Level 3 - Principal Learning
Engineering (ENG3U6)

SAMPLE INTERNALLY ASSESSED UNIT

UNIT 6 - PRODUCTION AND MANUFACTURING

Diploma – Principal Learning
Engineering

Level 3 / Unit 6
Production and manufacturing (ENG3U6)

Sample Internally Assessed Unit

CANDIDATE'S WORK

Level 3 Unit 6: Production and Manufacturing

Task 1

Production Plan – Manufacture of Printed Circuit Boards at Matric Remote Controls

Step No.	Task	Tools or Equipment needed	Materials needed	Quality Assurance actions	Quality Control actions
1	Make a stainless steel stencil for the positions of surface mount components	Laser etching machine	Stainless steel sheet	Fixture will be used to position to sheet for the stencil	Hole positions will be checked manually by comparison with the drawing
2	Silk screen application of solder paste to the printed circuit board (PCB) for surface mount components	MPM screen printer	PCB, solder paste	Programmed directly from CAD drawing to avoid operator errors. Use of two cameras to align the board on an automatic conveyor. Use of stainless steel template made in step 1 to make sure solder paste is applied in the correct place	See step 4
3	Assembling surface mount components onto the PCB using a pick and place machine	Mydata mi19 surface mount machine	Reels of electrical components, PCB with solder paste	Programmed directly from CAD drawing to avoid operator errors. Fixture used to ensure that the PCB is correctly positioned	Visual inspection of first six parts in the batch using microscope to ensure that parts are not skewed, checking against the drawing if necessary
4	Checking that the PCBs have been assembled correctly	Terradyne flying probe machine	Assembled PCB	Programmed directly from CAD drawing to avoid operator errors. Conveyor used to position PCB	Manufacturing defect analysis machine checks for open circuits, short circuits, wrong parts, missing parts, parts oriented incorrectly.

					Testing is carried out on every product.
5	Lead forming of through-hole components to have the proper spacing to be inserted in the board	Manual process	Loose components		
6	IC programming	Computer	Integrated circuits (ICs)		See task 10.
7	Label making, including any details to be printed on components	Computer and printer	Labels, components requiring printing	Chain belt used to position components for printing	First label will be visually checked by operator
8	Assembly of through hole components onto the PCB	Contact machine	Electrical components, assembled PCB	Positioning jig used. Camera used to provide larger image, light beam shows where the part should be placed, component details shown on screen	See tasks 10 & 11
9	Soldering of through hole component boards	Automatic wave solder bath	Assembled PCB, solder	CNC process using a library of data for different products. Conveyor used to ensure board is positioned correctly	All soldered boards are visually checked to make sure that all leads have been soldered. See also tasks 10 & 11
10	Functional testing of the completed board	Multimeter, oscilloscope	Completed PCB	N/A	Multimeter for circuit outputs, oscilloscope for output of IC components. Testing is carried out on a statistical sample of the batch (6 per 1000).
11	Final visual testing & certification	Microscope	Completed PCB	N/A	Visual checking that components are in the right place. Testing is carried out on a statistical sample of the batch (6 per 1000).

