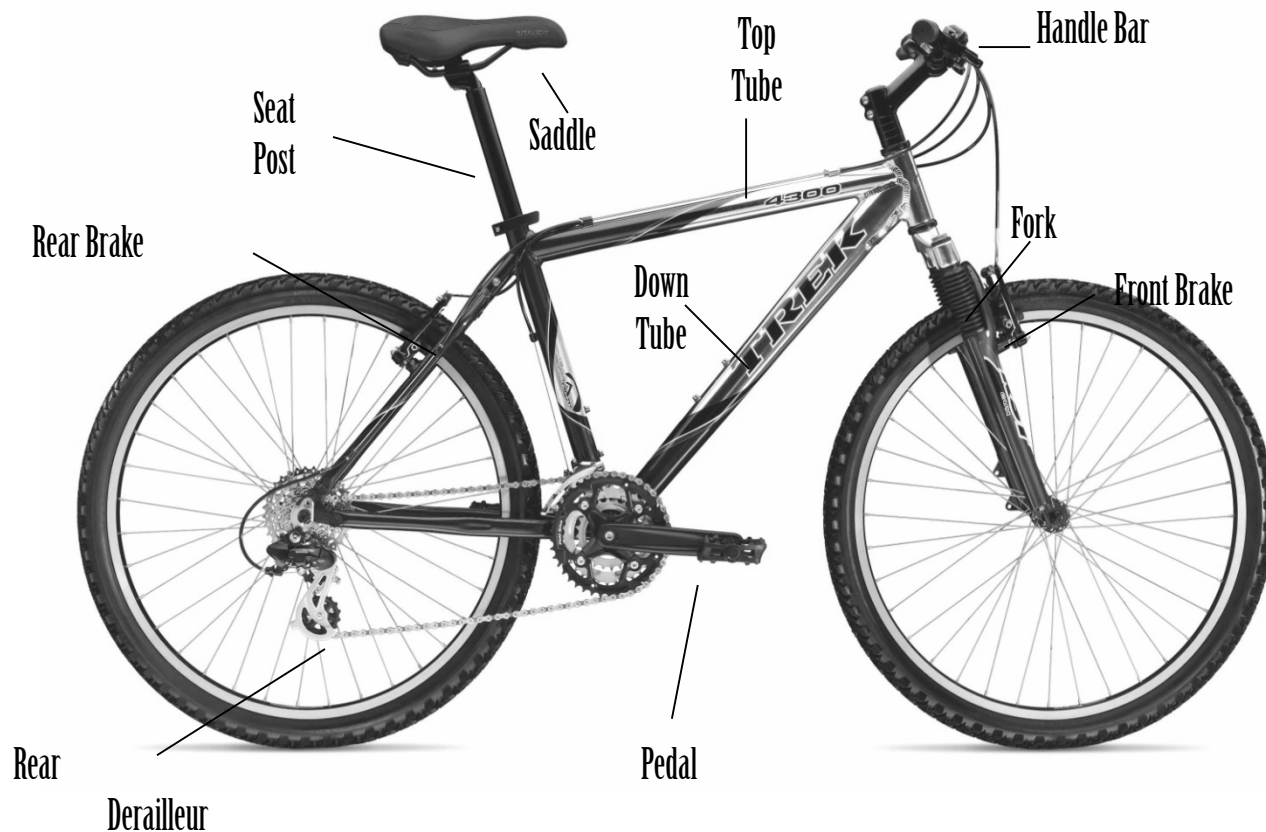


Selecting manufacturing processes

- Manufacturing process decisions
- Deformation processes
- Casting processes
- Sheet metalworking
- Polymer processing
- Machining
- Finishing
- Assembly
- Material compatibilities / Process capabilities
- Material costs, Tooling costs, Processing costs

How would we manufacture a mountain bike ?



(Courtesy of Trek Bicycle, 2002)

Manufacturing process decisions

- How do we choose the specific manufacturing processes?
- How do the selected materials influence the choice of manufacturing processes?
- Would product function or performance issues influence our choice of processes?
- What criteria should we use to select processes?
- Which criteria are more important?
- Who will make the final decisions?

Parts undergo sequence of processes

- *Primary* - alter the (“raw”) material’s basic shape or form.
 - Sand casting
 - Rolling
 - Forging
 - Sheet metalworking
- *Secondary* - add or remove geometric features from the basic forms
 - Machining of a brake drum casting (flat surfaces)
 - Drilling/punching of refrigerator housings (sheet metal)
 - Trimming of injection molded part flash
- *Tertiary* - surface treatments
 - Polishing
 - Painting
 - Heat-treating
 - Joining



Manufacturing Process/s - What are the considerations?



Part / Mfg. Process Considerations

Product Quality

Surface Finish

Accuracy

Size

Part (overall)

Feature sizes

Material Classification

Cost

Plant

Equipment

Tooling

Material

Part/Component

Production Volumes

Parts per hour/day/week

Shape Capability

Boss/depressions 1D

Boss/depressions >1D

Holes

Undercuts int./ext.

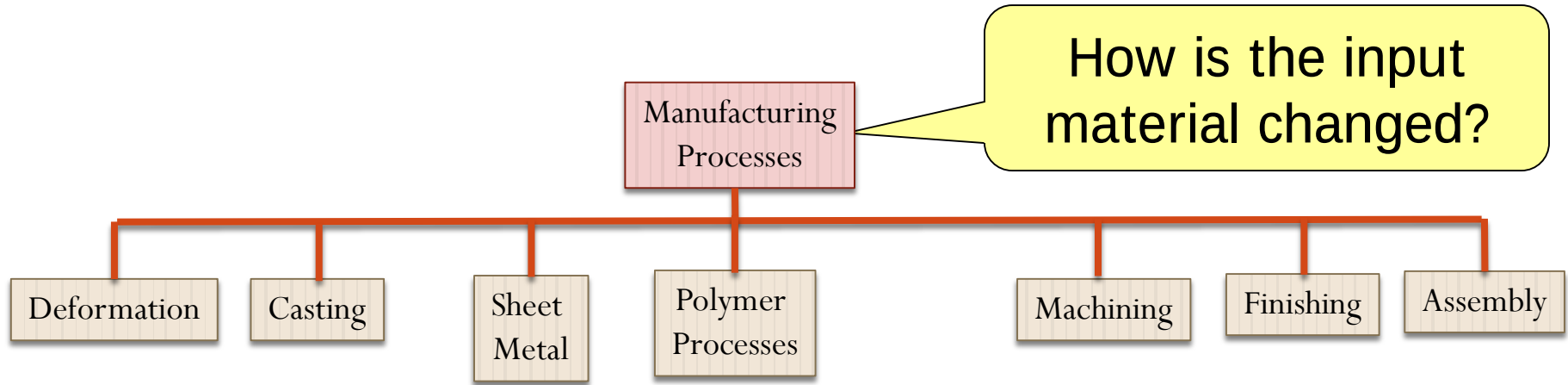
Uniformity of walls

Cross-sections – uniform/regular

Rotational Symmetry

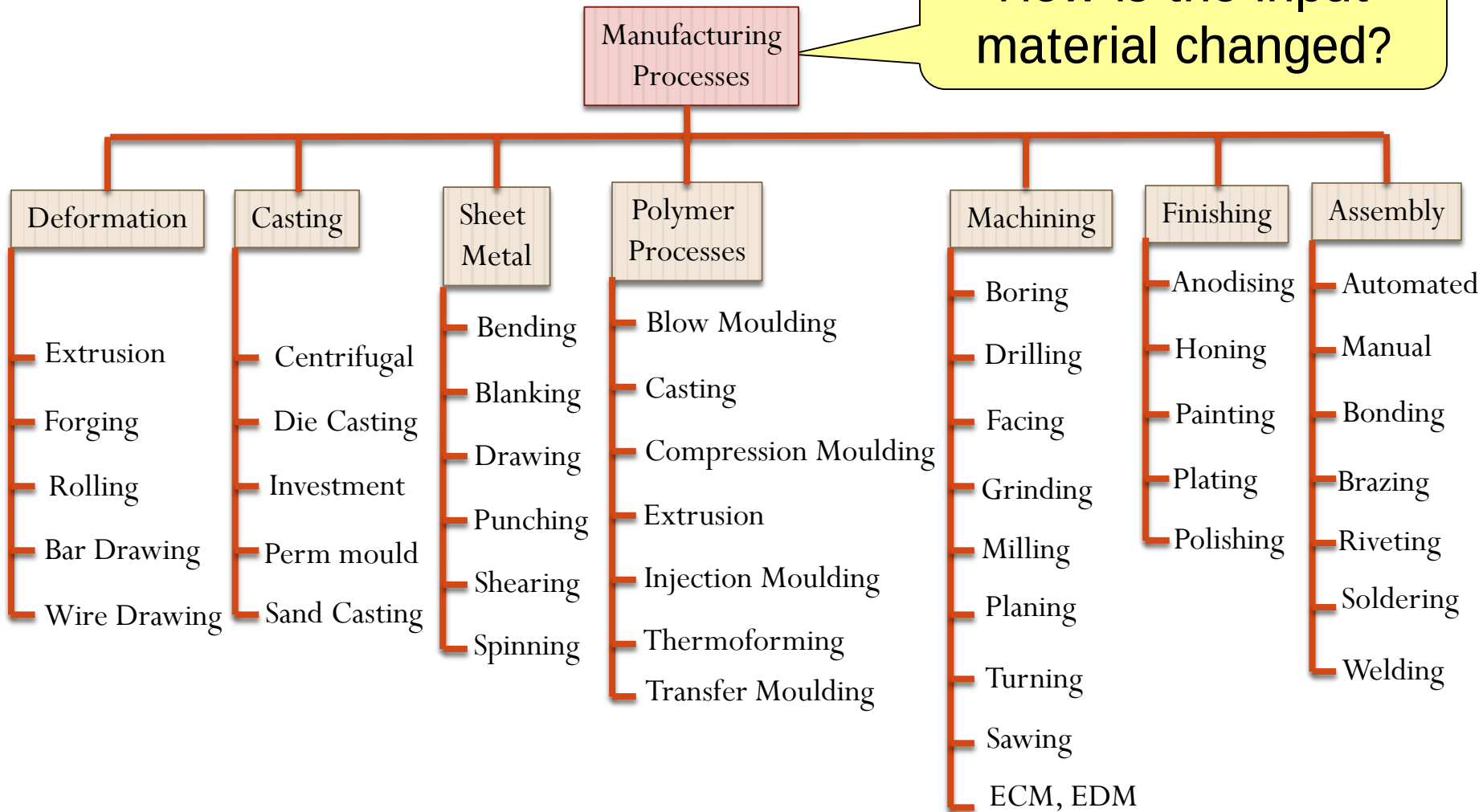
Captured Cavities

Types of manufacturing processes



Types of manufacturing processes

How is the input material changed?

