

# 2.008 Quiz 2 Review

# Quiz Scope & Logistics

- Quiz 2 will cover HW 5 - 7 and through Lecture 15 - 24. Even if content was not explicitly asked about in a HW, if it was discussed in class, it is fair game for the quiz
- Quiz 2 will have **Part A (~ 80 mins in class on 5/8)**
  - You are allowed one double sided, handwritten 8.5" x 11" notes sheet. This is for equations and any other pertinent information
  - We will supply you with calculators for the exam
  - Show your work, box your answers
- Quiz 2 will have **Part B**
  - Take home exam. (Open Book/internet, etc but no collaboration.)
  - Will be released same time as Part A but due through Canvas 48 hours later.

# Cumulative Score Correction

<b>Part A, In-Class Component</b>		
Problem 1		Out of 15 points
Problem 2		Out of 31 points
Problem 3		Out of 24 points
<b>Part B, Take-Home Component</b>		
Problem 4		Out of 30 points
<b>Total</b>		<b>100 points</b>

# Concepts to know

# Casting (*Part A*)

- 1) Understand the advantages/disadvantages of different types of casting processes.
- 2) Understanding principles of various casting methods and being able to apply theory of heat transfer and fluid mechanics to perform basic sizing calculations related to casting.
- 3) Understand how to apply cooling time relations to estimate cooling times for sand casting and die casting
- 4) Understand the implications of the value of flow rate/heat transfer ratio in terms of defects, runner diameter sizing, etc.
- 5) Understand the implications of having laminar vs turbulent flow.

# Forming (*Part A*)

- 1) Understanding material structure, grain size and parameters that dominate metal forming.
- 2) Have understanding of bending, stretching and drawing.
- 3) Understand springback relation and general sheet metal bending process.
- 4) Understand sheet metal Design For Manufacturing (Boothroyd Reading)
- 5) Understand stress/strain relations for ductile materials.
- 6) Have general understanding of rolling, forging, extrusion and drawing.

# Additive - 3D printing (*Part A*)

- 1) Understand the workflow for additive manufacturing.
- 2) Understand the different types of common AM methods that were covered and tradeoffs.
- 3) Know what limits the rate of each process
- 4) Understand the feature resolution possible with each, as well as common defects
- 5) Know which materials match which process as well.
- 6) Understand 3D printing in the context of rate, flexibility, cost and quality relative to other manufacturing processes

# Additive - Electronics + Composites Manufacturing (*Part A*)

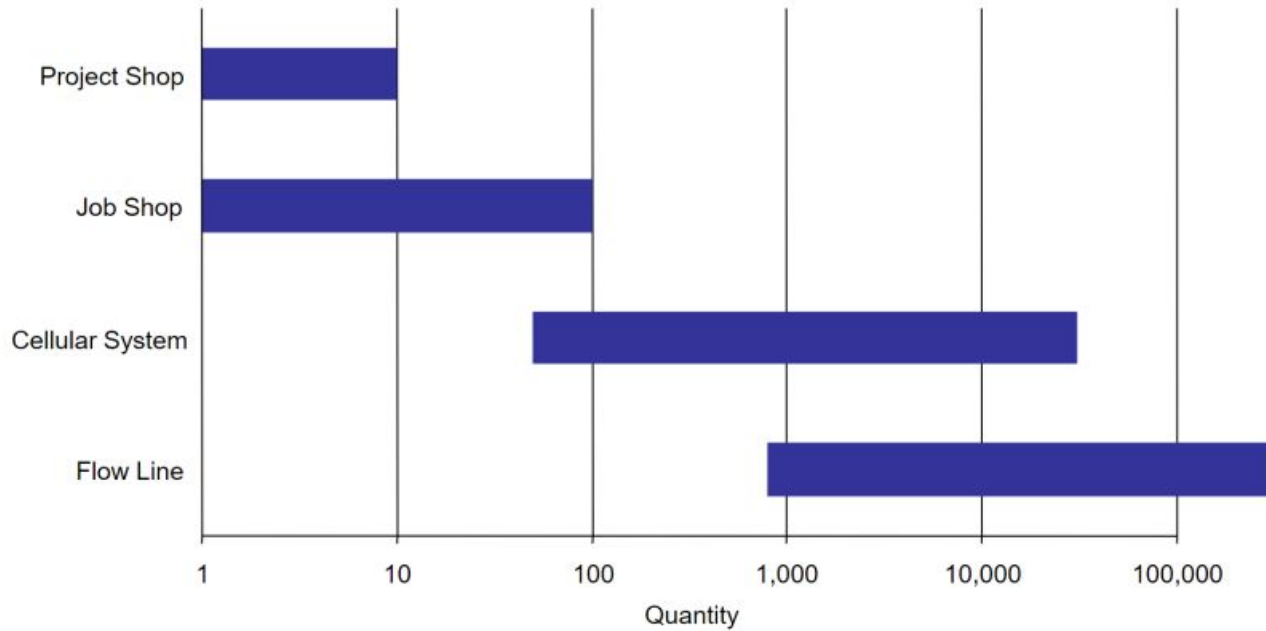
- 1) Understand the Generic Flow Diagram.
- 2) Understand which processes are subtractive and which are additive.
- 3) Understand process of photolithography/ soft lithography and purpose of photoresist.
- 4) Understand CVD/PVD
- 5) Understand Etching. (isotropic vs anisotropic)
- 6) Understand purpose of Ion Implantation.
- 7) Understand manufacturing attributes.
- 8) Understand the process and benefits of using polymer matrix composites.



