# ISyE 6334 – Group Project (Fall 2025)

**Due:** December 9, 2025 **Teams:** Up to 3 students

**Submission:** Upload a single PDF containing an executive summary (2–3 pages) and appendices (spreadsheets, screenshots, and code from Excel/Matlab/R).

## The SparkFire Venture

## Background

You are analysts at **SparkFire LLC**, a Georgia-based distributor of fireworks. The wholesaler **Leisure Limited** supplies temporary roadside stands for the July 4 season. Participants purchase inventory, sell it during the week before the holiday, and return unsold boxes for a **partial refund**.

Returned boxes lose quality, so only part of the wholesale cost is refunded. To encourage competition, Leisure Limited offers a **Corvette Prize** to the stand with the **highest statewide sales volume**.

Your supervisor, **Talia Rogers**, has asked you to determine how many firecracker sets to order and to analyze how pricing, refund policy, discounts, and contextual information affect profit and risk.

## Base Market and Cost Information

| Item | Symbol | Base Value | Notes |
|---|---|---|---|
| Wholesale cost | $c$ | \$3.00 | before discount |
| Selling price | $p$ | \$5 or \$6 | decision variable |
| Refund fraction | $f$ | 0.50 | scenarios 0.25–0.75 |
| Return shipping | $s$ | \$0.50 | per unit |
| Administrative fee | $K$ | \$20 | per order |
| Prize value | $V$ | \$40,000 | Corvette reward |
| Discount tiers | – | see Part 7 | wholesale reductions |

**Demand:** Uniform(120, 420) sets; independent of price in the base case.

## Interpreting Ambiguity

Real projects contain imperfect information. Some details are intentionally slightly ambiguous (e.g., prize thresholds, signal accuracy). Identify the ambiguity, state a reasonable assumption, and justify it (1–3 sentences). There is no single "correct" interpretation—grading emphasizes the quality and consistency of your reasoning.

## The Assignment (100 Points Total)

| Part | Topic | Points |
|---|---|---|
| 1 | Conceptual Analysis | 5 |
| 2 | Optimal Order Quantity | 7 |
| 3 | Refund Sensitivity | 7 |
| 4 | Pricing Decision | 8 |
| 5 | Risk & Simulation | 12 |
| 6 | Behavioral Incentive (Prize) | 13 |
| 7 | Quantity Discounts | 13 |
| 8 | Context Signal & Deferred Purchasing | 20 |
| 9 | Open-ended discussions | 20 |
| | **Total** | **100** |

## 1 – Conceptual Analysis (5 pts)

Should the optimal order quantity exceed, equal, or fall below expected demand (midpoint = 270)? Explain using overage vs. underage trade-offs **without first calculating** the optimal $Q$.

## 2 – Optimal Order Quantity (7 pts)

Determine the optimal order quantity ($Q^*$) that maximizes expected profit, assuming $p = \$5$ and $f = 0.5$. Show your newsvendor model, profit equation, and numeric result.
*Reflection ($\leq$ 100 words):* Identify one significant limitation of the uniform-demand assumption and how a different distribution (e.g., Normal or Lognormal) could bias $Q^*$ or expected profit.

## 3 – Refund Sensitivity (7 pts)

Re-compute $Q^*$ for refund rates $f = 25\%$ and $f = 75\%$. Discuss how refund generosity affects the optimal order quantity, expected profit, and SparkFire's financial risk.

## 4 – Pricing Decision (8 pts)

Assume demand is not affected by price. Find the new optimal quantity $Q^*$ if the price is set to $p = \$6$ (with $f = 0.5$). Compare the expected profits of the $(p = \$5, Q^*_{p=5})$ and $(p = \$6, Q^*_{p=6})$ policies and recommend a course of action.
*Reflection ($\leq$ 50 words):* Briefly comment on how your $p = \$6$ policy might change if raising the price decreased demand (no calculation needed).

## 5 – Risk & Simulation (12 pts)

Using the optimal policy from Part 2 ($p = \$5, Q^*$), simulate $\geq 500$ trials of demand and profit. Report the mean profit, standard deviation of profit, and the probability of a loss (profit $< 0$). Propose one risk-mitigation strategy based on your findings.
*Local Reflection ($\leq 75$ words):* How might Georgia's weather (e.g., a very rainy June) or local regulations (e.g., a last-minute fireworks ban in a major county) affect your results?

## 6 – Behavioral Incentive (13 pts)

Leisure Limited awards \$40,000 to the stand with highest sales. SparkFire estimates a 5% chance of winning if actual sales are $\geq 400$ units. Other states use 3% if actual sales $\geq 380$ or 7% if actual sales $\geq 420$ are mentioned as context.

(a) Modify your profit model to account for the possibility of awards.

(b) Find the new quantity $Q^{**}$ that maximizes total expected returns.

(c) Compare $Q^{**}$ to $Q^*$ (from Part 2) and discuss how this incentive scheme encourages risk-seeking or risk-averse behavior.