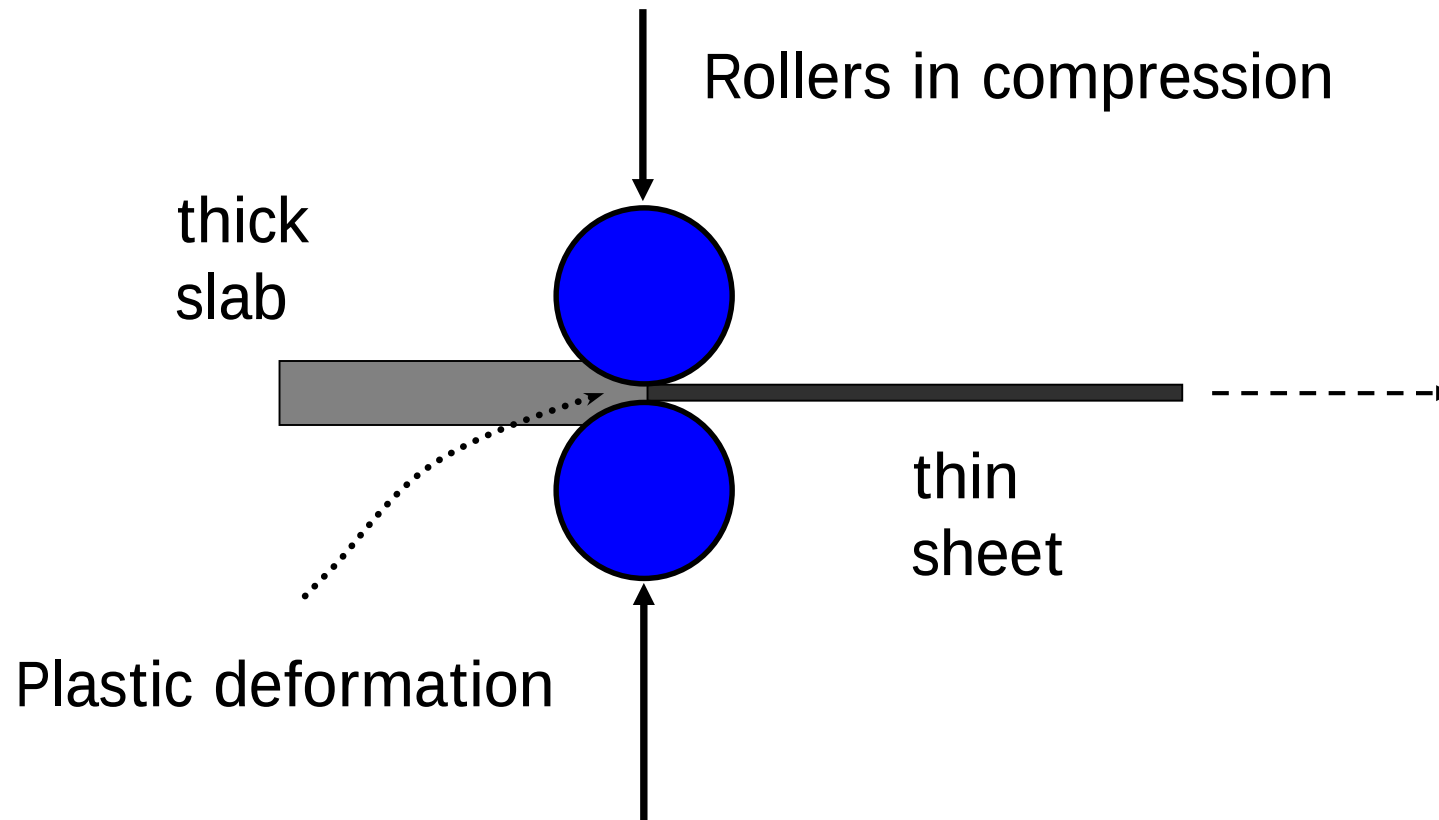


Activity – Moodle

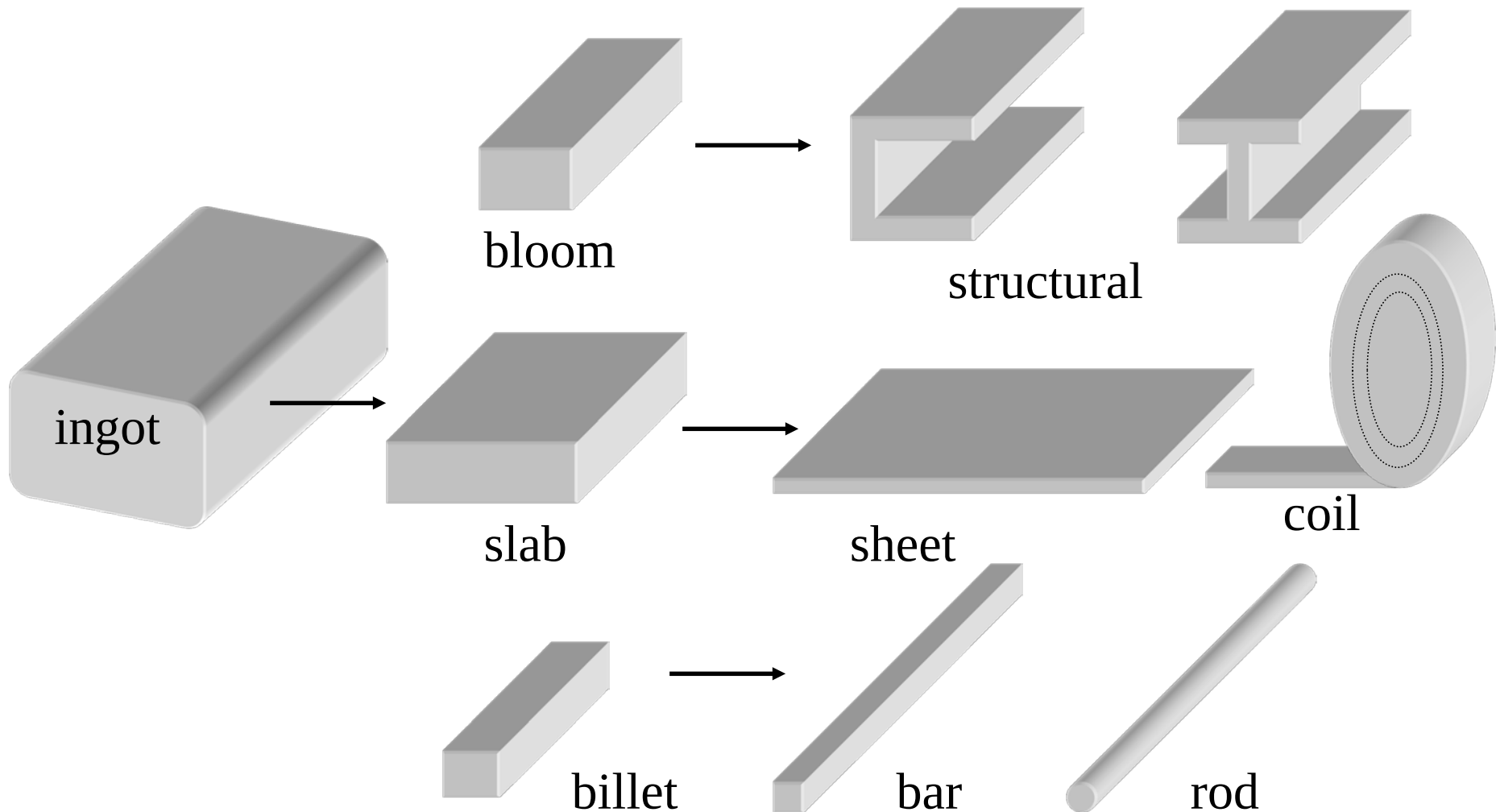
Deformation processes

- Rolling
- Extrusion
- Drawing
- Forging

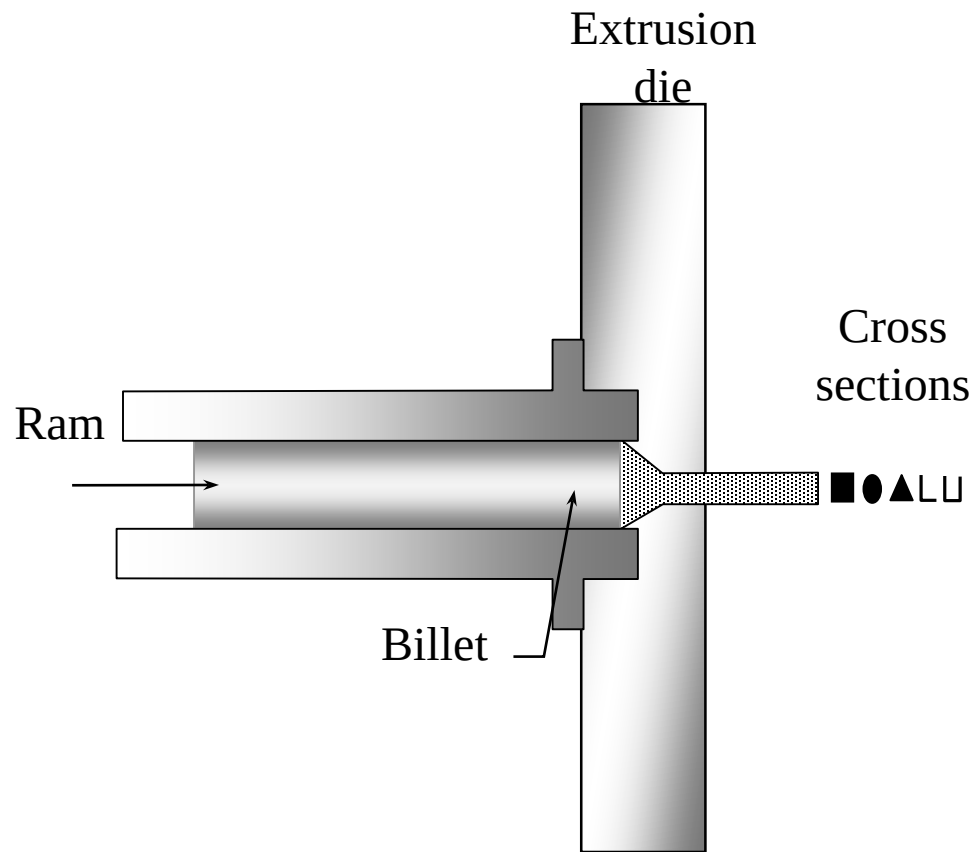
Rolling (of ductile materials)



