2.4 Manufacturing processes and scales of production

Name: _____ Class: _____ Date: _____ **Total: 30 marks**

KEY WORDS wasting • forming • additive manufacturing • computer-aided manufacture (CAM) • batch production • mass production • mass customization • just-in-time

Objective

Build the skills to answer exam questions on **manufacturing processes**: wasting, forming, additive manufacturing and joining, CAD/CAM, choosing a process, **scales of production**, mass customization, and automation, just-in-time and lean production.

You must be able to:

- classify processes as wasting, forming, additive or joining
- choose a process from the material, shape, quantity, accuracy and cost
- explain one-off, batch, mass and continuous production and why cost per item falls with scale
- calculate the break-even quantity between two production methods
- explain CAD/CAM, CNC and mass customization
- evaluate automation, just-in-time and lean production

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1 Key knowledge and worked examples

■ Process families

family	how	examples
wasting (subtractive)	remove material	sawing, drilling, milling, turning, laser cutting
forming	shape without removing material	casting, injection moulding, vacuum forming, extrusion, blow moulding
additive	build layer by layer from a digital model	FDM printing, resin printing, laser sintering
joining	fix parts together	permanent: welding, rivets, adhesives; temporary: screws, bolts, clips

CAD/CAM: the CAD model controls CNC machines (routers, lathes, laser cutters, 3D printers): accurate, repeatable parts and easy design changes, but machines cost a lot and need skilled set-up. Temporary joints make repair and recycling easier.

Choosing a process: material (thermosets cannot be remelted), shape (hollow → blow moulding; constant section → extrusion; thin sheet shell → vacuum forming; complex inside shapes → additive), quantity (a mould pays only for many parts), accuracy and finish, cost, waste and energy.

■ Scale of production

scale	example
one-off	a wedding dress, a bridge, a prototype
batch	bread, school furniture
mass	cars, phones, pens
continuous flow	oil refining, steel, paper

As scale rises, fixed costs (moulds, machines, set-up) are shared by more items, so **cost per item falls**; but the investment is large and the product is hard to change. **Mass customization** : buyers choose colours, sizes or features, and flexible automated lines make each order.

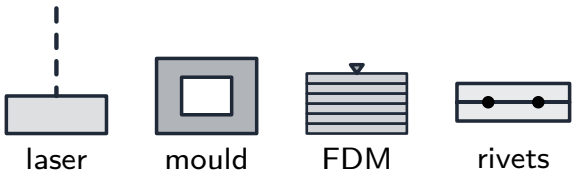
Production systems: automation (consistent, fast, works all day; costly to set up; changes jobs); **just-in-time** (little stock, but one late delivery stops the line); just-in-case (safe but costly stock); **lean production** (remove waste: overproduction, waiting, transport, extra processing, stock, movement, defects).

Worked example. 3D printing costs ¥12 per item; injection moulding costs ¥2 per item after a ¥20,000 mould. $12n = 20\,000 + 2n$, so $n = 2000$: printing is cheaper

below 2000 items, moulding above.

2 Practice

2.1 Identify the process family for each process: laser cutting, injection moulding, FDM printing, riveting. [2]

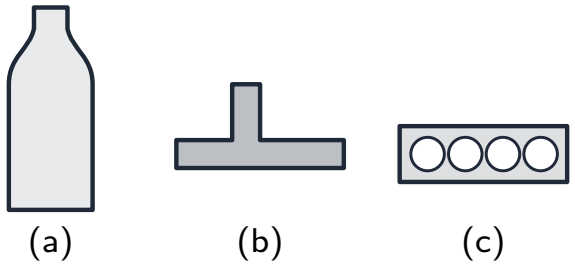


2.2 Identify a suitable process to make each product:

(a) a plastic drinks bottle; [1]

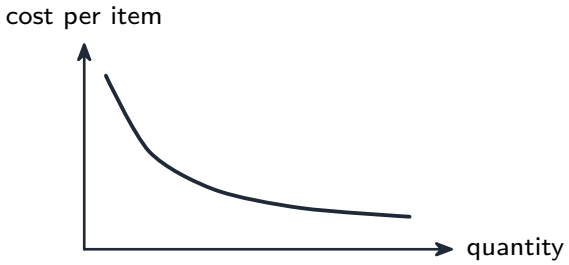
(b) a long aluminium window-frame section; [1]