# Manufacturing Systems (*Part A + Part B*)

- 1) Know the difference between a job shop, manufacturing cells, and transfer line, and what sorts of task/quantities are expected at each.
- 2) Review the Beer Game and Lean Game Activities, what were the key challenges in each game, how did round 2 play address them
- 3) Understand the role buffers play in manufacturing lines and where they can be placed for maximum efficiency
- 4) Know how to calculate the production rate of zero and infinite buffer lines, be familiar with little's law, equations for zero and infinite buffer lines and when to use them
- 5) Understand the difference between the MATLAB Scripts and which is appropriate to use when.
- 6) How to draw and interpret block diagrams.

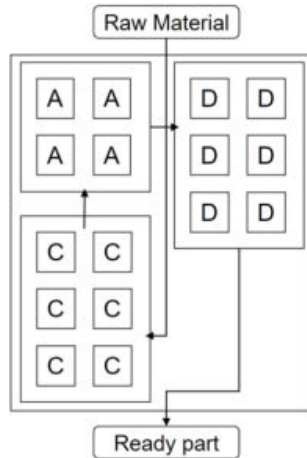
# Manufacturing System and Quantity



# Types of Factory Layouts

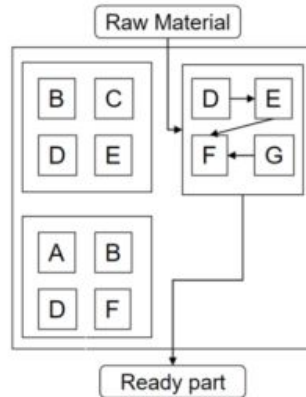
## Job Shop:

Machines/Resources are grouped according to the process they perform



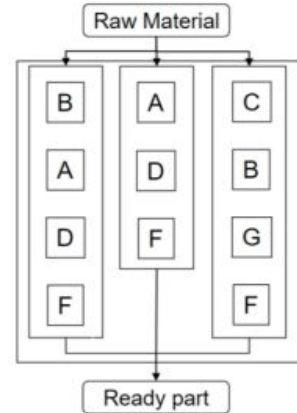
## Cellular System:

Machines/Resources are grouped according to the processes required for part families



## Flow/Transfer Line:

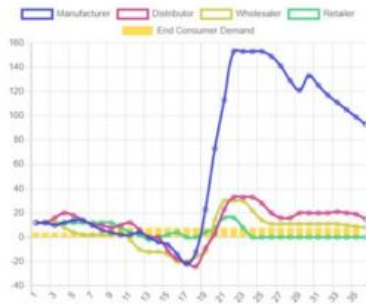
Machines/Resources are Grouped in lines according to the processes sequence of part(s)