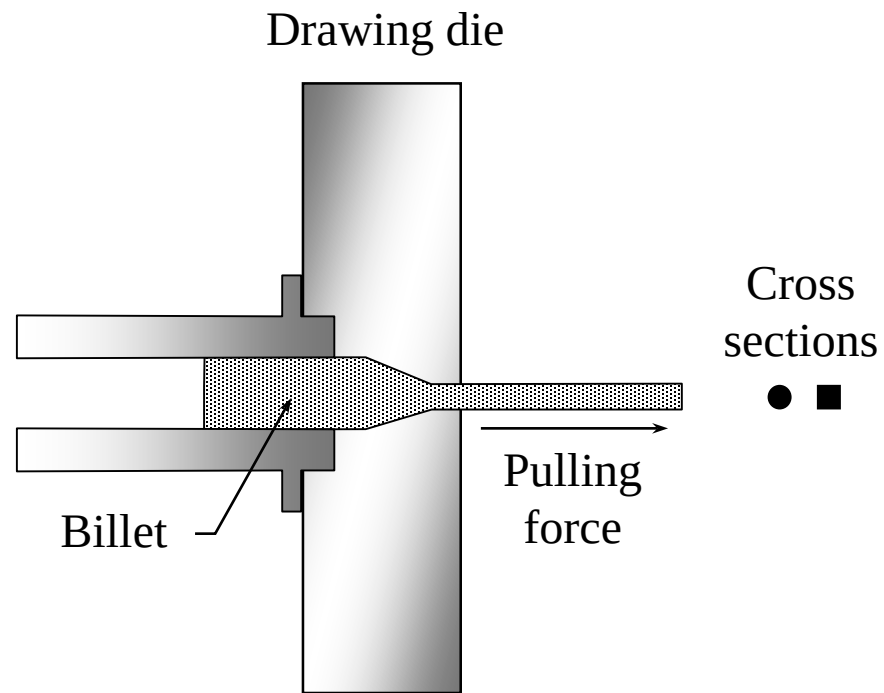
Rolling



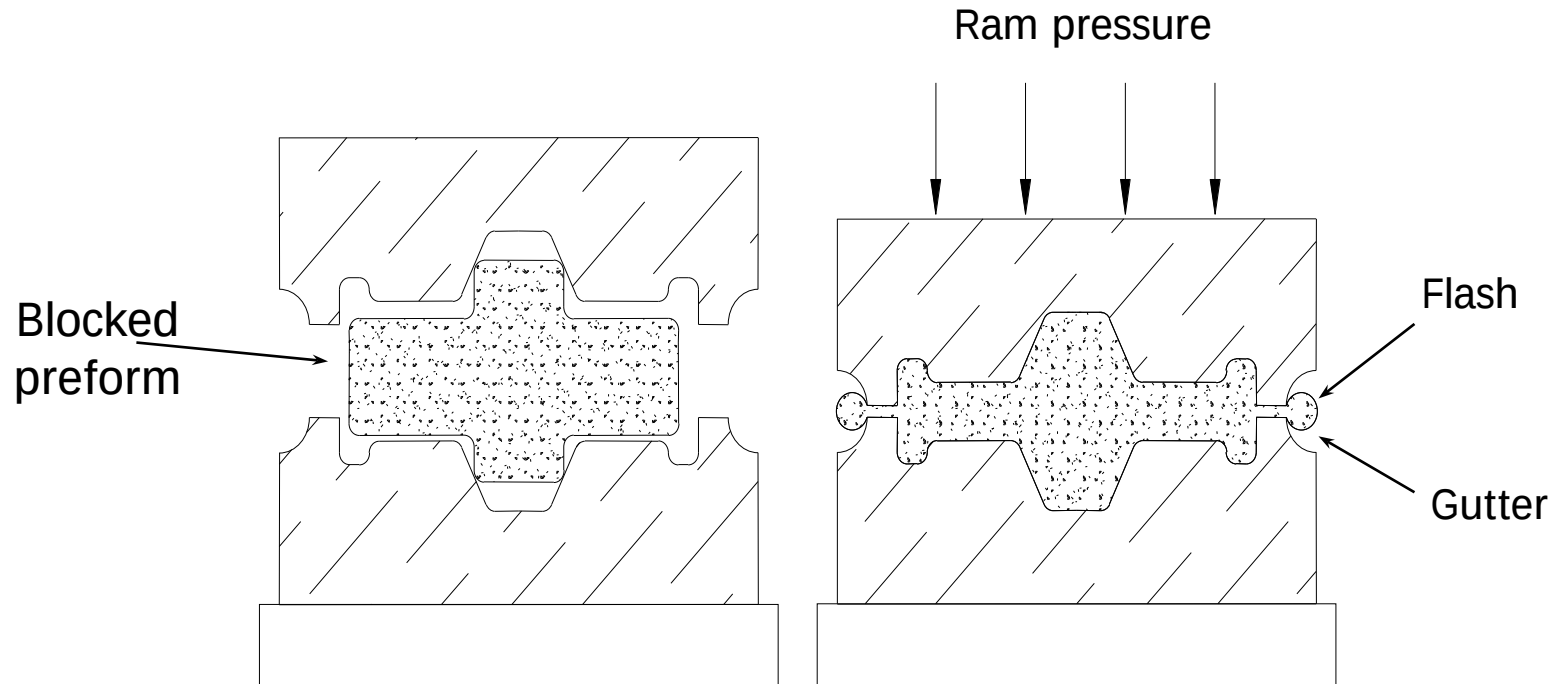
Extrusion



Drawing



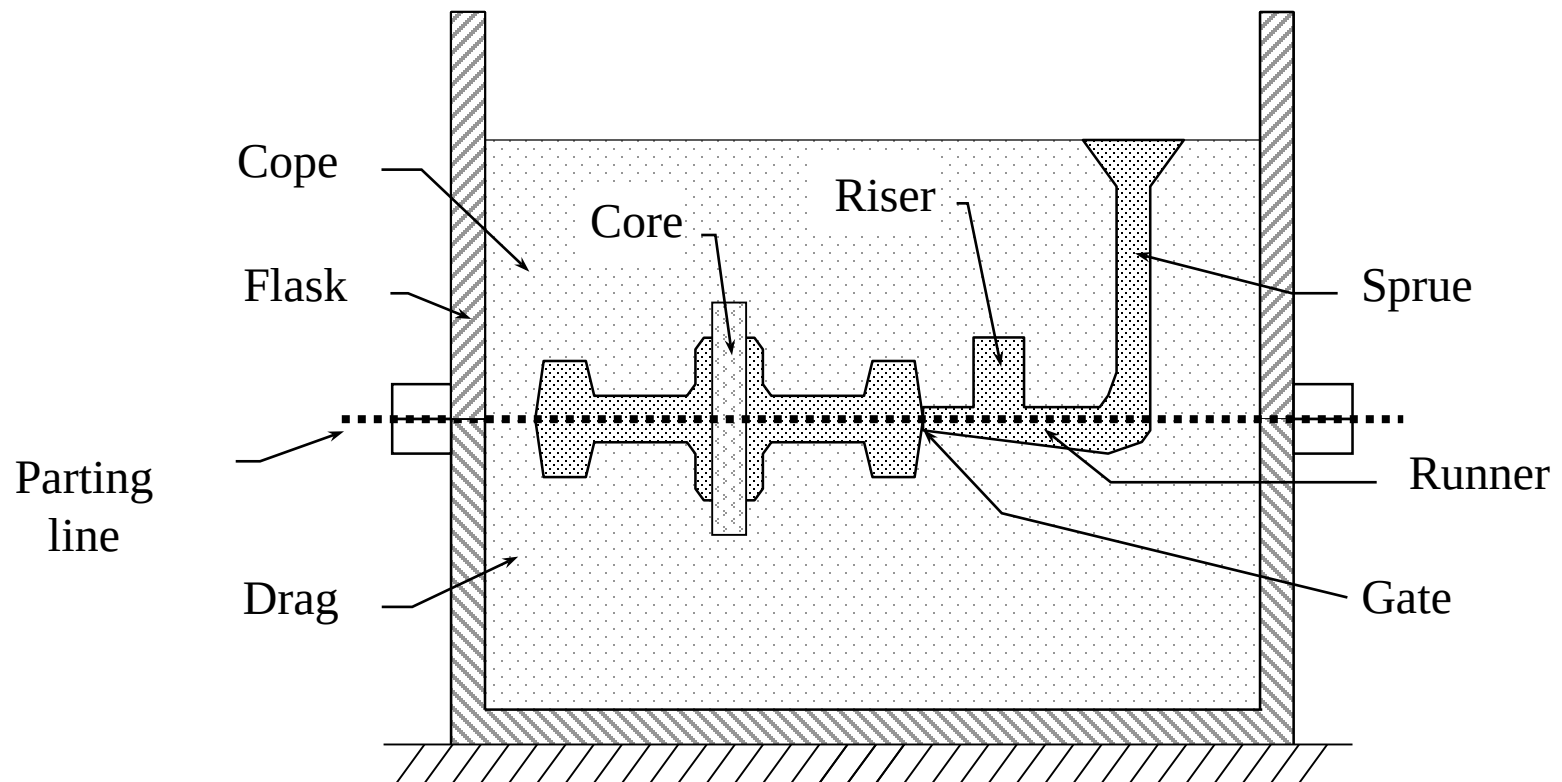
Forging (closed-die)



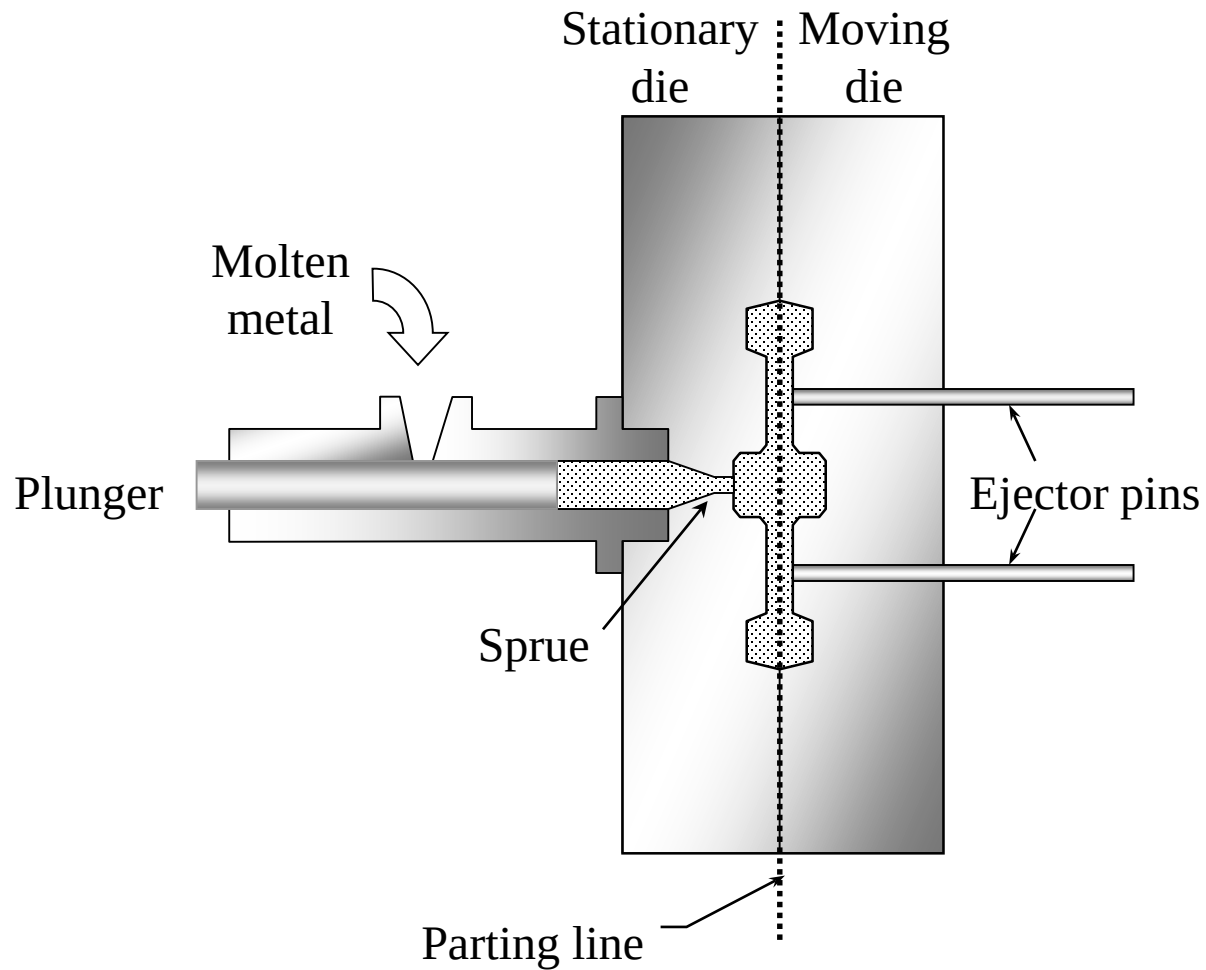
Casting Processes

- Sand casting
- Die casting
- Investment casting

Sand casting (closed-mold)

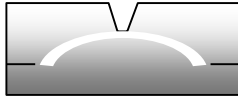


Die casting

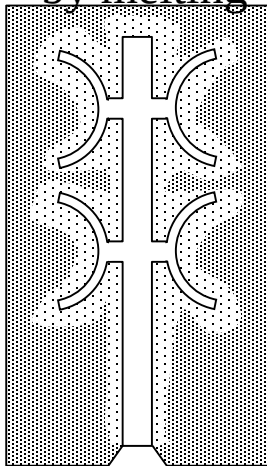


Investment casting

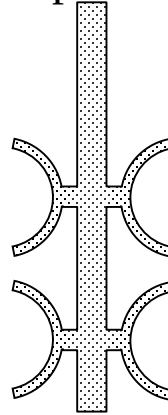
Wax pattern
is cast



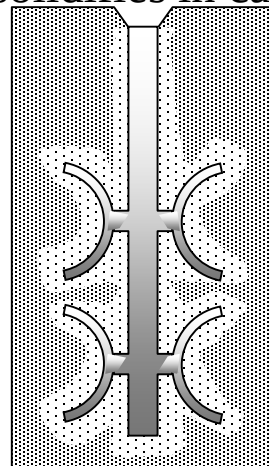
Wax removed
by melting



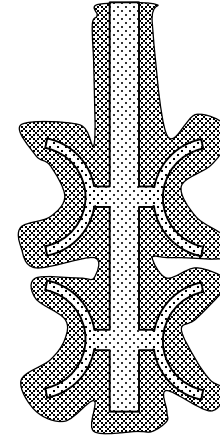
4-part pattern tree



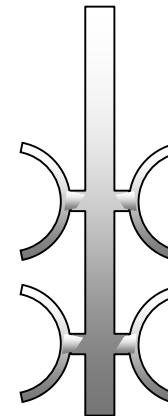
Molten metal
solidifies in cast



Ceramic mold
(hardened slurry)



