# MIT 2.008 Design and Manufacturing II

Spring 2025

**Homework 5 – Manufacturing Systems & Cost**

Released: April 2, 2025 2:00 PM

**HOMEWORK TOTAL POINTS: 100 pts**

## Problem 1: Supply Chains/Beer Game Review

The first set of questions will serve as a review of the beer game activity you explored in class. You may view the results of your game here:
https://play.zensimu.com/session/bNJEPrsDpsUnQHX59tvA/results
If you need a refresh, feel free to play a demo game at the following link:
https://beergameapp.com/

a) You are a newly hired supply chain engineer, tasked with improving demand forecasting to counteract both backlogs and overstocks. Considering the original linear supply chain used for the beer game, where do you expect demand variability to be highest? Explain the phenomenon which causes this.

b) Could a different configuration of the Beer supply chain network improve performance? Draw two proposed configurations and for each provide one benefit and one tradeoff as opposed to the linear supply chain of the beer game activity.

Config 1:

| | |
|---|---|
| Benefit: | |
| Tradeoff: | |

Config 2:

| | |
|---|---|
| Benefit: | |
| Tradeoff: | |

c) How would higher inventory costs influence your beer game strategy and the resultant stock/costs?

d) How would higher backorder costs influence your beer game strategy and the resultant stock/costs?

e) Assuming the original configuration, suppose the wholesaler shifts to using a distributor with a shorter lead time (for the same beer). What is one benefit and one potential tradeoff of this change, compared to the original supplier?

f) Assuming the original configuration, suppose that each of the four roles (manufacturer, distributor, wholesaler, retailer) agrees to share their current stock levels and demand with each of the other roles. What is one benefit and one potential tradeoff of this change, compared to the situation where the whole supply chain's demand and stocks are not mutually visible?

## Problem 2: The Amazon Fire Tablet

The 7'' Amazon Fire tablet (Figure 1) has a sales price of $50. The low cost of this device is an impressive indication of the scalability of the underlying manufacturing processes, including those for electronics and touchscreen displays.

*Figure 1: Amazon Fire Tablet.*

Assume you are seeking to understand the manufacturing cost of the Amazon Fire tablet to determine the profit margin, starting with the back case (Figure 2).

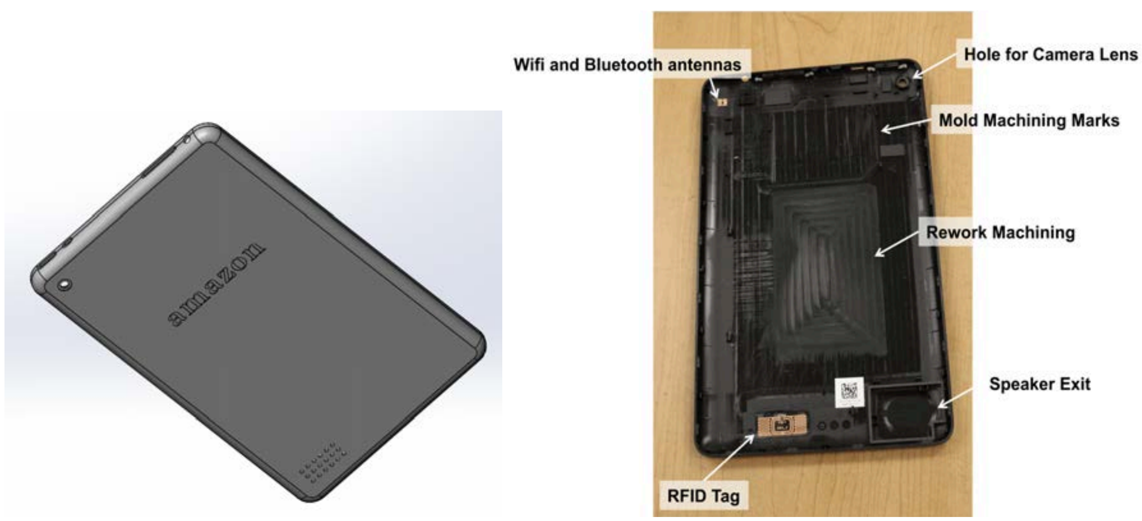


*Figure 2: Back case of Amazon Fire Tablet, showing model and internal features.*

Below is a cost-volume curve (Figure 3) for the back case up to a maximum annual production quantity of 1,000,000 units. This cost-volume curve incorporates 4 contributors to cost: tooling, equipment, overhead, and material. **The specifications and calculations used to determine cost per part are available in Appendix I.**