# Beer Game and Lean Game



## Beer Game: Q5



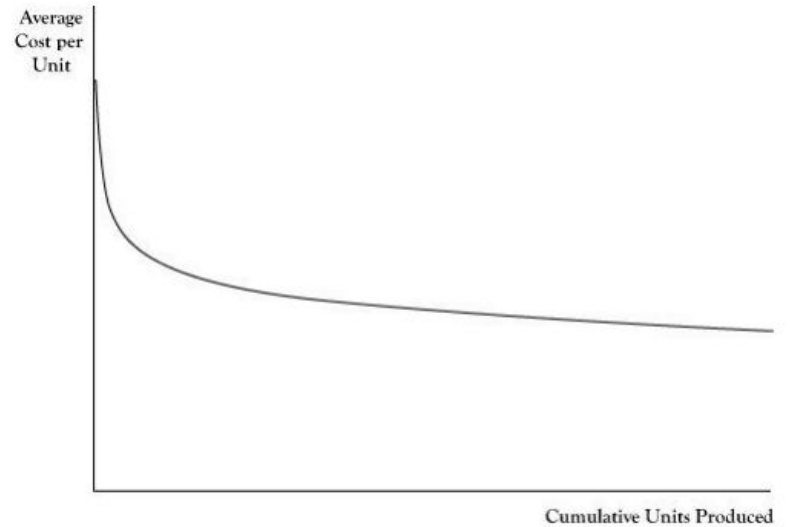
## Lean Game: Q7



- Move stations
- Reduce batch size
- Auto-inspect work - Jidoka (be able to remove dots)
- Balance workload (make all stations 100% flexible)
- Level production plan (Heijunka)
- Add click-guides to reduce defects - poka-yoke / error-proofing
- Kanban (pull-system)
- Reduce tool-changeover time (SMED)

# Cost

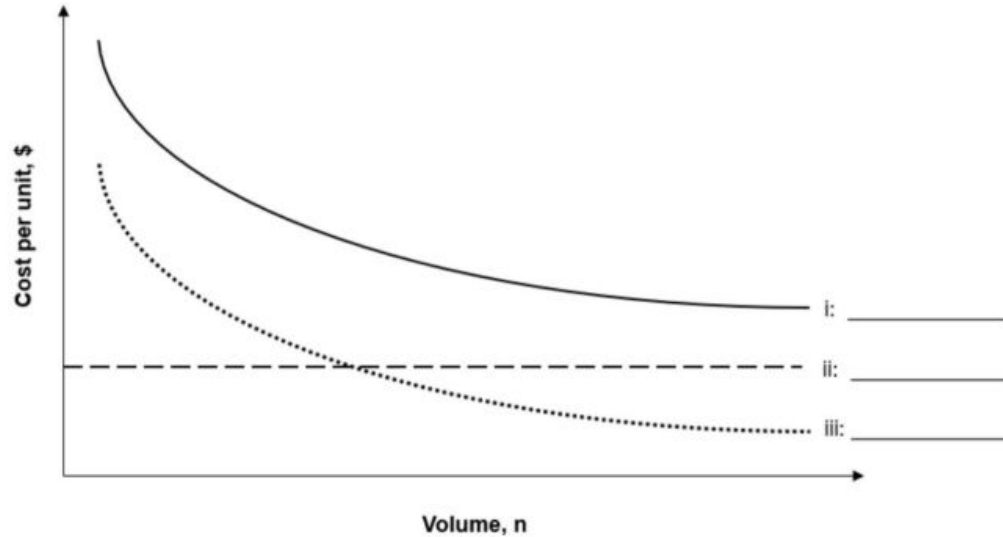
- 1) Know what the unit cost vs  $n$  plot looks like and why it gets its shape
- 2) Understand how to identify a fixed vs a variable cost for the manufacturing processes you've learned about



# Short Answers to Review

# Cost

- a. A plot of cost per unit vs. volume for a typical part is shown below. The plot features 3 curves, label each curve with the correct title.



