CPIM Exam – Basics of Supply Chain Management
Practice Study Sheet

Index

This study guide contains my notes on topics from "Introduction To Materials Management" as preparation for the first CPIM Exam. It is ordered by chapter. You need to **purchase this book** in order to make sense of the notes – they are highlights for quick review

Chapter One – Introduction to Materials Management

- Lead time shrinks and inventory increases as you go from 1) engineer to order 2) make to order 3) assemble to order 4) make to stock
- Three critical elements of the supply chain are 1) flow of materials 2) flow of information 3) fund transfers
- Manufacturing Planning and Control consist of 1) Production Planning 2) Implementation and Control 3) Inventory Management
- Production Planning includes 1) forecasting 2) master planning 3) material requirements planning and 4) capacity planning
- Implementation and Control includes 1) Production Activity Control and 2) Purchasing
- Five basic inputs to the Manufacturing Input and Control system are 1) product description / bill of material 2) process specifications 3) time needed to perform operations, in standard time 4) available facilities and 5) quantities required
- Physical supply and distribution includes 1) transportation 2) distribution inventory 3) warehousing 4) packaging 5) materials handling 6) order entry

Chapter Two – Production Planning System

- Priority – what is needed, how many and when; Capacity is the capability to produce goods and services. In the long run, they must be in balance
- Manufacturing Planning and Control System has five levels (sorted by level of detail):
    1. Strategic Business Plan
    2. Production Plan
    3. Master Production Schedule
    4. Material Requirements Plan
    5. Production Activity Control and Purchasing
- Strategic Business Plan 1) marketing determines product & pricing 2) Finance finds funds 3) Production meets needs through machinery & labor 4) Engineering is responsible for design. Reviewed every 6 months to a year
- Production Plan 1) quantities by product group 2) desired inventory levels 3) equipment, labor and material needed 4) availability of resources needed. Planning horizon 6-18 months and reviewed monthly or quarterly
- Master Production Schedule (MPS) is for production of individual items. The planning horizon is 3-18 months out. Master scheduling is the process of making an MPS. The plans are changed weekly or monthly
- Material Requirements Plan (MRP) is a plan for production and purchase of items in the master production schedule. Purchase and Production Activity control use the MRP for controlling raw materials. The planning horizon is a day to a month
- Production Activity Control and Purchasing represent the implementation of the plan. Purchasing obtains material per the MRP and production carries out the tasks in the MRP
- Sales and Operations Planning is derived from the Strategic Business Plan and is made up of a Marketing Plan that links to the Production Plan (above) and a Detailed Sales Plan that links to the master Production Schedule (above)
- Manufacturing Resource Planning (MRP II) is the fully integrated planning and control system. It coordinates between marketing and production. It includes the sales and operations plan, the sales plan, master schedule, material requirements plan, purchasing, production activity control and performance measures
- Enterprise Resource Planning (ERP) is an accounting oriented information system for identifying and planning the enterprise. ERP encompasses the entire company and MRP II is manufacturing
- In the short term the product plan is limited by capacity. Changes can be made through overtime, build up of inventory, subcontracting and leasing extra equipment
- The production plan usually has a12 month time horizon, a few product groups, demand is fluctuating, plant and equipment are fixed
- Three basic strategies for making the production plan include 1) chase 2) production leveling (divide total production units by # of days for target) 3) subcontracting (make minimum demand and subcontract the rest)
- Level production = (total forecast + back orders + ending inventory – opening inventory) / # of periods
- In a make-to-order environment, there is a backlog of customer orders

- Resource bill shows the critical resources needed to make one average unit in the product group. This is used for resource planning. You need to determine the materials (# of units * # of material required) and labor (# of units * # of hours) needed to make the plan in standard hours