*Assumption & Reflection ($\leq 150$ words):* State which prize rule you used (e.g., the 5% @ 400) and why. Discuss the limitation of adding a small expected value to the model versus the behavioral desire to win a \$40,000 prize.

## 7 – Quantity Discounts (13 pts)

The wholesaler offers all-units discounts. The unit cost $c$ changes based on the total $Q$ ordered:

| **Order Qty** | **Unit Cost ($c$)** |
|---|---|
| 1–199 | \$3.00 |
| 200–399 | \$2.85 |
| 400+ | \$2.70 |

(a) Modify your profit model to account for the piecewise cost function.

(b) Find the new optimal quantity $Q_d^*$ (for $p = \$5, f = 0.5$).

(c) Compare $Q_d^*$ and its expected profit to the $Q^*$ and profit from Part 2.

(d) Briefly explain how quantity discounts can help coordinate a supply chain.

## 8 – Context Signal & Deferred Purchasing (20 pts)

A market signal ($S \in \{\text{High}, \text{Low}\}$) becomes available after the initial order. $P(\text{High}) = 0.45$.

$$D|S = \text{High} \sim U[240, 420], \qquad D|S = \text{Low} \sim U[120, 260].$$

**Two-stage process:**

- **Pre-season:** Commit to an initial order ($Q_0$) at the base cost $c_0 = \$3.00$.
- **In-season:** After seeing signal $S$, place a second, expedited top-up order ($Q_1(S)$) at a premium cost $c_1 = \$3.60$.

Refund ($f = 0.5$) and shipping ($s = 0.5$) terms are unchanged.

(a) Formulate the profit function $\pi(Q_0, Q_1(\cdot))$.

(b) First, determine the optimal total inventory $Q_S^*$ for each signal $S$ ($Q_H^*$ and $Q_L^*$) using the second-stage costs. This defines the optimal policy $Q_1^*(S) = \max(0, Q_S^* - Q_0)$.

(c) Second, optimize the initial $Q_0$. Find the $Q_0^*$ that maximizes the total expected profit across both scenarios. Report the full policy $(Q_0^*, Q_1^*(\text{High}), Q_1^*(\text{Low}))$ and the total expected profit.

(d) Compute the **Value of Signal and Reactive Capacity (VOSRC)** using:

$$\text{VOSRC} = [\text{Full Model Profit}] - [\text{Baseline Profit}],$$

where Baseline Profit is your optimal expected profit from Part 2 and Full Model Profit is your optimal expected profit from Part 8(c).

*Justification ($\leq$ 4 sentences):* Based on your VOSRC, when is paying the expedited premium rational given the quality of this signal?

## 9 – Open-Ended Discussion (Choose 2 out of 4, each worth 10 points out of 100)

Tie your answers to your analysis (Parts 2–8) and SparkFire's context.

**OE1. Contract Design.** Propose a simple two-parameter contract (e.g., buyback + quantity-flex or buyback + penalty) that aligns SparkFire and Leisure Limited incentives. Explain how it changes overage/underage trade-offs ($C_o, C_u$) and what data you'd need to set parameters.

**OE2. Prize Mechanism Redesign.** The Corvette prize can induce over-ordering. Redesign the incentive (e.g., prize based on profit, sell-through rate, or tiered thresholds) to reduce waste while preserving motivation. Explain expected behavioral changes.

**OE3. Two-Stand Allocation.** Suppose SparkFire operates two nearby stands and can rebalance limited inventory on July 3. Outline an allocation/hedging heuristic and the conditions under which pooling materially improves profit.

**OE4. Negotiation Playbook.** If you could change one term—refund fraction $f$, shipping $s$, or expedited cost $c_1$—which gives the largest improvement per unit change? Support with a brief sensitivity argument referencing your results (e.g., effects on VOSRC or $Q^*$).

## Deliverables

1. **Executive Summary (2–3 pages)**
   State all assumptions and how ambiguities were resolved. Summarize key results ($Q^*, Q^{**}, Q_d^*, Q_0^*, Q_1^*(\cdot)$). Include reflections from Parts 2, 4, 5, 6, and 8, and your responses to any two Open-Ended prompts ).

2. **Technical Appendix**
   Intermediate tables (expected sales, refunds, profits by $Q$). Simulation settings ($\geq 500$ runs, seed if used). At least one Excel formula-view screenshot showing actual cell formulas.

3. **Reproducibility Notes**
   List software version, random-number method, and replication instructions.

## Academic Integrity

Use of generative-AI tools for numerical or explanatory answers is **not permitted**. All modeling, logic, and spreadsheets must be your team's own work. Clearly state your assumptions and include formula screenshots as proof of authorship.

## Submission Checklist

- Executive summary (2–3 pages)
- Assumptions clearly stated and justified
- Formula-view screenshot included
- $\geq 500$ simulation trials
- Reflections completed (Parts 2, 4, 5, 6, 8)
- Two Open-Ended responses
- File named `SparkFire_TeamMemberLastNames##_Final.pdf`