(c) a thin plastic tray for chocolates. [1]

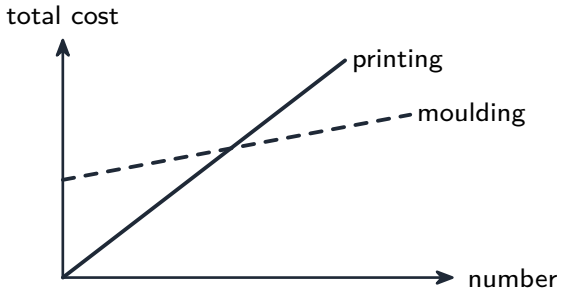


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2.3 Explain why the cost per item falls as the scale of production rises. [2]

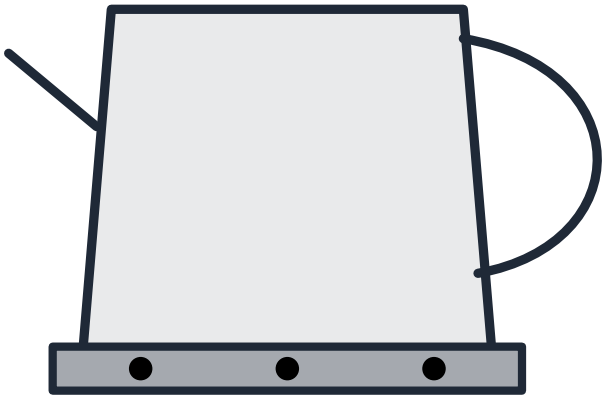


2.4 A phone stand can be 3D printed for ¥15 each, or injection moulded for ¥5 each after a mould costing ¥25,000. Calculate the number of stands at which the two methods cost the same. [3]



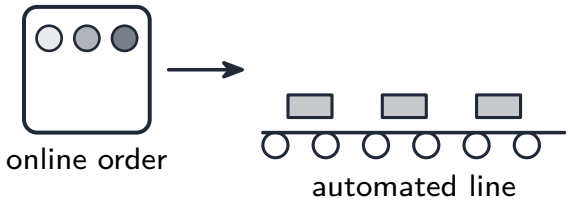
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2.5 Explain **one** advantage and **one** disadvantage of joining the case of a kettle with screws rather than adhesive. [4]



3 Exam-style questions

3.1 StrideFit makes running shoes by mass production. It plans to offer **mass customization**: customers choose colours, insoles and sizes online, and the soles are made on an automated line.



(a) Define **mass customization**. [2]

(b) Explain how CAD/CAM makes mass customization possible. [3]

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(c) StrideFit uses just-in-time stock control. Explain **one** risk of this. [3]

(d) Evaluate the plan to automate the sole production line. [8]

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Solutions

Marking: **M1** a correct method, **A1** the correct answer, **B1** an independent mark.

Each answer shows the steps, then the **result**.

2.1

laser cutting: wasting; injection moulding: forming; FDM printing: additive; riveting: joining: all four; two or three

2.2

(a) blow moulding

(b) extrusion

(c) vacuum forming

2.3

fixed costs such as moulds and machines are shared between more items; automation reduces labour per item / bulk buying lowers material costs

2.4

$15n = 25\,000 + 5n$; $10n = 25\,000$; $n =$ **2500** stands

2.5

advantage: screws can be undone; so the kettle can be repaired, or parts separated for recycling; disadvantage: more parts and assembly time; so the cost per kettle may rise / the joint may need a seal against water

3.1

(a) mass production combined with choice for each buyer; e.g. buyers choose colours, sizes or features and flexible automated lines make each order

(b) each order changes the CAD data, e.g. size and colours; the CAM software sends this straight to CNC machines / printers; so each shoe can differ with no new tools or set-up time

(c) parts arrive only when needed, so there is no buffer stock; a late delivery from a supplier, e.g. of foam, would stop the line; orders are delayed and customers may cancel

(d) award up to [8]: automation gives consistent quality and accurate soles for each custom order; works around the clock, so faster delivery; lower labour cost per pair in the long run; but high set-up cost for machines and software; needs skilled technicians for set-up and repair; some workers may lose their jobs or need retraining, which has a social cost; a breakdown stops all production; judgement: worth it if sales volume is high enough to cover the investment