1. **EOQ** (15 points)

   (a) State the assumptions of the classical Economic Order Quantity (EOQ) problem studied in class.

   (b) What happens to the optimal order quantity in the EOQ model if demand doubles?

   (c) Suppose that you reduce the setup cost $K$ from $100$ to $90$ and as a consequence of this you saved $40$ in the average annual cost. What can you say about the average annual savings if you further reduce the setup cost form $90$ to $80$?
2. **Multi-Item EOQ** (15 points) Suppose you know the unit cost \( c_i \), the number of hours per setup \( s_i \), and the annual demand rate \( \lambda_i \) of items \( i = 1, \ldots, n \). Assume that the setup cost of item \( i \) is \( K_i = a s_i \) and the inventory holding cost of item \( i \) is \( h_i = I c_i \) where \( I \) and \( a \) are respectively the cost of capital and the cost of labor.

(a) What is the relationship between the average number of hours (\( N \)) per year spent in setups and the average cost per cycle (ACS) if the items are managed optimally?

(b) How can the relationship discussed in part (a) be used to determine whether or not a set of items is optimally managed if you do not know \( a \) and \( I \)?

(c) Suppose that the items are not optimally managed. What can you do to reduce \( N \) without increasing ACS?
3. Diseconomies of Scale (15 points)

(a) What do we mean by diseconomies of scale in production?

(b) What kind of policies are optimal if there are diseconomies of scale in production?

(c) What happens when there are lower and upper bounds on inventory at the end of each period?
4. **Economies of Scale** (15 points)

   (a) What do we mean by economies of scale?

   

   (b) What can you say about $I_{t-1}x_t$ where $I_k$ is the inventory at the end of period $k$ and $x_k$ is the amount produced in period $k$?

   

   (c) Use the Wagner Whitin algorithm to minimize the total holding and ordering cost for the following problem: $r_1 = 20, r_2 = 40, r_3 = 50, h_1 = h_2 = h_3 = 1$ and $K_1 = K_2 = K_3 = 50$. 
5. Aggregate Production Planning (10 points)

(a) What are the goals of APP?

(b) What are the main problems with APP?

(c) Provide a precise linear programming formulation for the prototype example of Lecture 5 that minimizes the sum of the hiring, firing and holding costs.
6. **MRP** (15 points) Consider the following bill of materials: Item 1 requires 2 units of item A and one unit of item B, item 2 requires one unit of A, 2 units of B, and 3 units of C. Item A requires 2 units of B and one unit of C, item B requires 2 unit of C and one unit of E. Finally, item E requires 2 units of C and 1 unit of F.

(a) Order the items by level.

(b) Suppose that 50 units of item 1 are needed in period 10 and 100 units of 2 are needed in period 8. Suppose that the lead times of all items is one week. Find the gross requirement of all level 1 items.

(c) Suppose that 50 units of item A are scheduled to be delivered in period 2. Find the net requirements for item A.
7. **ERP Systems** (15 points) Use the Internet to investigate and write a brief report on the ERP offerings of one of the following companies: SAP, Oracle, PeopleSoft, Baan and J.D. Edwards. Your report should not exceed two pages in length. The report should include the name of the product, e.g., SAP R/3, its claimed capabilities, one success story and, if possible, one horror story.