1a) EOQ formula:

$$EOQ = \sqrt{\frac{2 \times 12{,}000 \times 1{,}000}{20}} = \sqrt{1{,}200{,}000} \approx 1{,}095 \text{ units}$$

However, as the shelf-life of the product is only a month, 95 units would be discarded if this much was ordered. Instead the optimal order quantity is min{1000, 1095} = 1, 000 units. That is, the store has to place 12,000/1000 = 12 orders /year

Approximately one order per month

Marking guidance:

- Correct EOQ formula, Correct substitution, Correct interpretation

1b)

$$\text{TC}\ (Q) = \frac{Q^*}{2} \times C_H + \frac{D}{Q^*} \times C_s + 50 \times D$$

$$\text{TC}\ (Q) = \frac{1{,}000}{2} \times 20 + \frac{12{,}000}{1{,}000} \times 1000 + 50 \times 12{,}000$$

$\text{TC}\ (Q) = 10{,}000 + 12{,}000 + 600{,}000 = 622{,}000$

1c) In-house production vs outsourcing

Advantages of in-house production

- Greater control over quality and freshness of the product
- Reduced dependency on suppliers
- Potential long-term cost savings

Disadvantages

- High capital investment
- Loss of supplier economies of scale
- Increased operational complexity
- Risk of underutilised capacity

Marking guidance:

- Balanced discussion
- Operations-focused arguments
- Clear comparison

1d) Competitive priorities and competitive advantage
Key competitive priorities:

- Cost – lean operations, economies of scale (e.g. Ryanair)
- Quality – consistency, reliability (e.g. Toyota)
- Delivery – speed and dependability (e.g. Amazon)
- Flexibility – product and volume flexibility (e.g. Zara)
- Innovation – new products/processes (e.g. Apple)

Operations can create advantage by:

- Aligning processes with strategy
- Making trade-offs explicit
- Supporting market positioning

Marking guidance:

- Understanding of priorities
- Clear link to operations
- Appropriate examples

1e)

- Make-to-Stock (MTS): Customers are not willing to wait for production. Therefore, goods made to be placed in stock prior to receiving an order; typical of commodities and continuous processing, some line production; Efficient production, but risk of obsolescence/high stock cost
- Assemble-to-Order (ATO): Customers value customisation and willing to wait for the assembly. Producers hold components stock to assemble an order as required by the customer; typical of line/ batch production; Responsive for customised products, but still cost of stock
- Make-to-Order (MTO): Customers value customisation and are willing to wait even longer for the product. Material ordered and product or service made only after the buyers order is received, Line, batch and job shop production; No FGI cost, but potentially less efficient production
- Engineer-to-Order (ETO): Product designed and built to customer order; typical of projects, some job shop

Strategy	**Description**	**Example**	**P:D Ratio**
MTS	Produce to forecast	FMCG goods	P:D>1
ATO	Assemble from modules	PCs	P:D =1 (close to 1)
MTO	Produce after order	Furniture	P:D<1
ETO	Design & produce	Construction	P:D<<1

Marking guidance:

- Correct definitions
- Accurate P:D interpretation

- Relevant examples

2a)

Example Digital Solutions	Description	Operational Problem Addressed	Expected Impact
ERP / MRP-integrated system	Integrates demand, inventory, and supplier data in real time	Lack of visibility, delayed replenishment	Reduced stock-outs, improved fulfilment reliability
Automated reorder alerts	Triggers purchase orders when inventory reaches threshold	Manual ordering delays	Faster response to demand spikes
Digital dashboards	Real-time monitoring of demand, queues, and supplier performance	Poor decision-making during weekends	Improved responsiveness and planning
Barcode / RFID tracking	Real-time tracking of components across supply chain	Inventory inaccuracies and handling errors	Reduced errors, improved inventory accuracy
Supplier performance analytics	Tracks lead-time and quality variation	Unreliable supplier deliveries	Improved supplier coordination and quality

Marking guidance:

- Clear digital solution described
- Strong link to bottlenecks and service consistency

2b)

DMAIC Stage	Purpose	Application to Delta Electronics
Define	Identify problem and objectives	Weekend delays, inconsistent order fulfilment, quality variation; objective to improve supply reliability and reduce delays
Measure	Collect reliable performance data	ERP collects demand volumes, lead times, defect rates, queue times
Analyse	Identify root causes and bottlenecks	Data reveals component shortages and supplier lead-time variability
Improve	Implement process improvements	Automated reordering, safety stock optimisation, supplier alerts
Control	Sustain improvements over time	Dashboards, SPC charts, standard procedures

Marking guidance:

- For each stage Correct DMAIC structure and the relevant applied example

2c)

Given:

- Target = 1.00 mm
- Specification limits = 0.95–1.05 mm
- Mean = 1.02 mm
- Standard deviation = 0.02 mm

Three Sigma limits:

- Lower = 1.02 − 3(0.02) = 0.96 mm
- Upper = 1.02 + 3(0.02) = 1.08 mm

Comparison:

- LSL = 0.95 < 0.96 → OK
- USL = 1.05 < 1.08 → NOT OK

Conclusion:

- Process is not capable under Three Sigma
- Risk of defects on upper side
- Improvement required (reduce variation or recenter mean)

Marking guidance:

- Correct calculations
- Correct interpretation and conclusion

2d)
Given and assumptions:

Assumption	Description
Demand	Constant weekly demand
Lot sizing	Fixed lot size as given
Inventory	All current stock available at start of Week 1
Safety stock	None assumed
Lead times	As stated in the question