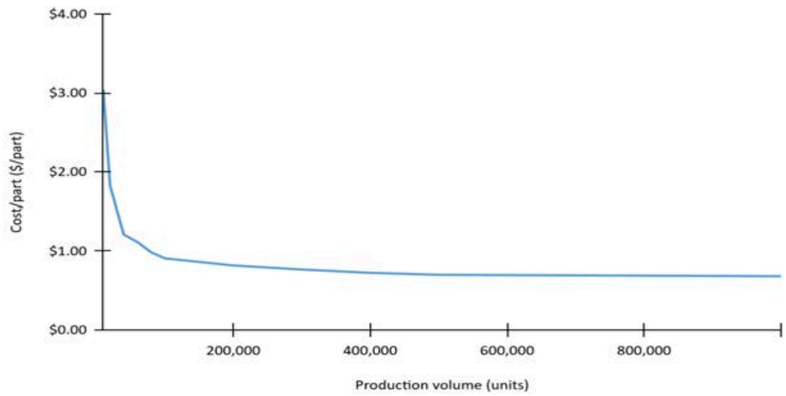


*Figure 3: Cost-volume curve for back case of the Amazon Fire tablet*

The table below shows each contribution's sensitivity to production volume.

| | **Production volume per year** | | |
|---|---|---|---|
| **Unit cost component** | **1,000** | **100,000** | **1,000,000** |
| Material | $0.06 | $0.06 | $0.06 |
| Tooling | $6.46 | $0.13 | $0.06 |
| Equipment | $18.00 | $0.18 | $0.02 |
| Overhead | $0.54 | $0.54 | $0.54 |
| **Total cost per part** | **$25.06** | **$0.91** | **$0.68** |

a) Which two cost components make the largest contribution at each production level? Why?

| | |
|---|---|
| 1,000: | |
| 100,000: | |
| 1,000,000: | |

b) The company has a choice of whether to use aluminum or steel tooling. From a tooling cost, perspective, what is the range of annual production volumes (e.g. less than x00,000 parts) at which they would choose aluminum? Steel? Is there a range in which the choice does not matter?

c) Your supplier suggested that by using a high-strength, fiber-reinforced polymer, you can make thinner cases (resulting in a thinner case that's about 20% lighter!) and thus increase your production rate by 50% (i.e., reduce cycle time by 33%). This reduced cycle time also means that you can shift from using 3 machines to only using 2. However, this reinforced material costs 50% more per unit mass than the standard material used for the Fire, with the same amount of waste (i.e. sprue geometries don't change). It also will require more dedicated oversight from your operators, increasing overhead costs by $10/hour. The mold/tooling cost is the same as before.

Using Appendix I and incorporating the changes above, fill out the table below with updated costs per component. At what volumes does switching to this polymer appear to be cost-effective?

| Production volume per year | | | |
|---|---|---|---|
| **Unit cost component** | **1,000** | **100,000** | **1,000,000** |
| Material | | | |
| Tooling | | | |
| Equipment | | | |
| Overhead | | | |
| **Total cost per part** | | | |

[space for calculations]

d) Your manufacturing engineers come back to you with some complaints after analyzing the control charts for an initial production run with the new material, saying that **short shot is now an elevated concern**. They say that to counteract this, they need to adjust sprue geometries such that the amount of scrap during production must now double, and this in turn reduces effective machine uptime from 80% to 70%.
Consider only the case for a production volume of 1,000,000. Is the new material more cost-effective compared to the original Amazon Fire tablet, given this new information?

**Appendix I: Amazon Fire Tablet Cost Model Assumptions and Results**

| | |
|---|---|
| **Machine Cost** | |
| machine cost ($/machine) | $60,000 |
| machine lifetime (years)* | 10 |
| # machines used for the line | 3 |
| **Cost per part = ($/machine) * (# machines) / lifetime / # parts** | |
| **Tooling Cost** | |
| cost of one set of tooling - aluminum ($) | $6,455 |
| tool life - aluminum (number of parts each tool can make) | 50,000 |
| cost of one set of tooling - steel ($) | $32,275 |
| tool life - steel (number of parts each tool can make) | 500,000 |
| **Cost per part: ($/tool) / (# parts) * # tool changes made** | |
| **Material Cost** | |
| part mass (kg) | 0.048 |
| material cost ($/kg) | $1.00 |
| scrap fraction | 0.2 |
| assume material cost is fixed at the value for 100,000 kg | |
| **Cost per part = part mass * material cost / (1 – scrap fraction)** | |
| **Overhead Cost** | |
| total overhead (including labor) per machine ($/hr) | $78/3 = $26 |
| cycle time (sec) | 60 |
| operating hours per day | 24 |
| machine uptime (%) | 80% |
| **Cost per part = $ overhead * cycle time / uptime** | |