1. (10 points) The demand for a certain product in a local supermarket is 80 boxes per month. Each box costs the supermarket $25. The shipping cost per order, regardless of the size, is $50, and receiving an order costs $80. Each order takes 1.5 months to arrive. The supermarket calculates holding costs based on the cost of capital at 15% per year. Currently, they order two weeks’ worth of demand with each order.

(a) (1 point) What is the average annual total cost of the current policy?

(b) (2 points) What is the optimal order quantity and associated annual total cost?

(c) (2 points) How does the optimal order quantity change if backorders are allowed at $15 per box per year?

(d) (3 points) With the backorder cost given in part (c), what is the optimal maximum shortage level permitted? What is the percentage time that the customers are waiting for their order? What is the average annual total cost in this case?

(e) (2 points) With the backorder cost given in part (c), what is the optimal reorder level with backordering?

2. (20 points) Suppose the demand for the product in Question 1 is not known in advance, and follows a normal distribution with mean 80 boxes per month and a standard deviation of 30 boxes per month. Furthermore, backordering costs are calculated as $15 per box per year.

(a) (2 points) What is the mean and standard deviation of demand during the lead time?

(b) (8 points) Calculate the optimal order quantity and reorder level if the supermarket wants to apply a \((Q, R)\) policy.

(c) (3 points) For the optimal policy in part (b), what are the type-I and type-II service levels?

(d) (5 points) Suppose the backordering cost is not known, and the supermarket aims to find an inventory policy with a 90% type-I service level. Find the optimal \((Q, R)\) values, optimal annual order setup and holding costs, and the imputed shortage cost under this policy.

(e) (optional, will not be graded) For the optimal policy in part (b), what is the safety stock level, what are the average annual holding, setup and backorder penalty costs?

3. (6 points) Read the article “Managing demand uncertainty: People, processes and leadership revolutionize HP media’s supply chain” by R. Wilkins, B. Thakur-Weigold and S. M. Wagner, Industrial Engineer, August 2012, pages 30–34. The article can be accessed through the Georgia Tech Library by searching in the ABI/INFORM database [http://search.proquest.com/abicomplete/index](http://search.proquest.com/abicomplete/index), or simply by searching by title in the library homepage. In answering the following questions, please do not copy and paste text from the article. Use your own words.

(a) (2 points) What is the main trade-off faced by the supply chain managers of HP within their operations? How does this relate to the \((Q, R)\) models we have been discussing in class?
(b) (2 points) Using 2-3 sentences, explain the demand-pull system employed by HP, and name two advantages of this system in terms of handling uncertainty in demand.

(c) (2 points) In order to hedge against uncertainty in a reactive way, HP also reduces production of certain products at various stages. In 2-3 sentences, briefly explain how this works.

4. (Optional, will not be graded) Answer the following questions about the newsvendor problem.

(a) Suppose demand follows a normal distribution and the optimal order quantity is greater than the mean of the distribution. Which of the overage and underage costs is higher? Briefly explain your reasoning.

(b) Assume that the demand follows a uniform distribution in the interval \([a, b]\). Under the optimal order quantity, the probability of a stockout is higher than that of having leftovers. In this case, which of the overage and underage costs is higher? Briefly explain your reasoning.