Step 1- Weekly Gross Requirement

Component	Units per Sensor	Weekly Demand (Sensors)	Gross Requirement / Week
Microcontroller	1	50	50
PCB	1	50	50

Sensor Module	2	50	100

Step 2- Net Requirements and Planned Orders

Microcontroller (Lead Time = 2 weeks, Lot Size = 50)

Week	Gross Req.	Opening Stock	Net Req.	Planned Order Receipt	Planned Order Release
1	50	100	0	–	–
2	50	50	0	–	–

PCB (Lead Time = 1 week, Lot Size = 100)

Week	Gross Req.	Opening Stock	Net Req.	Planned Order Receipt	Planned Order Release
1	50	200	0	–	–
2	50	150	0	–	–

Sensor Module (Lead Time = 1 week, Lot Size = 150)

Week	Gross Req.	Opening Stock	Net Req.	Planned Order Receipt	Planned Order Release
1	100	300	0	–	–
2	100	200	0	–	–

Step 3- Planned Order Releases

No planned order receipts or releases required in Weeks 1–2

Marking guidance:

- All gross requirements
- All net requirements
- Correct planned order releases

3a) Capacity per hour:

Preparing toppings: 60 / 1.5 = 40 pizzas/hour
Dough kneading and shaping: 60 / 1.5 = 40 pizzas/hour
Adding toppings: 60 pizzas/hour
Baking: 60 / 2 = 30 pizzas/hour
Finishing and serving: 60 pizzas/hour

3b) Remaining yield:

Mass Yield Loss=Capacity*Quality Failure Rate

Remaining yield=Capacity-Mass yield loss

Preparing toppings: 40*0.25=10
Dough kneading and shaping: 40*0.15=6
Adding toppings: 60*0.10=6
Baking: 30*0.60=18
Finishing and serving: 60*0.10=6

Preparing toppings: 40-10=30
Dough kneading and shaping: 40-6=34
Adding toppings: 60-6=54
Baking: 30-18=12
Finishing and serving: 60-6=54

3c) Effective Capacity = Remaining Yield (of the step and subsequent steps) * Capacity
<u>Effective Capacities</u>
Preparing Toppings: 40*0.75*0.85*0.9*0.4*0.9 = 8.26 pizzas/h
Dough Kneading and Shaping: 40*0.85*0.9*0.4*0.9 = 11.01 pizzas/h
Adding Toppings: 60* 0.9*0.4*0.9 =19.44 pizzas/h
Baking: 30*0.4*0.9 = 10.8 pizzas/h
Finishing Touches: 60*0.9 = 54 pizzas/h

3d) Lowest Effective Capacity = **Bottleneck Capacity**= System Capacity = Preparing Toppings

Pizza Making Process at Judge Pizzeria					
Process Step	Preparing Toppings (per pizza)	Dough Kneading and Shaping (per pizza)	Adding Toppings (per pizza)	Baking (per pizza)	Finishing Touches and Serving (per pizza)
Capacity per Employee	1 Pizza	1 Pizza	1 Pizza	1 Pizza	1 Pizza
Process Time	1.5 minutes	1.5 minutes	1 minute	2 minutes	1 minute
Quality Failures (avg. occurrence per pizza)	25%	15%	10%	60%	10%
Capacity	40 pizzas/h	40 pizzas/h	60 pizzas/h	30 pizzas/h	60 pizzas/h
Remaining Yield	0.75	0.85	0.9	0.4	0.9
Effective Capacity	8.262	11.016	19.44	10.8	54
Bottleneck	**X**				

3e) Applying Lean philosophy to Judge Pizzeria means focusing on eliminating waste, improving process flow, and creating consistent value from the customer's perspective. Based on the operational observations, the following action plan addresses the key issues affecting performance and service quality.

First, the restaurant should stabilise and improve the baking process, which is the main source of quality failure and rework. This can be achieved by standardising oven settings, ensuring temperature consistency, and introducing clear visual cues or timers to control baking time. Standardising dough thickness through portioning tools or simple moulds would also reduce variation and prevent undercooked or burnt pizzas.

Second, Judge Pizzeria should introduce standard operating procedures (SOPs) for each step in the pizza-making process. These procedures should define the sequence of tasks, quality checks, and time guidelines to ensure consistency. Visual controls, such as prep boards, order tickets, and quality reference photos, can help the employee monitor progress and identify problems early.

Third, the restaurant should implement the 5S approach to improve workplace organisation. Rearranging the kitchen so that the workstations follow the natural pizza-making sequence will reduce unnecessary movement and waiting time. Frequently used tools and ingredients should be placed within easy reach to streamline workflow.

Fourth, inventory and ingredient preparation should be managed through a pull system. Ingredients can be prepared in small, standardised batches before peak hours, with visual signals (such as labelled containers) indicating when replenishment is needed. This prevents interruptions during service and reduces waste from over-preparation.

Fifth, the restaurant can focus on smoothing demand and balancing workload. Analysing customer flow data can help anticipate peak periods between 18:00 and 20:00. Temporary staffing support or role sharing during these times would prevent overburdening the single employee and reduce waiting times. During quieter hours, the employee can focus on preparation, cleaning, and maintenance to sustain flow during peaks. Alternatively, happy hour, lunch deal kind of solutions can help with smoothing the demand.

Lastly, a continuous improvement culture should be established. The employees should be encouraged to identify recurring issues and suggest improvements through simple daily reflection or feedback routines.