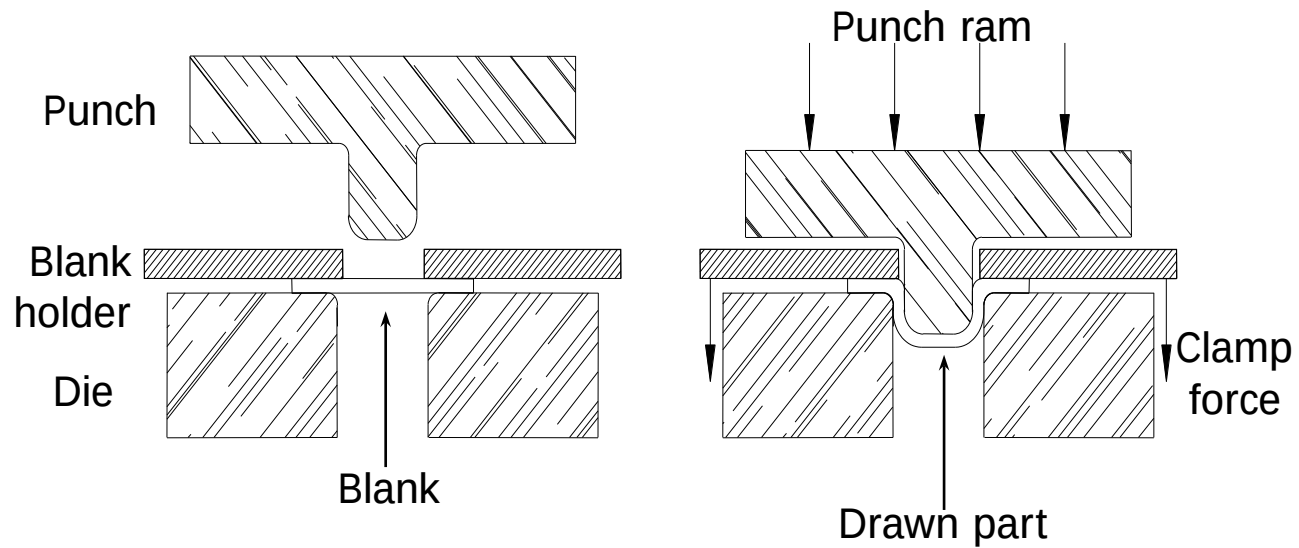
Ceramic mold is
removed



Sheet Metalworking

- Bending
- Blanking
- Drawing
- Punching
- Shearing
- Spinning

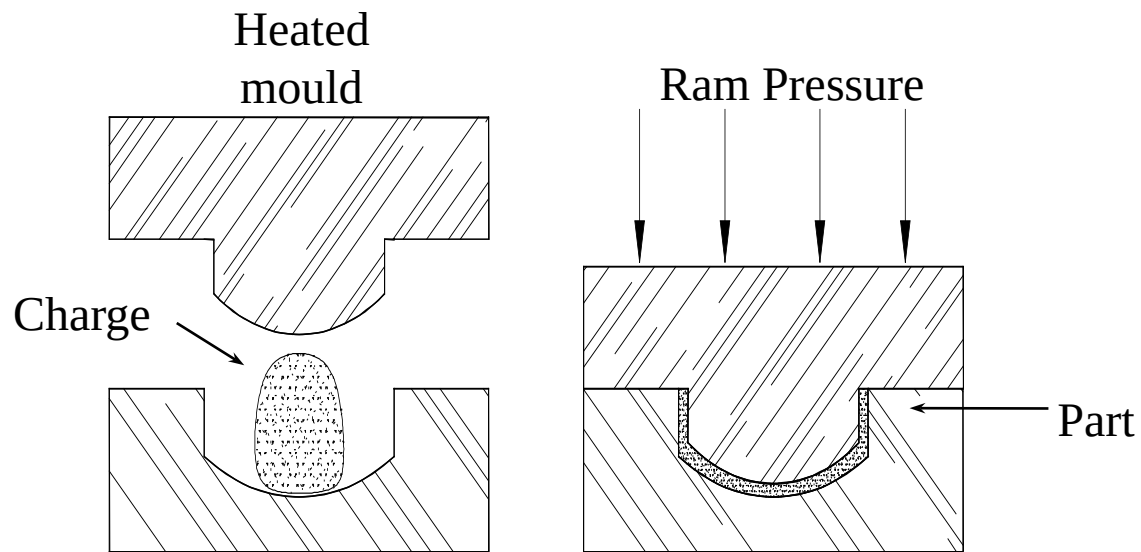
Sheet metal drawing



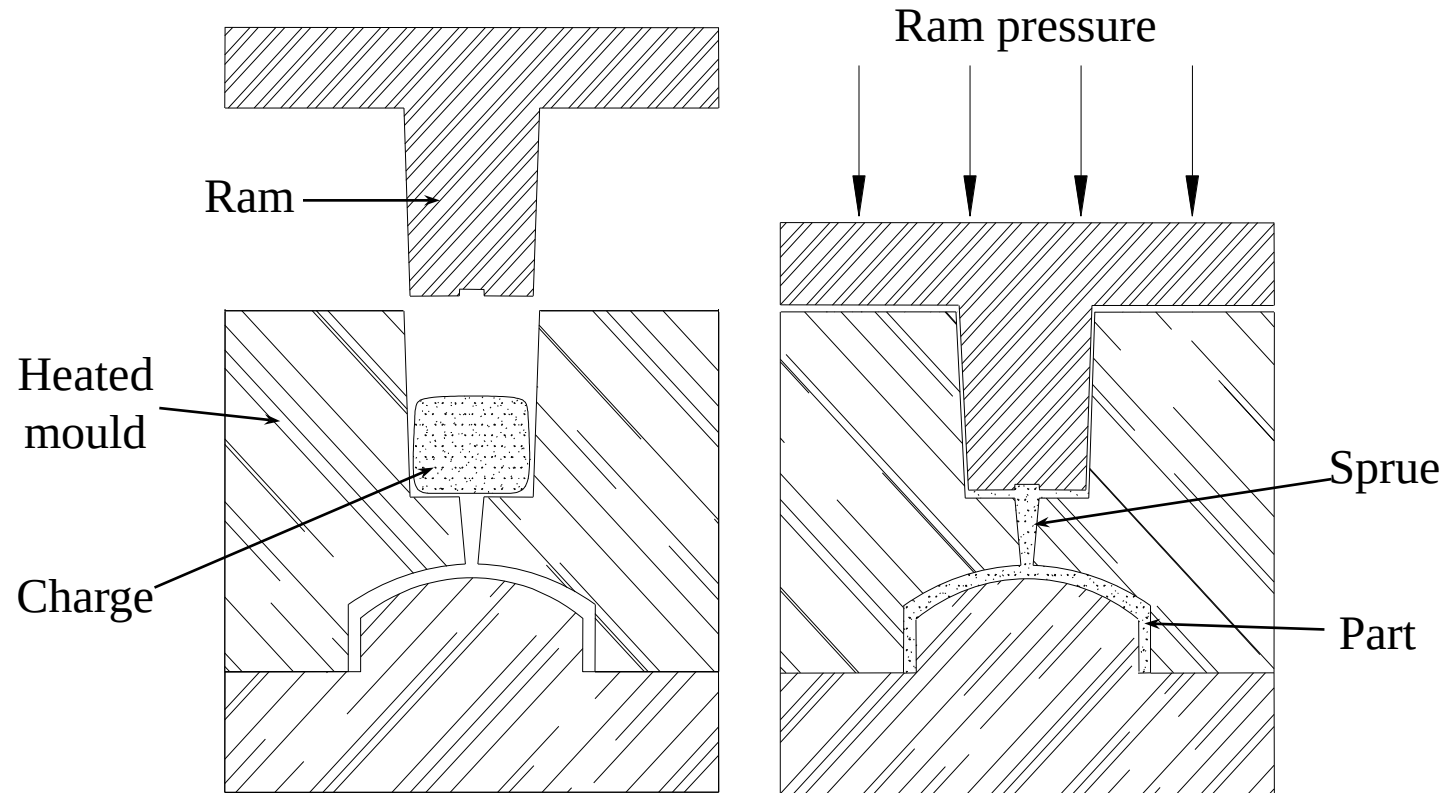
Polymer Processes

- Compression molding
- Transfer Molding
- Blow molding
- Injection molding

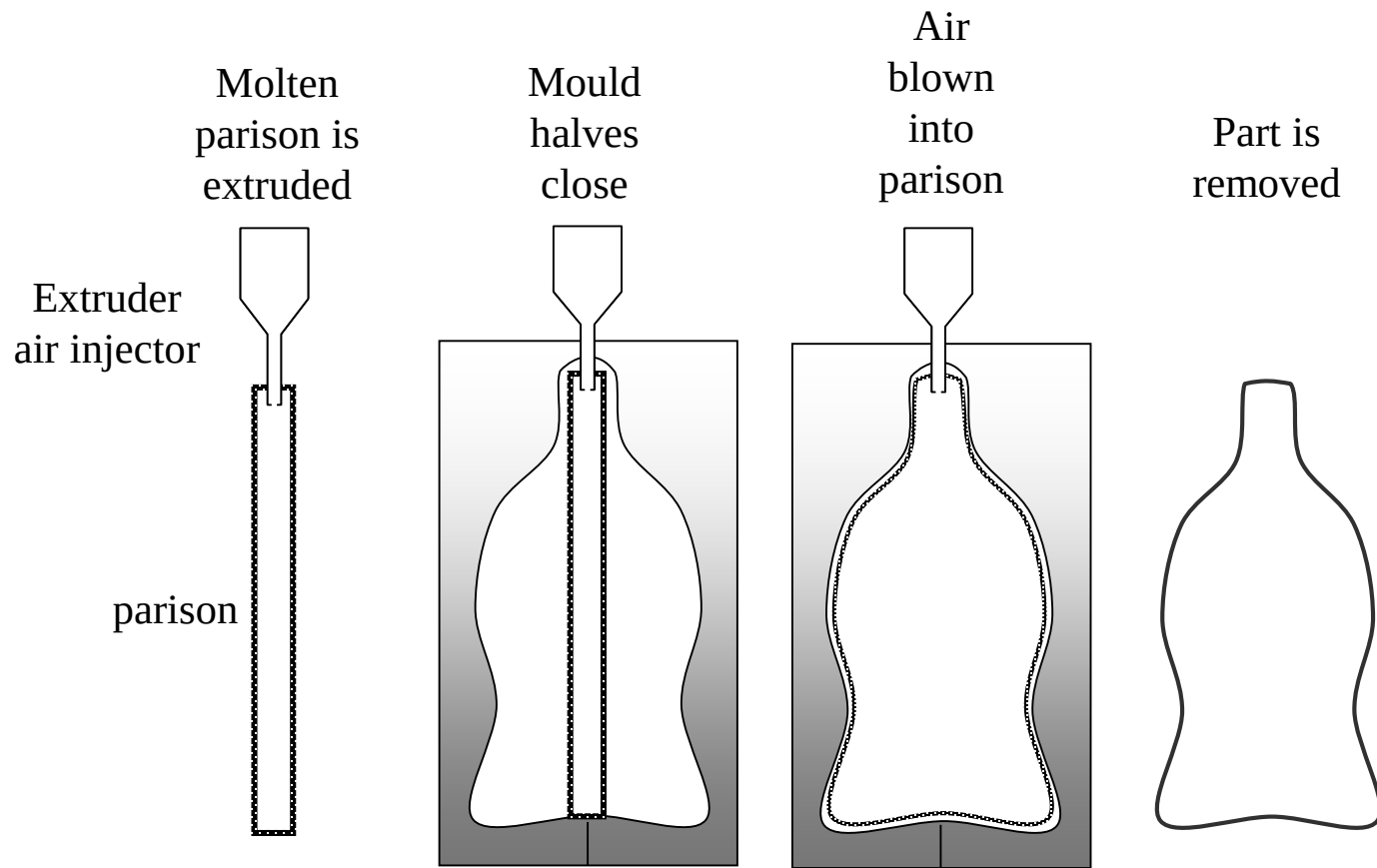
Compression molding



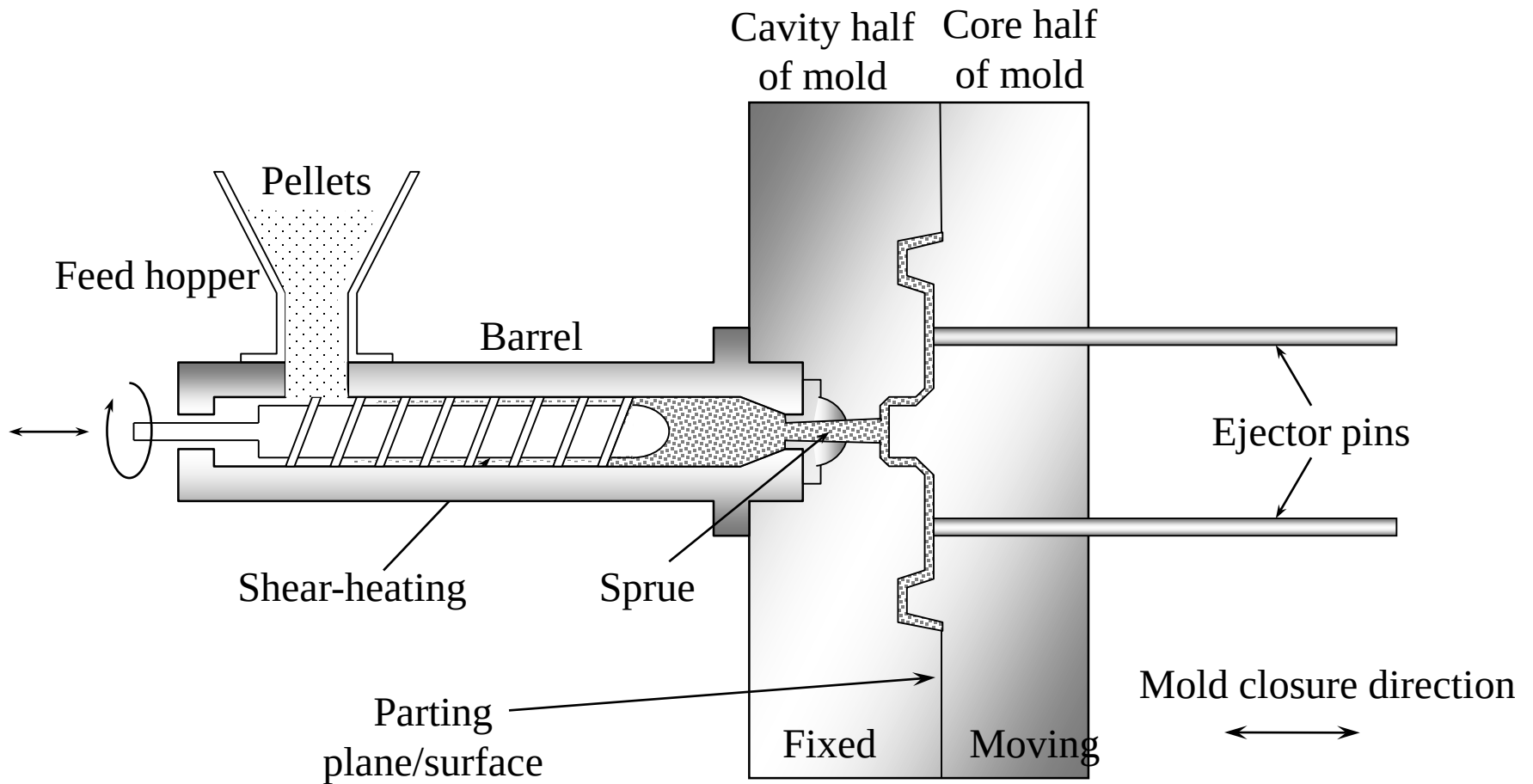
Transfer molding



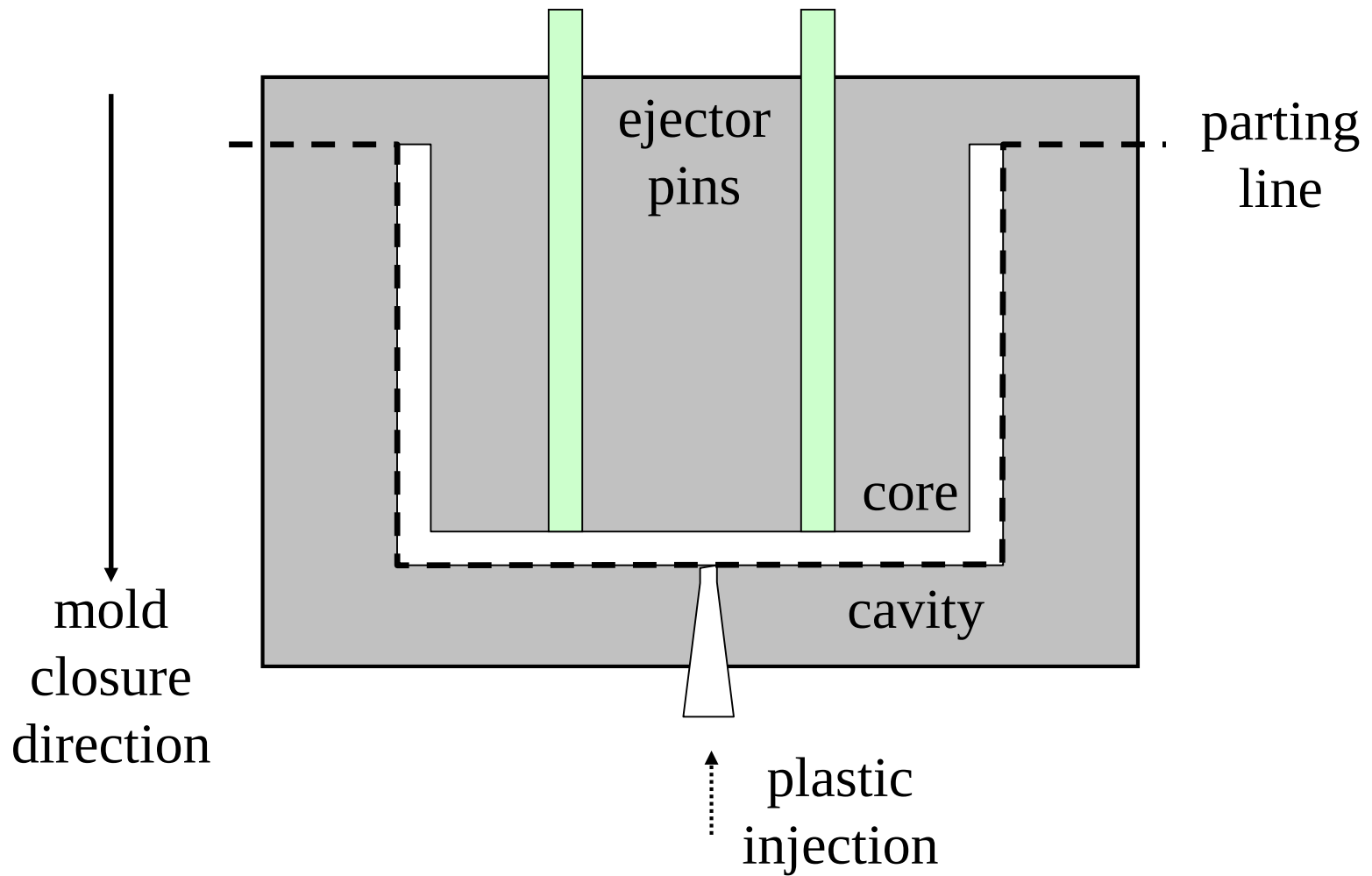
Blow molding



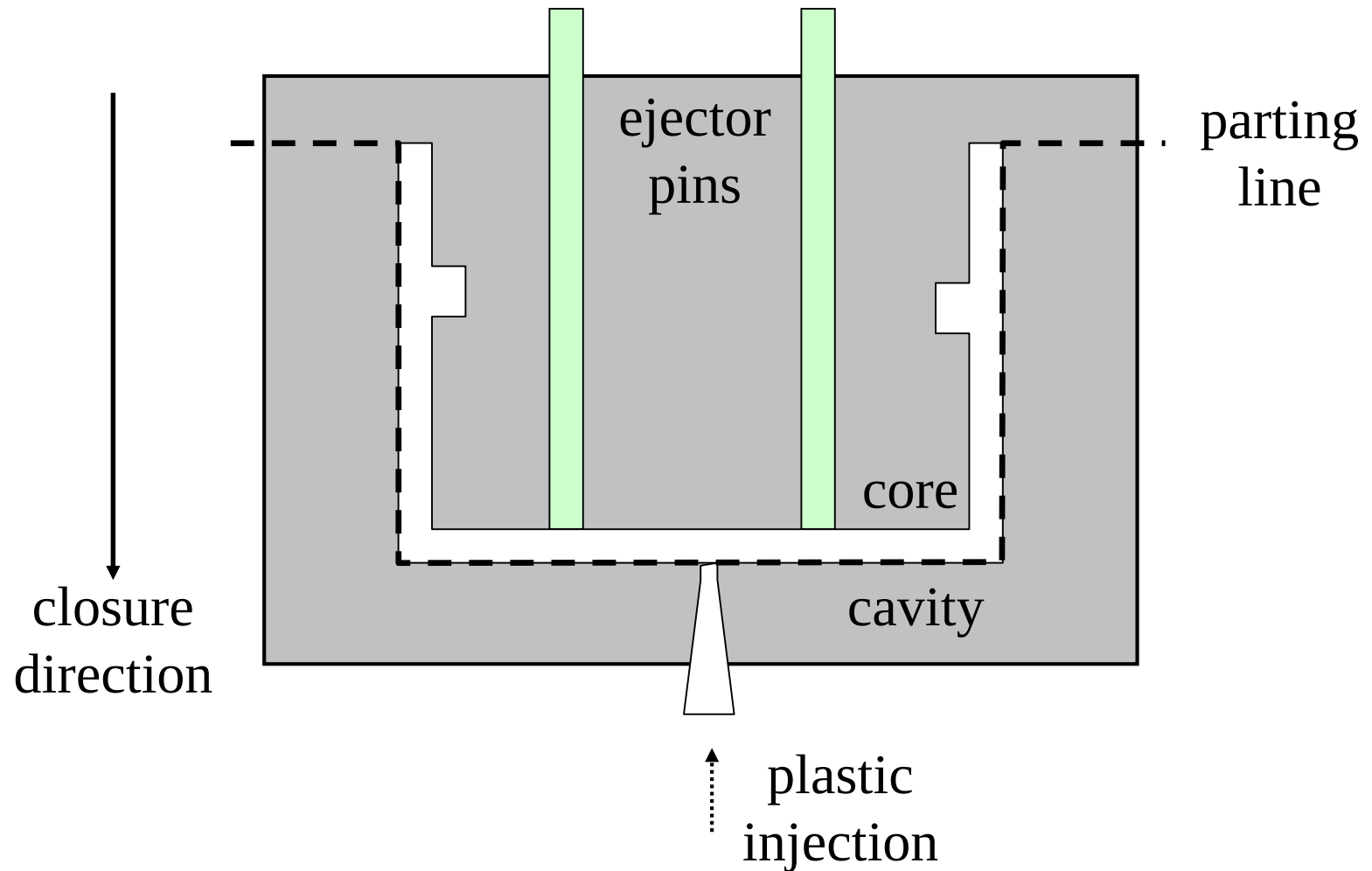
Injection molding



