set of tasks.
- The tasks could be performed by manual or robotic stations.
- No more than one type of processor could be assigned to the stations, i.e. a robot and worker cannot work at the same station.
- The management wants to build an assembly line to produce the blenders with minimum investment cost for the following alternative cycle times:
  - 80,
  - 100,
  - 120 seconds.

Table 1. Task structure

Type/ tasks	Immediate predecessors	Robotic Duration (seconds)	Manual Duration (seconds)
1	-	10	20
2	1	30	40
3	1	20	50
4	3	10	20
5	4	40	80
6	5	30	40
7	-	10	40
8	6,7	70	90
9	8	40	50
10	9	10	40
11	9	20	30
12	9	10	20
13	9	10	30
14	7	30	30
15	10,11,12	20	30
16	15	30	60
17	13,16	20	50
18	13,15	10	20
19	18	30	40
20	19	20	40

Table 2. Investment costs for stations with different number of processors (x1000 $)

Type / # of processors	Robotic	Manual
1	100	50
2	180	100
3	250	150
4	340	200

a) Build a mathematical model for this assembly line balancing problem which aims to minimize total investment cost and determine the assembly line for the above given alternative cycle times, namely 80, 100 and 120 seconds. By analyzing the trade-offs (if exist), compare these alternatives and make a suggestion to the firm.

b) The management suddenly realizes that there will be a large difference between the variable costs of using robotic and manual processors. The daily costs of using a single processor are $3 and $15 for robotic and manual processors, respectively.

Build a mathematical model for this assembly line balancing problem considering both the investment costs and the variable costs of using processors, and determine the assembly line for the above given alternative cycle times, namely 80, 100 and 120 seconds. You may assume that the assembly lines will be used for 5 years once they are built. You may also assume that there are 250 working days in a year and 8 working hours in a day. The costs of using both manual and robotic processors are charged based on the number of working days that they are used, regardless of the idle time of the processors in a cycle. By analyzing the trade-offs (if exist), compare these alternatives and make a suggestion to the firm.