Chapter Three – Master Scheduling

- Master production schedule (MPS) 1) links production planning to what will be built 2) calculates capacity and resources needed 3) drives the materials requirements plan 4) drives priorities for manufacturing
- To build the master production schedule (MPS) you need the following information
  1. the production plan
  2. forecasts for individual end items
  3. actual orders received from customers and for stock replenishment
  4. inventory levels for individual end items
  5. capacity constraints
- Objectives of MPS are to 1) maintain finished good inventory levels 2) make the best use of labor, materials & equipment 3) maintain inventory investment (WIP) at the required levels
- Develop a preliminary MPS, check MPS against capacity, resolve differences (this is called rough cut capacity planning)
- Rough cut capacity planning checks whether resources are available to support the preliminary master production schedule. Plan on a single product, not a group, and use the resource bill
- For make to stock, the MPS is a schedule of finished goods items, for make to order the MPS is a schedule of actual customer orders, for assemble to order, go to the base order
- Final Assembly Schedule (FAS) – schedule of what will be produced
- MPS is a plan for what production can and will do – it is not a sales forecast
- Available to Promise (ATP) is based on the MPS – portion of inventory that is not already committed and available to a customer. ATP = scheduled receipts + beginning inventory = actual orders scheduled
- Projected available balance (PAB) includes a calculation for customer orders. PAB = prior period PAB + MPS – greater of (customer orders or forecast demand)
- Frozen Zone – capacity and materials are committed to specific orders, senior mgmt approval required for changes.
- Slushy Zone – capacity and material are committed to less extent. Tradeoffs must be met between marketing and manufacturing
- Liquid Zone – any changes can be made to the MPS

Chapter Four – Master Requirements Planning

- Materials Requirements Planning has 2 major objectives1) determine requirements 2) keep priorities current
- Independent demand must be forecast; dependent demand is related to the demand for other items (higher level assemblies or products)
- Material Requirements Planning (MRP) drives Production Activity Control (PAC) and purchasing. MRP plans the release and receipt dates for orders. PAC and purchasing must plan and control the performance of orders to meet the due dates
- The Material Requirements Planning System has three inputs 1) master production schedule 2) inventory records 3) bills of materials
- Inventory records have 1) planning factors (header records) and 2) status of each item that changes with every transaction
- Bill of Material is "a listing of all the subassemblies, intermediaries, parts and raw materials that go into making the parent assembly showing the quantities of each required to make an assembly". Three points
  1. BOM shows all the parts required to make one item
  2. Each part or item has only one part number
  3. A part is defined by its form, fit or function. If any of these change, they become new, unique parts (i.e. if you paint something)
- Multilevel bills are formed as logical groupings of parts into subassemblies, based on the way the product is assembled (i.e. an auto has a frame, chassis, doors, windows and engine as subassemblies)
- Summarized parts list contains all the parts needed to make one assembly; produced by the product design engineer
- Planning bills are artificial groupings of components for planning purposes. They do not represent buildable products but an average product
- Where-used reports give the same information as a bill of material, but gives the parents for a component. Wheels might be used on several models of cars
- Pegging report is like a where used report but only shows parents for which there is an existing requirement (rather than all parents, even those with no current production)
- Bills of material are used for the following purposes
  1. product definition – components to make a product
  2. engineering change control – recording changes to design of a product
  3. service parts – replacement parts needed to fix a broken component are determined from the bill of material
  4. planning- define what materials are needed to create an end product
  5. order entry – the order entry system usually automatically configures the order with parts and calculates the total extended price
  6. manufacturing – provide a list of parts needed to make a product
  7. costing – method of determining direct material and a structure for recording direct labor and distributing overhead
- Lead time is the amount of time needed to perform an operation – it includes order preparation, queuing, processing, moving receiving and inspecting
- Exploding is the process of multiplying the requirements by the usage quantity and recording the appropriate requirements throughout the product tree

- Offsetting is the process of placing the exploded requirements in their proper periods based on lead time
- The planned order release of the parent becomes the gross requirement of the component
- Releasing an order means that authorization is given to purchasing to buy the necessary material or to manufacturing to make the component (check component availability first)
- Scheduled receipts are orders place on manufacturing or on a vendor and represent a commitment to make or buy. Scheduled receipts on the MRP record are open orders on the factory . When the goods are received into inventory and available for use, the order is closed out, and the scheduled receipt moves into on-hand inventory
- Net Requirements = gross requirements – scheduled receipts – available inventory
- Low level code is the lowest level on which a part resides in all bills of material. Determined by starting at the lowest level of a bill of material and working up to the part
- Responsibility of planner is to 1) launch (release) orders to purchasing or manufacturing 2) reschedule due dates of open (existing) orders as required 3) reconcile errors and try to find their cause 4) solve critical material schedules by expediting or re-planning 5) coordinate with others
- Planned orders are automatically scheduled by the computer. Released orders are responsibility of the planner. Firm planned orders can be held against changes
- Exception messages advise the planner when something needs attention
- Transaction messages mean that the planner must tell the MRP software of all actions such as 1) release an order 2) schedule a receipt 3) change to the data
- Feedback to the plan comes from 1) suppliers actions through purchasing 2) early or late completion at the factory 3) management actions such as changing the master production schedule
- Reducing systems nervousness of constant changes through firm planned orders