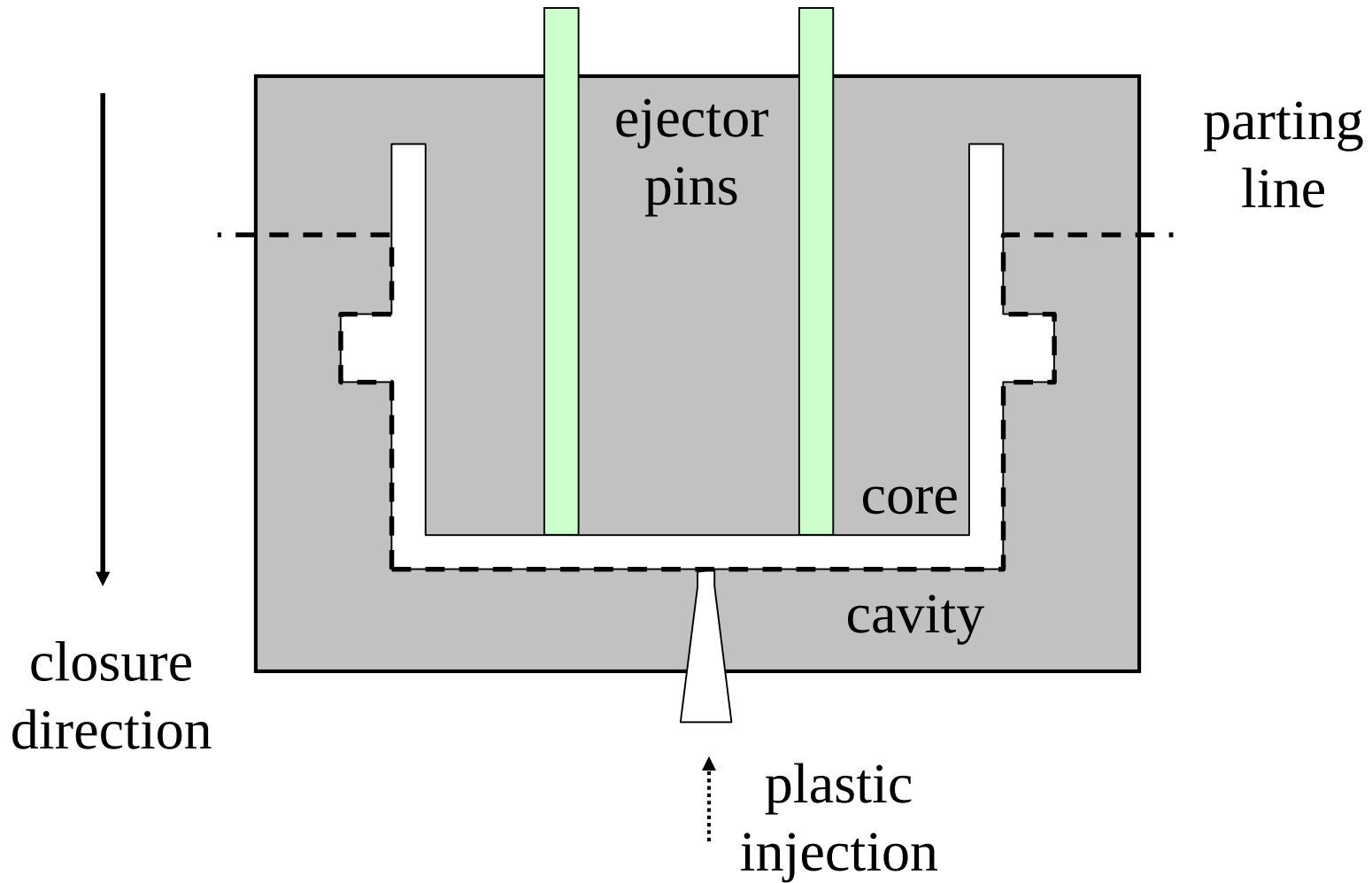
Example of a box ...with no undercuts



Internal undercuts



External undercuts



Solidification processes

molten material — **freezing** → solid Part

Casting Processes

Sand Casting

Die Casting

Investment Casting

Centrifugal

Polymer Processes

Injection Molding

Blow Molding

ThermoForming

Compression Molding

considerations

Flow (voids, flash)

Cooling time (cycle time)

Temperature

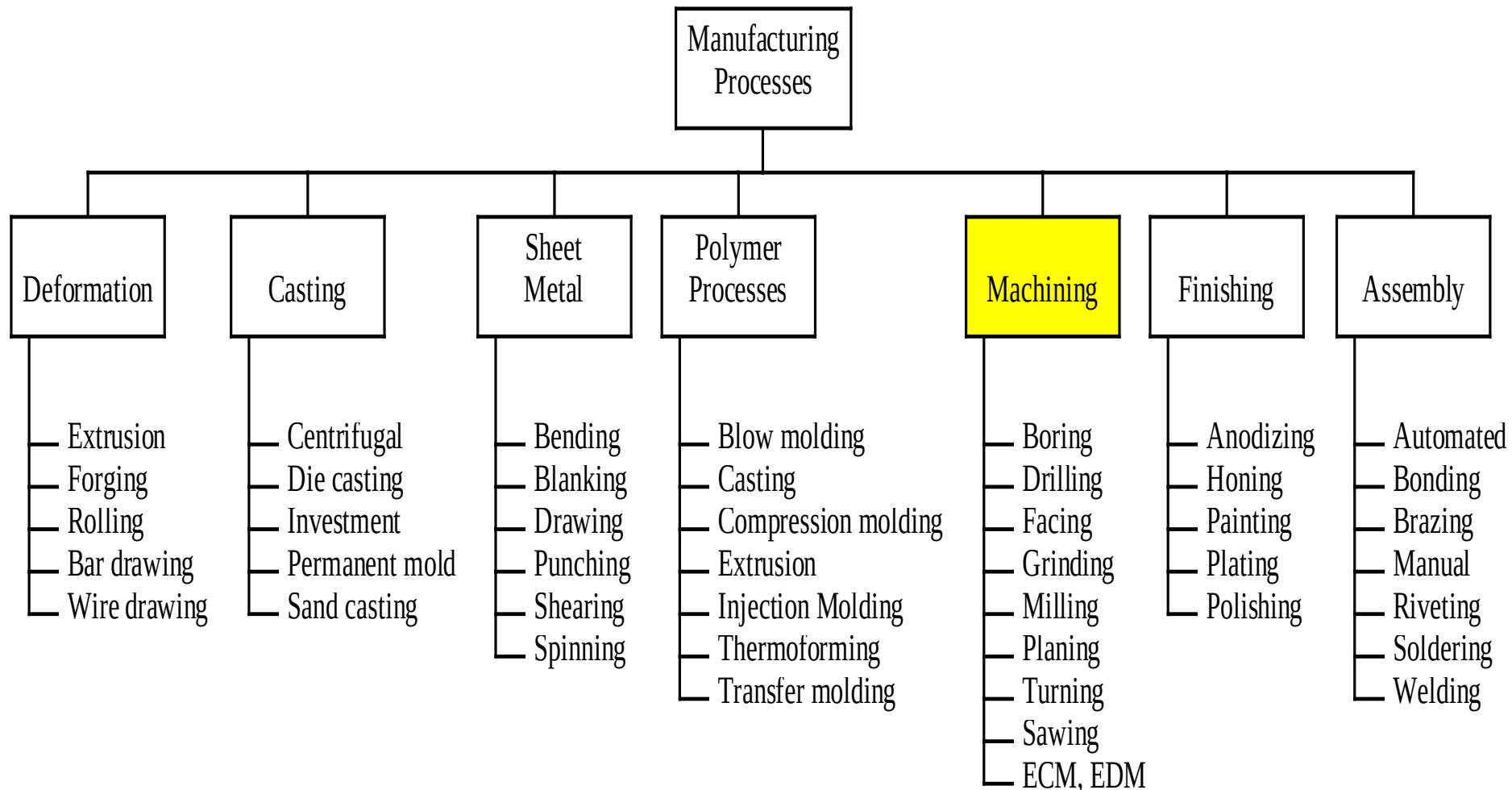
Mold complexity

Warping

Post processing

Costs (materials, tooling, processing)

Machining processes



Machining – removal of material...

