1. (5 points) Read the article “Engineers who make a difference: Closing the waiting gap. University of Toronto researcher’s computer model improves scheduling for hip and knee procedures” by David Brandt. *Industrial Engineer*. February 2012. Volume: 44. Number 2. This article can be accessed from your browser (open access). Answer briefly (a paragraph) the following questions:
   a. (1 point) Explain why it is difficult to give an accurate surgery date to an elective knee replacement surgery patient ahead of time.
   b. (2 points) Explain how operations research tools can be used to take into account urgent cases when scheduling elective patients.
   c. (2 points) How can the different stakeholders (patients, doctors, hospitals, etc.) benefit from the scheduling tool discussed in the article?

2. (35 points) Everything Gym is a retailer of exercise equipment and gear. An eco-friendly yoga mat is one of their most popular products. Customers can also personalize their yoga mats with their names and any of the available yoga mat designs. It is a unique feature only offered by Everything Gym in the area. Everything Gym wants to make sure they are holding the right amount of inventory for this important product. The cost of each yoga mat is $40. These yoga mats are shipped from Europe and the lead time is 1 month. The ordering cost is $1,500. Everything Gym estimates that the annual demand follows a normal distribution with a mean of 7,500 and a standard deviation of 900. Everything Gym also estimates an annual interest rate of 22% for carrying inventory. If a customer asks for the yoga mat and it is out of stock, the customer is added to a waiting list. Everything Gym estimates a shortage penalty cost of $50 per unit, due to loss of good will and the opportunity lost for making other sales to this customer.
   a. (2 Points) Compute the mean and standard deviation of the demand during the lead time.
   b. (8 Points) Assume that Everything Gym wants to implement a (Q, R) policy. Find the optimal values for the order quantity and the reorder level.
   c. (1 Point) Determine the safety stock.
   d. (2 Points) What are the average annual holding, setup and backorder penalty costs associated with this policy? If the yoga mat is sold at $75, would Everything Gym make a (expected) profit on this product?
   e. (3 Points) What would be the annual holding, setup and backorder penalty costs if there was zero variability in the demand? What is the cost of uncertainty? Hint: compare d) with e).
   f. (2 points) Using the policy you found in part b), find the (average) proportion of order cycles in which no stock-outs. Does this correspond to Type I or Type II service level?
   g. (2 points) Using the policy you found in part b), find the (average) proportion of demand that is unmet. Does this correspond to Type I or Type II service level?
h. (6 points) Since the penalty shortage cost is hard to quantify, Everything Gym wants instead to implement an inventory policy 90% Type I service level. What are the optimal (Q,R) values and the expected annual cost (setup and holding)? What is the imputed shortage cost corresponding to this policy?

i. (9 points) If the Everything Gym wants instead to achieve a 95% Type II service level, what are the optimal (Q,R) values and the expected annual cost (setup and holding)? What is the imputed shortage cost corresponding to this policy?

3. (5 points) A company follows a (Q,R) policy for a given product with an annual demand that follows a normal distribution of mean \( \lambda \) and standard deviation \( \sigma \). The holding cost is \( h \) per unit per year; the setup cost is \( K \); the shortage penalty cost is \( p \) per unit; and the lead time is \( \tau \) years. Assume that there is an increase in the setup cost, and the new setup cost is \( K' \) (i.e. \( K' > K \)), whereas all the other parameters remain constant.

a. (4 points) How would the increase in \( K \) affect the optimal order size \( Q \) and the optimal reorder point \( R \) (i.e., would each of them increase or decrease)? Show it analytically.

b. (1 point) Explain the cost dynamics.