Chapter Five – Capacity Management

- Capacity is the amount of work that can be done in a specific time span. "The capability of a worker, machine, work center, plan or organization to product output per period of time".
- Capacity is the rate of doing work, not the quantity of work done
- Capacity required is the capacity of a system or resource needed to produce a desired output in a given time period
- Load is the amount of released and planned work assigned to a facility for a particular time period
- Capacity management is responsible for determining the capacity needed to achieve the priority plans. "The function of establishing, measuring, monitoring, and adjusting limits or levels of capacity in order to execute all manufacturing schedules
- Capacity Planning is the process of determining the resources required to meet the priority plan and the methods needed to make that capacity available
- Capacity control is the process of monitoring production output, comparing it with capacity plans, and taking corrective actions when needed
- Capacity planning process is as follows
  1. determine the capacity available at each work center in each time period
  2. determine the load at each work center in each time period
  3. resolve differences between available capacity and required capacity
- Resource Planning involves long-range capacity resource requirements and is directly linked to production planning. If the resource plan cannot be devised to meet the production plan, then the production plan has to be changed
- Rough cut capacity planning is medium range and the capacity requirements plan is short range.
- Inputs for the Capacity planning include 1) open shop orders 2) planned order releases 3) routings 4) time standards 5) lead times 6) work center capacities
- An open order file is a record of all the active shop orders
- Planned order releases are determined by the computer's MRP logic based upon the gross requirements for a particular part
- Routing is the path that work follows from work center to work center as it is completed. A routing file should exist for every component manufactured and contain 1) operations to be performed 2) sequence of operations 3) work centers to be used 4) possible alternative work centers 5) tooling needed at each operation 6) standard times for setup and run for each piece
- A work center is composed of a number of machines or workers capable of doing the same work. A work center file contains information on the capacity and move, wait and queue ties associated with the center
- The move time is the time taken to move material from one workstation to another. The wait time is the time a job is at a work center after completion and before being moved. The queue time is the time a job waits at a work center before being handled. Lead time is the sum of queue, setup, run, wait and move times.
- Capacity available is the capacity to produce a quantity of output in a given time period. It is effected by 1) product specifications 2) product mix 3) plant and equipment 4) work effort
- Unit of output is appropriate if there is not a wide variety of products produced such as paper mills measuring in tons of paper; if not, the common element is time
- Standard time is the time required to make the product using a given method of manufacture (through time study techniques)

- Demonstrated capacity is figured from historical data (and is the average, not maximum output). Calculated or rated capacity is based on available time, utilization, and efficiency
- Utilization = hours actually worked / available hours * 100%
- Efficiency = actual rate of production / standard rate of production * 100%
- Rated capacity = available time * utilization * efficiency
- The time needed for each order is the setup time and the run time
- Load is the sum of the required times for all the planned and actual orders to be run on the work center in a specified period. Calculate load by 1) determine standard hours of operation time for each planned and released order for each work center by time period 2) add all the standard hours together
- Work center load report shows 1) over capacity 2) under capacity work centers
- Scheduling is defined as "timetable for planned occurrences"
- To calculate back scheduling (start with the due date and work backwards to the start date) you need to know
  1. quantity and due date
  2. sequence of operations and work centers needed
  3. setup and run times for each operation
  4. queue, wait and move times
  5. work center capacity available (rated or demonstrated)
- The process of develop a schedule 1) for each work order, calculate the required time at each work center 2) starting with the due date, schedule back to get the completion and start dates for each operation
- Two ways of balancing capacity available 1) alter the load (shift orders ahead or back) 2) change the capacity of available (schedule over time, adjust the workforce by hiring or firing workers, shift workforce b/n work centers, use alternate routings on work centers to shift away from bottlenecks, subcontract)