Sawing –using a toothed blade.

Milling – from a flat surface by a rotating cutter tool.

Planing – using a translating cutter as work-piece feeds.

Shaping - from a translating work-piece using a stationary cutter.

Boring - increasing diameter of existing hole by rotating the work-piece.

Drilling- using a rotating bit forming a cylindrical hole.

Reaming – to refine the diameter of an existing hole.

Turning - from a rotating work-piece.

Facing - from turning work-piece using a radially fed tool.

Grinding - from a surface using an abrasive spinning wheel.

Electric discharge machining - by means of a spark.

Machining process considerations

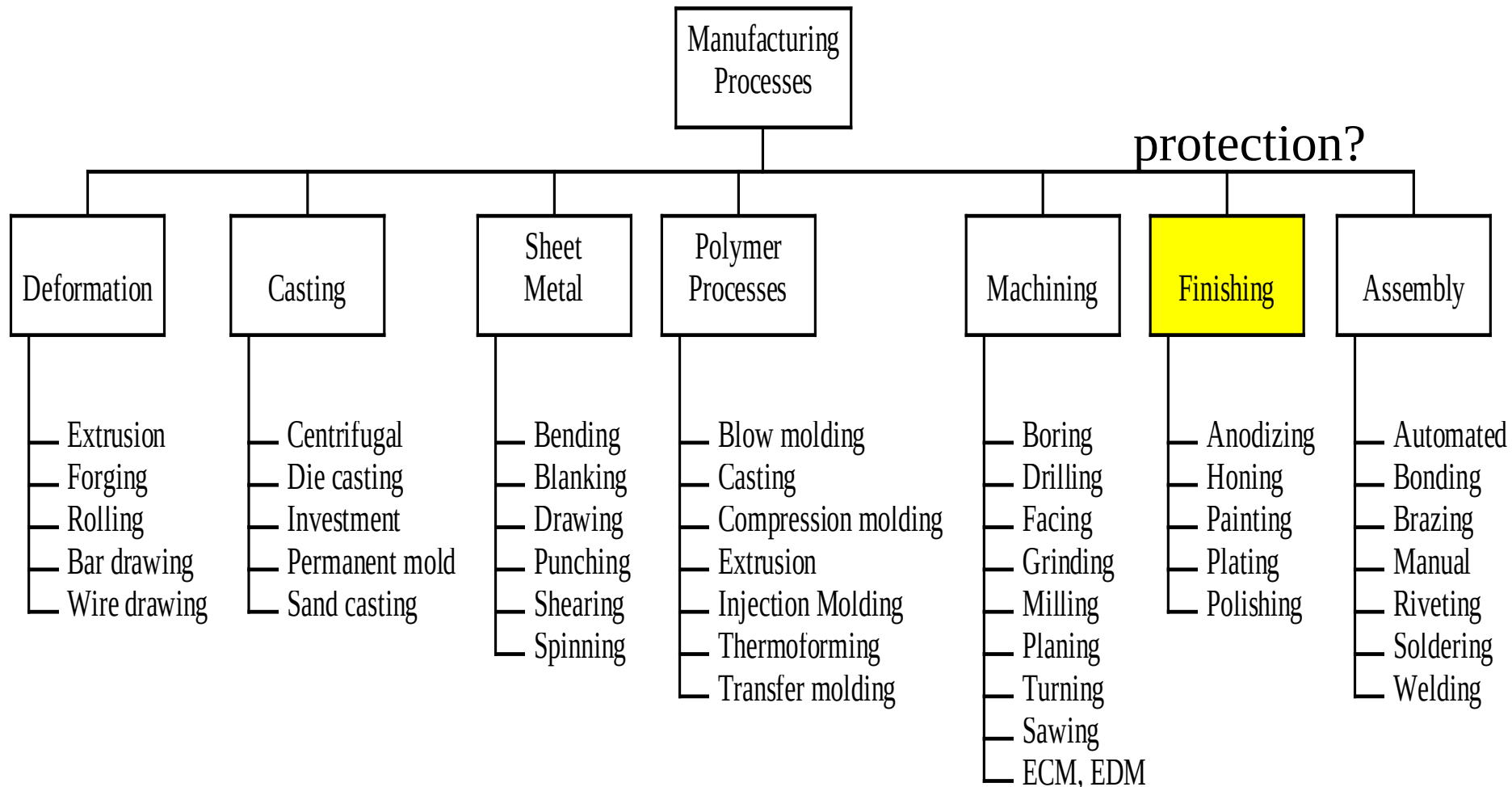
solid material — **machining** → material removed

sawing, turning, boring, milling,
drilling, grinding, ECM

considerations

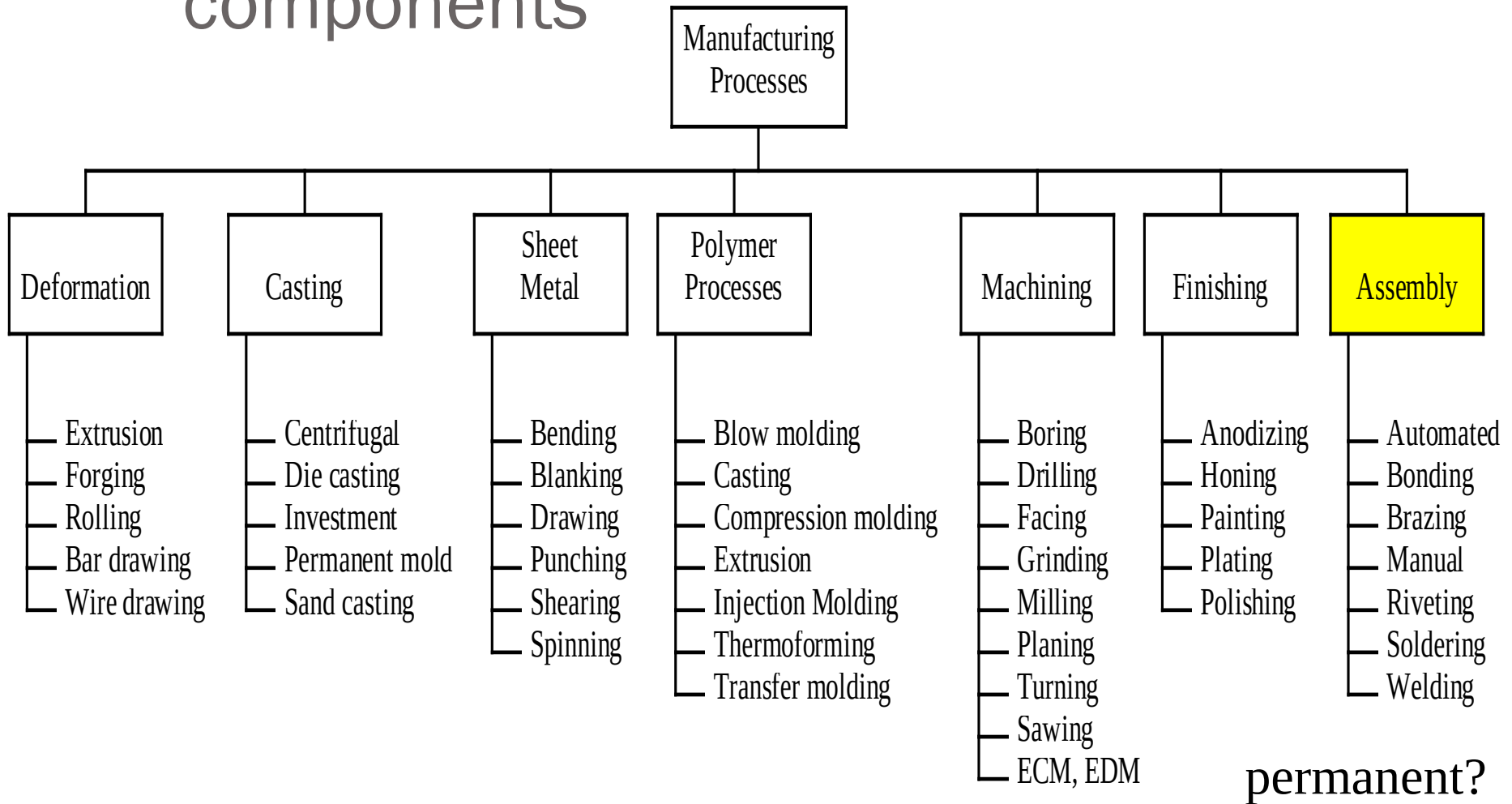
hardness, strength of material
shear forces = strong jigs & fixtures
tool/bit wear, replacement
size of workpiece, fit machine?
volume removed
rate of removal, hp needed
tolerances
operator skill, CNC
costs (materials, tooling, processing)

Finishing processes



Assembly processes

– fastening / joining of 2 or more components



Process / Material Screening

Process-First Approach

Part Information

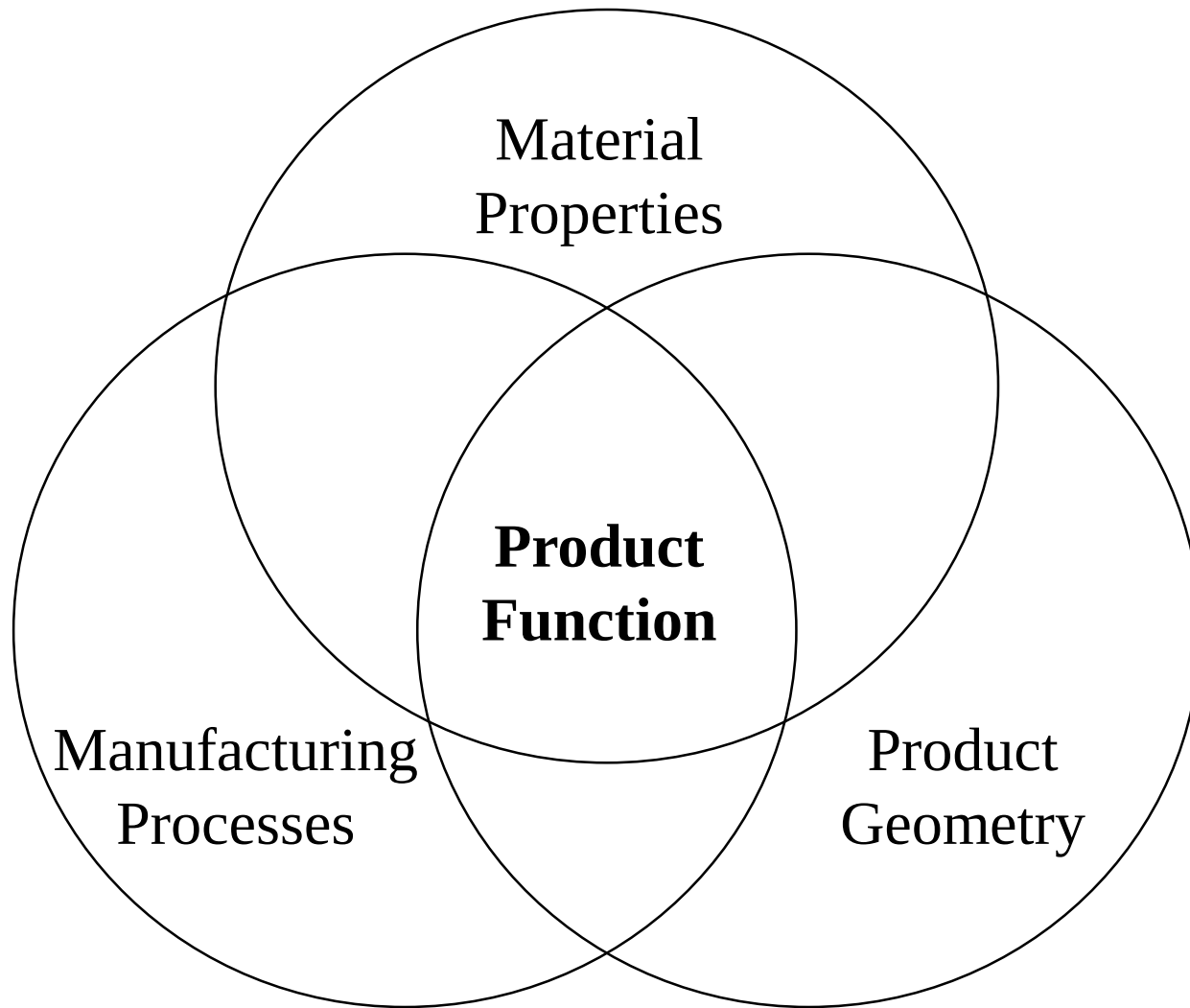
1. Production Volume
2. Part Size (overall)
3. Shape Capability (features)
 - boss/depression 1D
 - boss/depression >1D
 - holes
 - undercuts (int./ext.)
 - uniform walls
 - cross sections –
(uniform /regular)
 - rotational symmetry
 - captured cavities