Level 3 Unit 6: Production and Manufacturing

Task 2

Timing Plan for the manufacture of the first batch

Step No.	Task:	Equipment needed:	Day:																																								Critical Quality Control activities:	Additional notes:
			M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F	M	Tu	W	Th	F		
1	Time from order to delivery for the Printed Circuit Board, 4 week lead time, source: APM)	Bought in item																					Q																				Visual check by goods inwards	
2	Making the stainless steel stencil (3 week lead time, source: The Laser Centre)	Bought in item																					Q																				Visual check against drawing by goods inwards	
3	Buying in the standard electrical components (48 hour delivery, source: Rapid Electronics)	Bought in item																					Q																				Check of catalogue number by goods inwards	
4	Application of solder paste	MPM screen printer																																									Checked by Step 6	Based on 120 PCB/hr (10 min cycle for batches of 12)
5	Surface mounting of electrical components	Mydata Mi19																								Q																	Visual inspection of first 6 parts using microscope; checked by step 6	Based on 21000 components/hr, average 30 components/board, with 4 hour setup
6	Checking the parts are assembled correctly	Terradyne																								Q	Q	Q															Quality Control Activity	Based on 120 PCB/hr (10 min cycle for batches of 12)
7	Lead forming of through hole components	Manual process																																										Advised by teacher
8	Programming of Integrated circuits	Manual process																																									Checked by tasks 12 & 13	Advised by teacher
9	Label making and printing	Manual process																						Q																			Visual check of first label by operator	Advised by teacher
10	Assembly of through hole components	Contact machine																																									Checked by tasks 12 & 13	Based on 250 components/hr, average 5 components/board, with 1 hour setup
11	Soldering of through hole components	Solder bath																																									Checked by tasks 12 & 13	Continuous process, capable of 720 PCB/hour
12	Functional testing of the completed board (6 per 1000)	Multimeter																																	Q	Q	Q						Quality Control Activity	
13	Visual inspection & certification (6 per 1000)	Manual process																																				Q	Q				Quality Control Activity	
14	Dispatch to customer	Manual process																																							Q		Dispatcher to check quantity and address	

Notes:

Shaded areas are the planned timings, Q indicates a quality check at this point. As it says in the case study, each machining process is assumed to have 1 day of inventory before it in the above plan
Timings for bought in parts were researched by asking possible suppliers. Timings for machining were based on components counted during the product analysis, information given in the case study and looking up the types of machines on the internet.
Total Lead Time 39 working days (7 weeks 4 days)

Level 3 Unit 6: Production and Manufacturing

Task 3

Report to the Sales Director
Production Changes Required to Make a Small Batch

When considering how the manufacture of the sample batch of 100 remote controls is different from normal manufacture, we need to know:

- How the scale of manufacture affects the manufacturing system and the processes used in general
- The benefits of CAD, CAM and CAE
- The implications during production of the sample batch at our company

How The Scale Of Manufacture Affects The Manufacturing System And Processes Used In General

Scale of manufacture means the number of parts products that have to be made.

If vary large quantities of the same parts are to be made, such as cars, these might be made by mass production on an assembly line. The key feature of mass production is that all the products are the same. Mass production systems normally use a lot of CNC machines, as these are able to produce the parts faster and more consistently than manual processes. Mass production may also use automatic work handling devices to load the machines or conveyors to move the parts along the line. The high cost of these machines and automation can be divided between the large number of parts to be made.

If the products need to be made in large numbers but may need to be changed, like special parts for rally car engines, then they might be made by large batch production. Large batch production normally uses a lot of CNC machines, as these are able to produce the parts faster and more consistently than manual processes. The parts may be held in the machines by specially-made jigs and fixtures, and checked using Go-No Go gauges and templates. The cost of these production aids is met by the number of parts to be made, but it would not be cost effective to fully automate the processes like in mass production.

If the products need to be made in small numbers, like parts for formula one cars, then they might be made by small batch production. This is similar to large batch production but the number of CNC machines used is slightly less and the number of manual machines more. There may be less jigs and fixtures, depending upon the number of parts to make.

If products are to be made as one-off's, like prototype cars, then they will mainly be made using manual machining processes and put together by hand. Parts made this way cost more than those made in batches, which in turn cost more than those made by mass production.

In summary, the more parts that are to be made, the more automation is used and the less manual labour. Parts made in large quantities can use more automation as the cost can be divided between the number of parts to be made. More automation means that parts can be made to the same quality but much faster, so they cost less.

The Benefits Of CAD, CAM And CAE

CAD means Computer Aided Design, which means that the drawings of the parts are done using computers. CAM means Computer Aided Manufacture, which means that the parts are made using Computer Numerical Control machines. CAE means Computer Aided Engineering, which means that CAD is used to draw the part and then it is sent to CNC machines to be made by CAM.