Chapter Six – Production Activity Control

- Production Activity Control (PAC) is responsible for executing the master production schedule and the material requirements plan (also use labor and machines correctly, minimize WIP, and maintain customer service). The Materials requirements plan authorizes PAC to:
  1. release work orders for manufacturing
  2. take control of work orders and ensure timely completion
  3. responsible for detailed planning of order flow through manufacturing
  4. manage day-to-day activity
- Dispatching is releasing orders to the shop floor as authorized by the material requirements plan
- Control is 1) ranking orders by priority 2) compare actual performance of work orders to scheduled 3) monitor & control WIP, lead times and queues 4) Report efficiency, operation times, order quantities and scrap
- Flow manufacturing (high volume standard products) can be repetitive manufacturing (cars) or continuous manufacturing (gasoline). Major characteristics
  1. routings are fixed and arranged accordingly; the amount of time to perform work at one center is roughly the same as other work centers
  2. work centers produced a limited range of similar products
  3. material flows via mechanical transfer (little WIP)
  4. capacity is fixed by the line
- Intermittent manufacturing has many variations in product design, process requirements and order quantities. Major characteristics
  1. Flow of work is varied and depends on design. They will take more or less time at each work station (not balanced)
  2. machinery and workers are flexible
  3. throughput times are long, WIP is large
  4. capacity required depends on the mix of products being built and is difficult to predict
- Production Activity Control (PAC) must have four Planning Files to route materials through manufacturing — item master file, product structure file, routing fie and work center master file
- Item Master File – there is one record for each part number. Includes header information such as description, lead time, quantity on hand & available
- Bill of Material File listing the single level quantities to assemble a parent
- Routing file consists of a series of operations needed to make the item
- Work center master file contains all relevant data on a work center including capacity, number of machine and labor hours, efficiency, utilization, etc…
- Every active manufacturing order (in process) has a record in the shop order master file. The shop order detail file contains a record of each operation needed to make an item
- Objective of scheduling is to meet delivery dates and make the best use of manufacturing resources
- Manufacturing lead time consists of 1) queue time 2) setup time 3) run time 4) wait time 5) move time (transit between work centers). Typically in intermittent manufacturing queue time consists of 85-95% of total lead time
- Cycle Time / Throughput Time – length of time from when material enters a production facility until it exits

- Forward scheduling assumes that material procurement and operation scheduling start when the order is received, and that the operations are scheduled forward from this date. This results in an early completion and the earliest delivery date for a product
- Backward scheduling is scheduling the last operation first and working back to the latest start date. WIP is reduced and there is little slack may impact customer service
- Infinite loading assumes that the workstations have capacity available when required. It does not consider the impact of other orders in the system
- Finite loading takes into account the other orders
- Operation overlapping – the next operation is allowed to begin before the entire lot is completed on the previous operation. This reduces total manufacturing time; need to decide sub-lot size
- Operation splitting also reduces lead time – cut order in ½ and run on two machines at the same time; additional setup time is incurred but run time is cut in half
- Load leveling shifts load to different time periods when there is a shortage of capacity
- Overloaded work stations are called bottlenecks when required capacity is greater than the available capacity, or "a facility, function, department or resource whose capacity is equal to or less than the demand placed upon it"
- Throughput is the total volume of production going through a facility. Bottlenecks control the throughput of all products processed by them. Work should be scheduled at the bottleneck at the maximum rate it can process work (its capacity)
- Bottleneck principles include the following:
  1. utilization of a non-bottleneck resource is not determined by its potential (or capacity), but by another constraint in the system
  2. using a non-bottleneck resource 100% of the time does not produce 100% utilization
  3. capacity of the system depends on the capacity of the bottleneck
  4. time saved at a non-bottleneck saves the system nothing
  5. capacity and priority must be considered together
  6. loads can, and should, be split
  7. focus should be on balancing flow through the shop
- Bottleneck principles include the following:
  8. establish a time buffer before each bottleneck (an inventory queue)
  9. control the rate of material feeding the bottleneck
  10. do everything to provide the needed bottleneck capacity (better utilization, few setups)
  11. adjust loads (use alternate work centers, subcontracting, even if more expensive)
  12. change the schedule (last resort)
- Theory of constraints is a five step process 1) identify the constraint (limits throughput not inventory or production) 2) exploit the constraint (consider rotating shifts so that the constraint is never allowed to be idle 3) subordinate everything to the constraint (don't focus on anything else) 4) elevate the constraint (find ways to increase the available hours of the constraint) 5) once the constraint is not a bottleneck, find the new one and repeat these steps
- Scheduling system for the constraints is called Drum-Buffer-Rope
- Drum is the "drumbeat" or pace of production
- Buffer is important because the constraint should never be starved for inventory
- Rope – pull in material into the constraint at the right time
- To control queue and meet delivery commitments, production activity control must 1) control the work going in an coming out of a work center (called input / output control) 2) set the correct priority of orders to run at each work center. Generally, if queue can be controlled, delivery can be met