Material First Approach

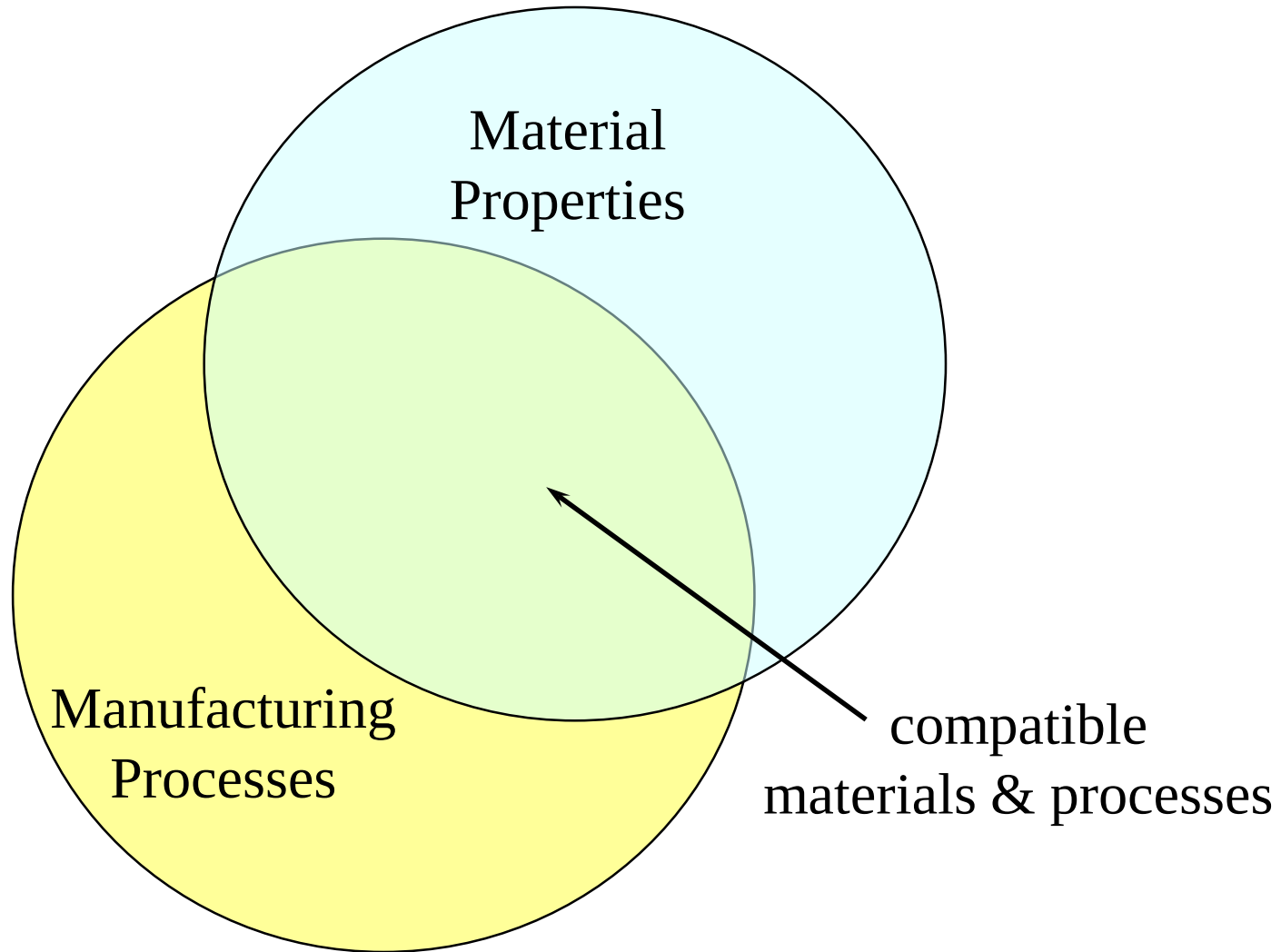
Application Information

1. Applied Loads
 - magnitude
 - cyclic nature (fatigue)
 - rate (slow, impact)
 - duration (creep)
2. Ambient Conditions
 - temperature
 - moisture
 - sunlight (ultra-violet)
 - chemical liquids/vapors
3. Safety/Legal (FDA, UL)
4. Cost

Product function is interdependent



Are materials compatible with mfg. process?



Material-Process Compatibility

ME 488 Design for Manufacture & Assembly

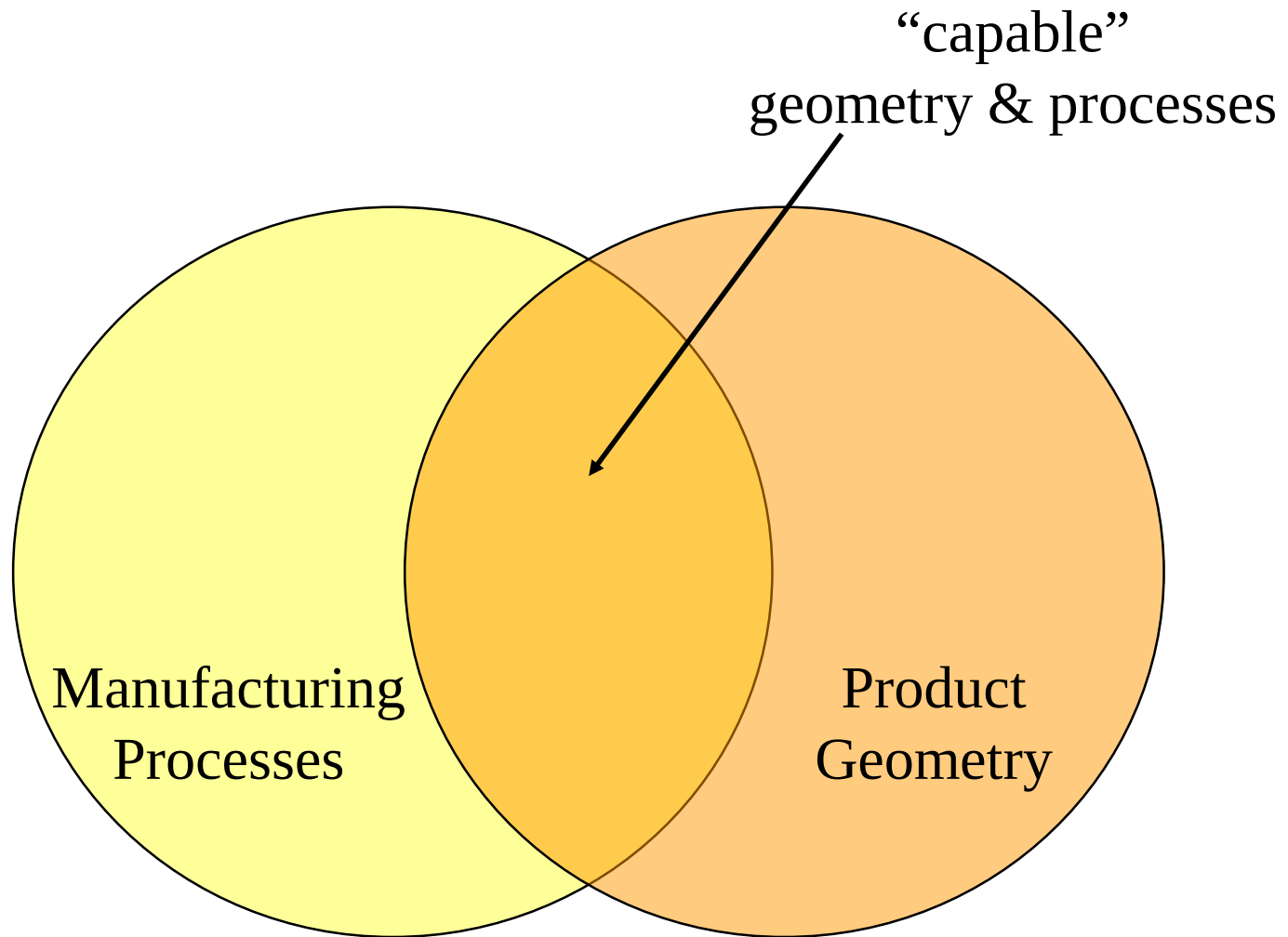
Materials Compatibility

© R. J. Eggert, BSU (Based on data from Boothroyd, Dewhurst & Knight) pg 47

revision

9/02/03

Is process capable of producing part geometry?



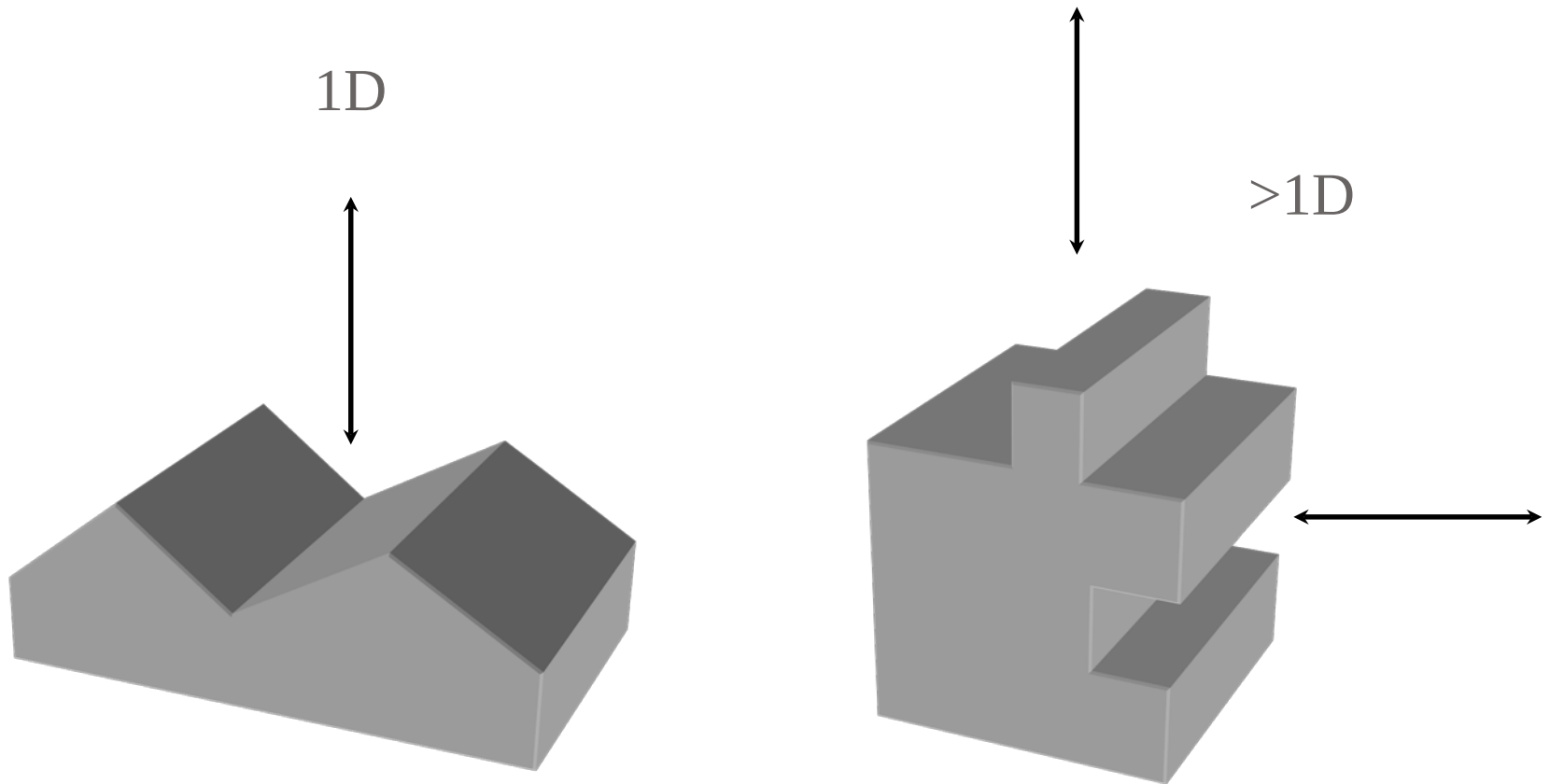
Process-first selection approach

Part Information

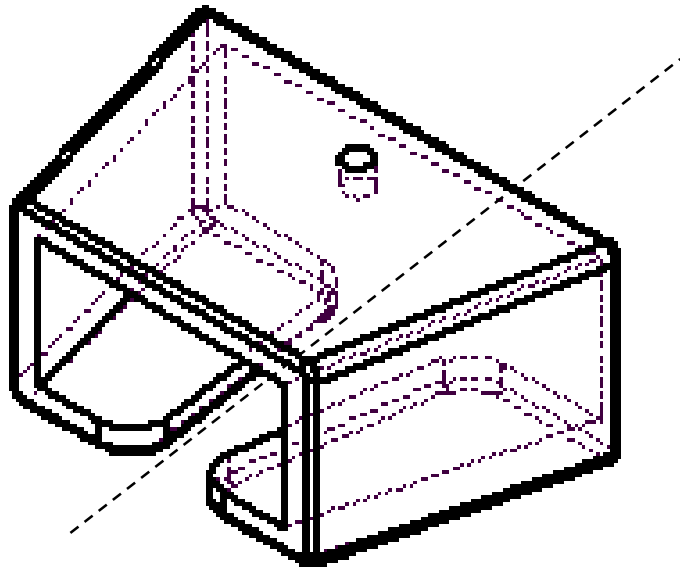
1. Production Volume (run qty)
2. Part Size (overall)
3. Shape Capability (features)

boss/depression 1D boss/depression >1D holes undercuts (int./ext.) uniform walls	uniform cross sections regular cross sections rotational symmetry captured cavities
--	--

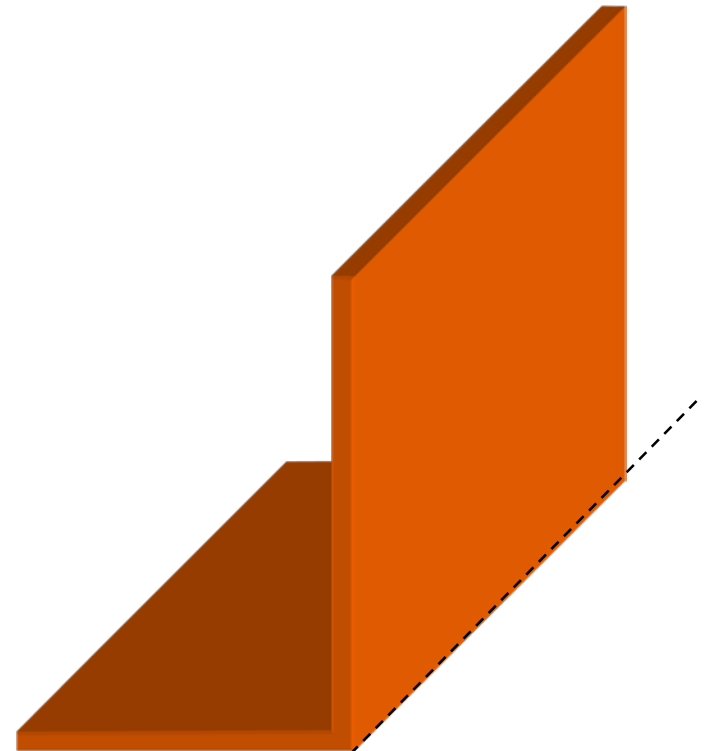
Depressions 1D, >1D



Uniform wall (thickness) but...