The benefits of CAD are:

- You can make models of the circuit to check that it works before you make it.
- Drawings can be made by editing existing drawings, which speeds up the process.
- Drawings can be changed more easily, as you don't have to restart them as you do if they have been done by hand.
- Drawings are easier to store.

The benefits of CAM are:

- The machines work faster than manual machines.
- All the parts are made the same so there are less quality problems.
- CAM machines can work without taking breaks or holidays.

The disadvantages of CAM machines are that they cost more than manual machines and take time to programme.

The benefits of CAE combine those for CAD and CAM. By putting CAD and CAM together, it is possible to design and make products faster, so they get to the market quicker.

The Implications During Production Of The Sample Batch

When making the remote control circuits, we normally use large batch production. This is because different customers want different versions of the product, so it is not suitable for mass production.

For our normal production, we use CAM machines to put the surface mount parts on and check the PCBs, as they work much faster than we could do it manually and the cost can be divided between the large numbers of remote controls in each batch. These machines work straight from the CAD drawings, which means that we are using CAE. As well as speeding up how fast products get to market, this helps to ensure that we are always meeting the needs of the design, so it means quality problems are reduced.

By using CAE, this means that we can make about 3,000 remote controls each day and that we can quickly bring most batches from design to making, in a lead time of 7 weeks 4 days.

For the sample batch, we would not be able to use the CNC machines as the batch is too small. Because it takes 4 hours to change over a machine, it would mean that we would not be able to make anything else on that day, so we would loose production of 2,900 remote controls.

The processes that we would need to use instead and the implications of using these processes are listed on table 1. We would still need to produce a CAD design for these products. We would not need to pay for a stainless steel template but it would probably cost more to buy the PCBs as these would also have to be made specially.

The effect of using the different process will be to increase the number of quality problems. Even though we wouldn't make the stainless steel template, the lead time to complete the batch will also be increased from our normal 7 weeks 4 days to 9 weeks 2 days. It will also mean that the work to do the batch will change from a total of about 34 man days for a batch of 2000 to about 25 man days for the batch of 100, i.e. from about 8.2 minutes per remote control to about 120 minutes per remote control.

Level 3 Unit 6: Production and Manufacturing

Task 3, Table 1

Production Plan – Manufacture of Printed Circuit Boards at Matric Remote Controls

Step No.	Task	Tools or Equipment normally used	Tools or equipment that will be used for the sample batch	Implications
1	Make stencil for solder paste	Laser etching machine	Not done	Defect rate will be much higher without the template, meaning more risks of product failure and rework.
2	Application of solder paste to the printed circuit board	MPM screen printer	Not done (see step 3).	
3	Assembling surface mount components onto the PCB	Mydata mi19 surface mount machine	Manual soldering	Less precision and more solder applied, so the boards will not look as professional. More risk of solder bridges and heat damage to components, increasing defect rate. Manual soldering will take about 10 days, compared to 1 day using the CNC machine.
4	Checking that the PCBs have been assembled correctly	Terradyne flying probe machine	Manual testing using a multimeter and an oscilloscope. Full batch to be tested.	Manual testing will take about 5 days, compared to less than 1 day using the CNC machine. The first four days of this could be done at the same time as the soldering was going on.
5	Lead forming of through-hole components	Manual process		Same process, but would only need 1 day for a batch of 100.
6	IC programming	Computer		Same process, but would only need 1 day for a batch of 100. Note: requires control programme to be developed, estimated 1 day.
7	Label making, including any details	Computer and printer		Same process , but would only need 1

	to be printed on components			day for a batch of 100 – note: requires CAD details of the product
8	Assembly of through hole components onto the PCB	Contact machine		Same process , but would only need 1 day for a batch of 100 – note: requires CAD details of the product
9	Soldering of through hole component boards	Automatic wave solder bath		Same process, but would only need 1 day for a batch of 100
10	Functional testing of the completed board	Multimeter, oscilloscope		Same process, but should test the full batch rather than just a sample.
11	Final visual testing & certification	Microscope		Same process