- An Input / Output control system is a method of managing queues and work-in-process lead times by monitoring and controlling the input to, and output from, a facility. This information is shown on an input / output report
- Operation Sequencing is a technique for short-term planning of actual jobs to be run in each work center based on capacity and priorities. Control of priorities is exercised through dispatching
- Dispatching is the function of selecting and sequencing available jobs to be run at individual work centers. It contains the work center, standard hours, part number and details, priority information, and jobs coming to the work center
- Dispatching rules include 1) first come, first served 2) earliest job due date 3) earliest operation due date 4) shortest processing time
- Critical ratio = (due date – present date) / lead time remaining. CR < 1 (order behind schedule) CR = 1 (on schedule) CR > 1 (order ahead of schedule) CR zero or less (order is already late)
- Production reporting provides feedback on what is happening at the plant. Types of information needed include 1) order status 2) weekly input / output by work center 3) exception reports 4) inventory status 5) performance summaries

Chapter Seven – Purchasing

- Purchasing is the "process of buying". Manufacturing Planning and Control (MPC) must decide when to order which raw materials. Purchasing then places the order and is responsible for seeing that the order arrives on time
- Manufacturing firms spend 50% of their sales dollars in the purchase of raw materials, components, and supplies
- Purchasing objectives include 1) obtaining right quantity and quality of services 2) getting the lowest costs 3) ensuring best supplier services 4) maintaining good supplier relationships
- To meet objectives must 1) determine purchasing specifications 2) select right suppliers 3) negotiate the best price 4) administer process
- Purchasing cycle consists of 1) receiving requisitions 2) select suppliers (RFQ) 3) determine correct price 4) issuing purchase orders 5) follow up to ensure delivery dates met 6) receiving and accepting materials 7) approving invoices for payment
- Specification elements consist of 1) quantity requirements 2) price requirements 3) functional requirements
- Functional specifications are concerned with the end use of the item and what the item is expected to do. Functional specifications are the most important specifications
- Quality can be said to be met if it satisfies the needs of the user. The phases of providing user satisfaction include 1) quality and product planning 2) quality and product design 3) quality and manufacturing 4) quality and use
- Functional specifications can be described 1) by brand 2) by physical characteristics including performance 3) by engineering drawings
- Description by brand is used where the items are patented or the supplier has created a preference
- Specifications are by buyer (custom) or by standard specifications (industry or government standards)
- There are three types of supplier sourcing
    1. sole sourcing – only one supplier available
    2. multiple sourcing – use more than one supplier for the item (better service and lower cost)
    3. single sourcing – dedicate to one supplier when there is more than one available to produce a long-term partnership
- Factors in selecting suppliers include 1) technical ability 2) manufacturing capability 3) reliability 4) after-sales service 5) supplier location 6) other considerations (credit terms) 7) price
- Ranking method is used (criteria and weight) to select suppliers
- Fair price is a competitive price. Use fixed and variable costs to analyze.
- Four types of products for price negotiations 1) commodities (copper, coal, etc…) 2) standard products (by many suppliers) 3) items of small value (lower cost of ordering) 4) made to order items
- Planner / buyer responsibilities include 1) developing materials requirements 2) developing schedules 3) issuing shop orders 4) releasing material 5) priorities etc…
- Contracting buying assures suppliers a given amount of business and minimizes transaction costs
- EDI enables customers and suppliers to electronically exchange transaction information such as purchase orders, invoices and material requirements
- Internet, Intranet, and Extranet (shared Intranet) available only to company and other party sharing