$$\frac{\text{Total Cost}}{n} = \frac{\text{Fixed Cost}}{n} + \text{variable cost}$$

<input type="checkbox"/>	Total cost
<input type="checkbox"/>	Variable cost
<input type="checkbox"/>	Fixed cost

# Manufacturing Systems

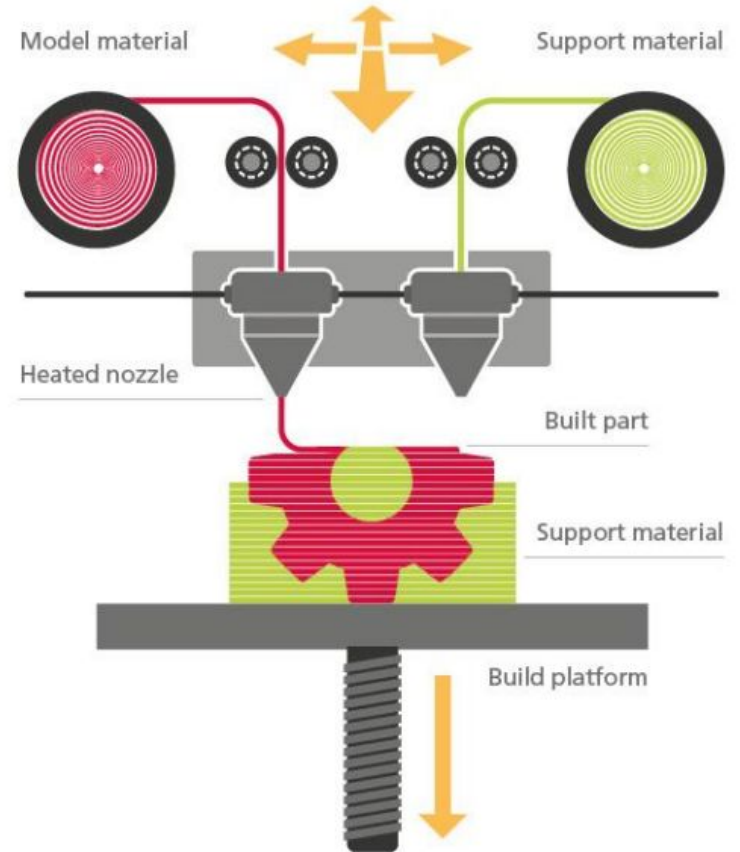
Consider a transfer line with a bottleneck machine and non-zero buffers. Given a choice of sequencing the machines differently, do you prefer the bottleneck to be the first machine or the last machine