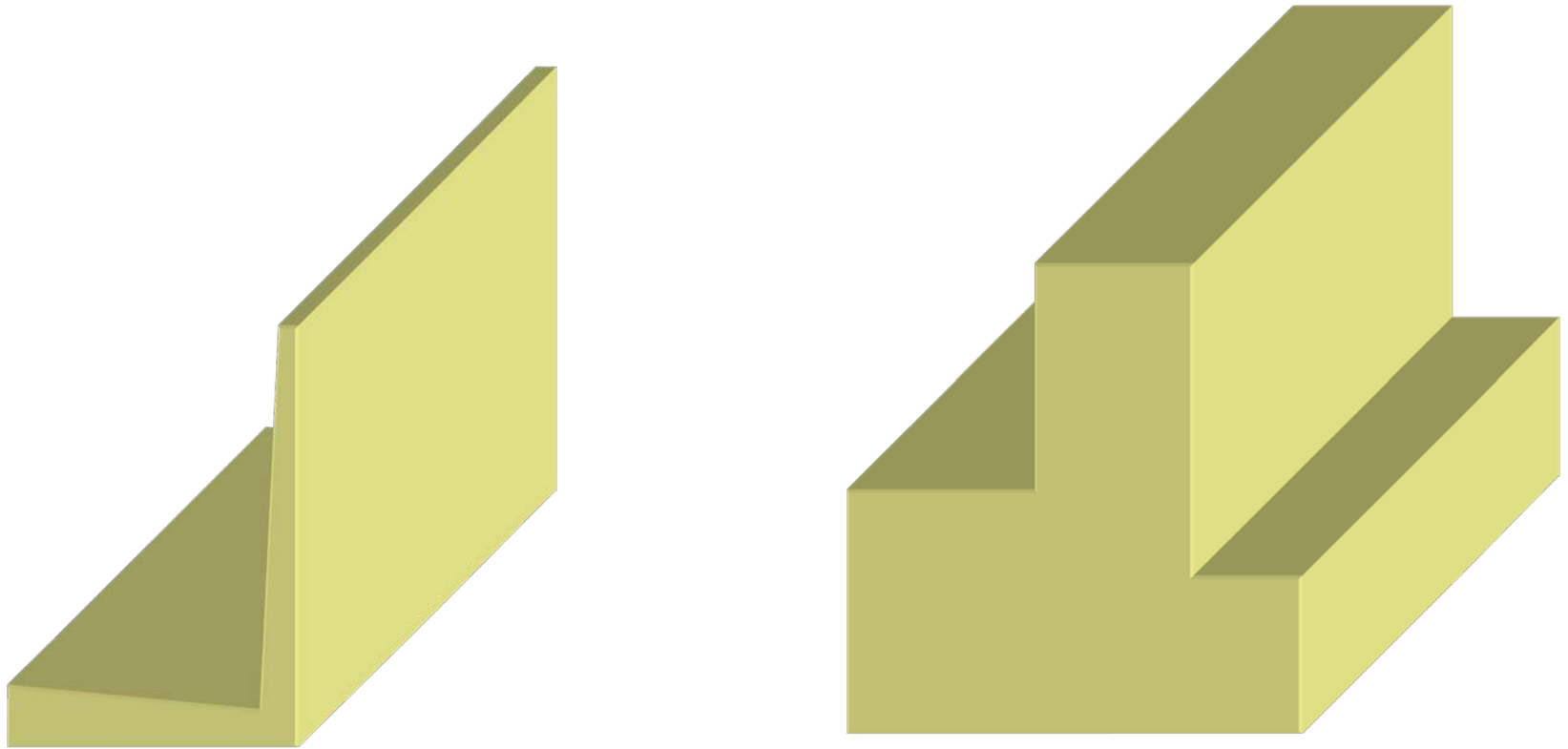


Varying cross section



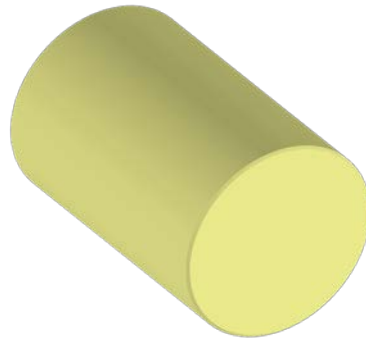
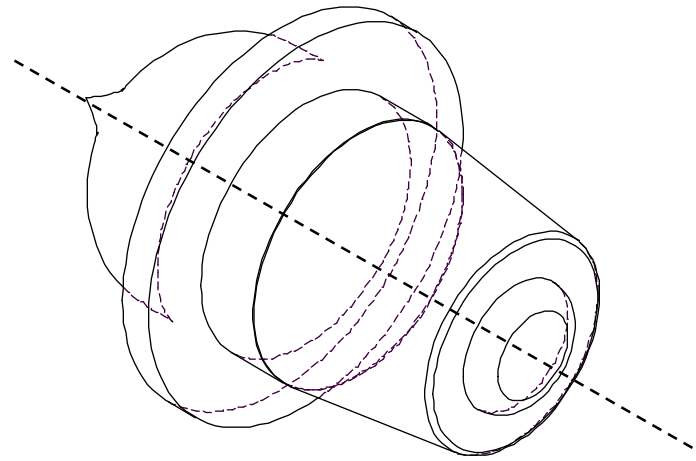
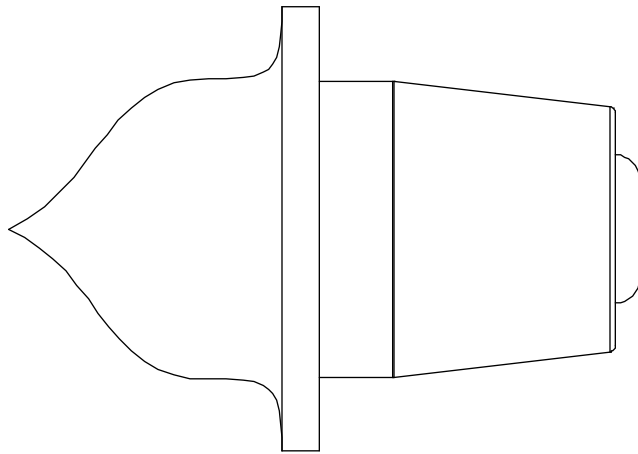
Constant cross
section

Uniform cross section (constant cross section)



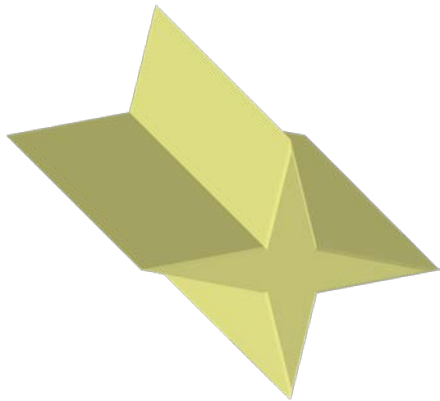
Non-uniform wall thicknesses

Axis of rotation (symmetry)



Regular cross section (regular pattern)

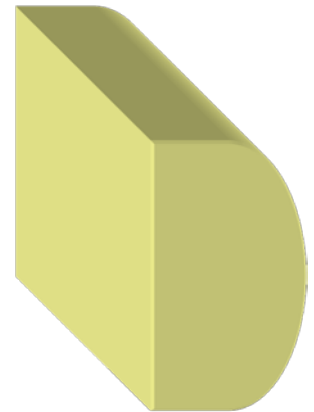
Regular
(i.e. pattern)



Regular
(i.e. pattern)



not-regular



Enclosed (hollow)

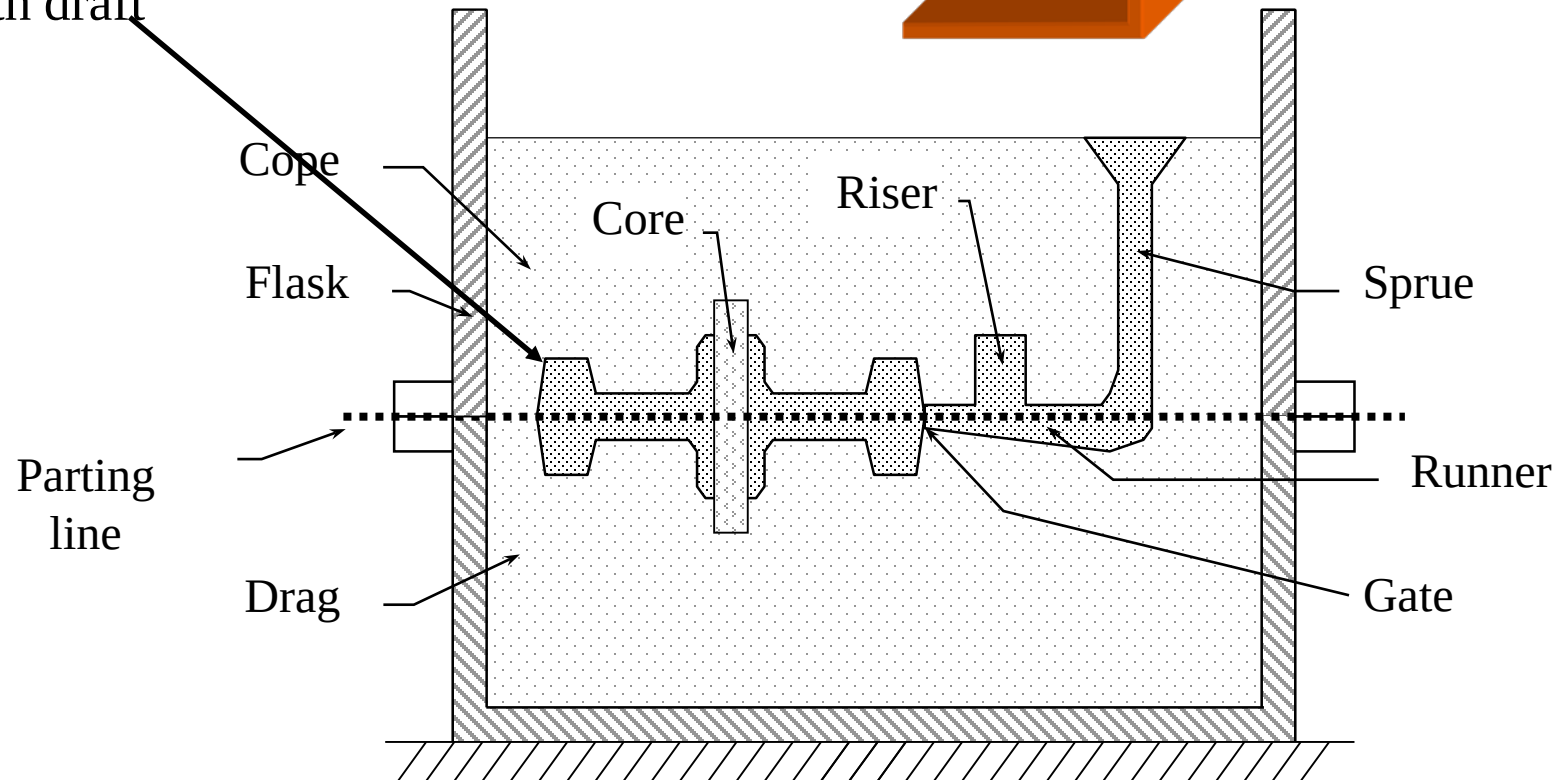


And, rotationally molded parts

Draft free surfaces

No draft

With draft



Shape generation capability (of processes)

ME 488/588 Design for Manufacture & Assembly										Process Capabilities for Shape Generation									
Date:	9/2/03																		
Engineer:	R. J. E.																		
Part Name:	no features part																		
	Part Data Input: ➡	N	N	N	N	N	N	N	N	N									

End of Part 1