1. First
2. Last
3. Doesn't Matter



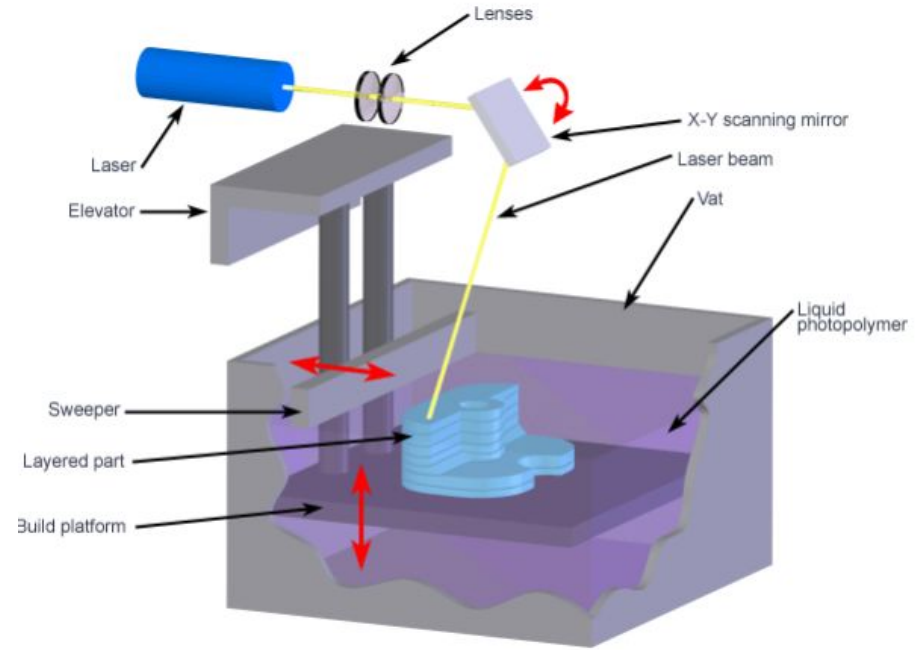
# Additive Manufacturing

The layer thickness in a **Fused Deposition Modeling (FDM)** machine is determined by the extruder-die's [height / diameter / feed rate]



# Additive Manufacturing

For **Stereolithography (SLA)**, a [ultraviolet / infrared / microwave] laser beam is focused on a selected surface area of the photopolymer and then moved around in the x-y plane to [melt / solidify] that cross-section of the part.



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# Bending

$$\frac{R_i}{R_f} = 4 \cdot \left( \frac{R_i}{t} \cdot \frac{Y}{E} \right)^3 - 3 \cdot \left( \frac{R_i}{t} \cdot \frac{Y}{E} \right) + 1$$

**Y = Yield stress**

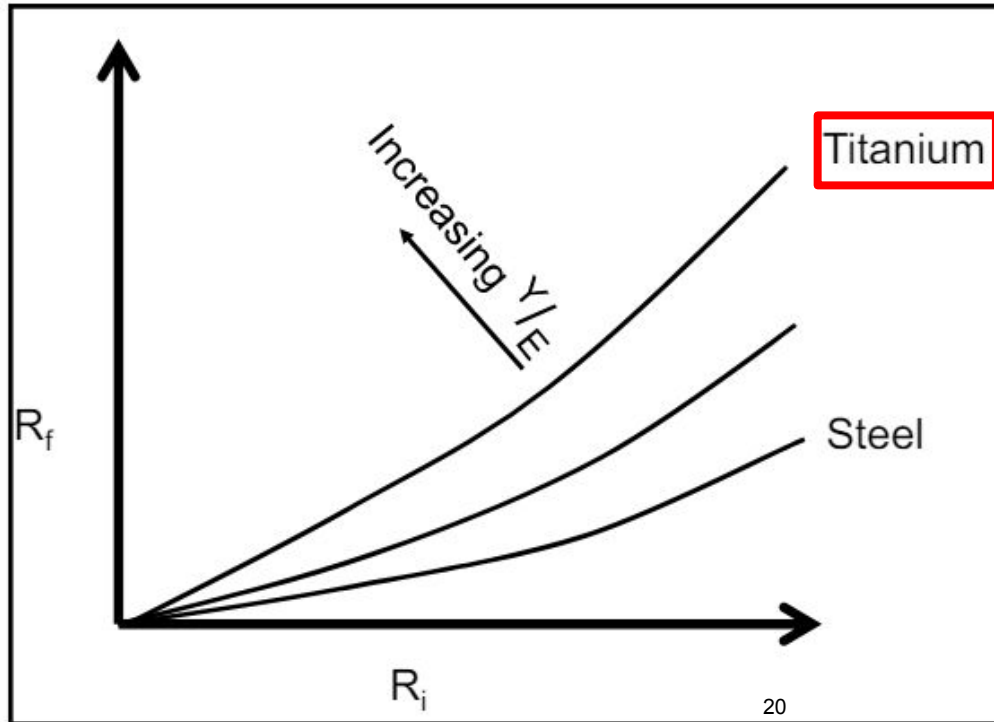
**E = Young's Modulus**

**t = thickness**

Springback Increases with:

1. Increasing Y
2. Increasing  $R_i/t$
3. Increasing E
4. Increasing Y/E

# Bending



Which material has more springback ?

$$\frac{R_i}{R_f} = 4 \cdot \left( \frac{R_i}{t} \cdot \frac{Y}{E} \right)^3 - 3 \cdot \left( \frac{R_i}{t} \cdot \frac{Y}{E} \right) + 1$$

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## 2.008 Design and Manufacturing II

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