Chapter Eight – Forecasting

- Demand management is the function of recognizing and managing the demand for products. It includes 1) forecasting 2) order processing 3) making delivery promises 4) interfacing between manufacturing planning and control and the marketplace
- Order processing occurs when a customer's order is received
- Demand shows the need for an item; sales shows what was actually sold. Because demand cannot always be satisfied, demand is higher than sales
- Demand patterns include four types:
  1. Trend – increasing in a steady pattern of demand, or level. Can be geometric or exponential
  2. Seasonality – fluctuates depending on the time of year
  3. Random variation – many factors effect demand. Pattern of variation can usually be measured
  4. Cycle – wavelike increases and decreases in the economy impact demand
- Stable demand retains their shape and dynamic changes do not. The more stable the demand, the easier it is to forecast. The average demand can be the same as it is for stable and dynamic patterns. Usually the stable pattern is forecasted
- Independent demand is not related to the demand for any other product or service. Dependent demand occurs where demand is derived from a second item. Only independent demand needs to be forecasted
- Forecasting has four major principles:
  1. Forecasts are usually wrong. Expect errors
  2. Every forecast should contain an estimate of error
  3. Forecasts are more accurate with families or groups
  4. Forecasts are more accurate for nearer time periods
- Three principles of data collection are:
  1. Record data in the same terms as needed for the forecast 1) data based on demand, not shipments 2) forecast time period should be the same as the schedule period 3) the items being forecasted should be controlled by manufacturing
  2. Record the circumstances of the data. Other factors like sales promotions and competitors' sales are important
  3. Record demand separately for different customer groups – wholesale vs. retail may have different trends
- Three forecasting techniques are 1) qualitative techniques 2) extrinsic techniques 3) intrinsic techniques
- Qualitative techniques are projections based on judgment, intuition and informed opinions (SWAGS)
- Extrinsic forecasting techniques are projects based on external factors (bricks to housing starts, tires to gasoline consumption). This is more useful for forecasting demand for a large family of products (cars)
- Intrinsic forecasting techniques use historical data to forecast. These are the most important techniques, including:
  1. average demand
  2. moving averages
  3. exponential smoothing (a moving average without retaining prior months) – 90% of the forecast is based on the prior months' average and 10% on the current months' average.

New forecast = alpha * (latest demand) + (1 – alpha) * (previous forecast) with alpha between 0 and 1

4. Seasonal index shows how high above or below an average for a product. Seasonal index = period average demand / average demand for all periods. Average demand is "deseasonalized demand". For seasonal demand, 1) only use deseasonalized data for forecast 2) forecast deseasonalized demand 3) apply the seasonality index to the deseasonalized forecast

- Forecast error is the difference between actual demand and forecast demand. Due to bias and random variation
- Bias exists when the cumulative actual demand varies from the cumulative forecast. Bias is a systemic error; need to change the forecast
- Random variation – demands on the demand pattern of the project. Average error should be zero
- Mean absolute deviation (MAD) is a way to measure forecast error.
- Normal distribution by standard deviation +- 1 MAD (60%), +- 2 MAD (90%) +- 3 MAD (98%). MAD is a tracking signal to see if there is bias. Tracking signal = sum of forecast errors / MAD

Chapter Nine – Inventory Fundamentals

- Inventories usually represent between 20 and 60 percent of total assets
- Aggregate inventory management works according to their classification (raw material, work in progress, and finished goods) and the function they perform rather than at the individual unit level. It involves 1) flow and kinds of inventory needed 2) supply and demand patterns 3) functions that inventories perform 4) objectives of inventory management 5) costs associated with inventories
- Item inventory management is also managed at the item level. Management rules include 1) which individual items are most important 2) how individual items are to be controlled 3) how much to order at one time 4) when to place an order
- Raw Materials are purchased goods received which have not entered the production process, including materials, component parts and subassemblies
- WIP is raw materials that have entered the manufacturing process and are being worked on
- Finished goods are ready to be sold as competed items
- Distribution inventories are finished goods located in the distribution system
- Maintenance, repair and operational supplies (MRO) are items that are used in production but don't become part of the final product, including hand tools, spare parts, etc…
- Anticipation inventories are built up in anticipation of future demand (i.e. created ahead of xmas)
- Safety stock is to cover unpredictable fluctuations in supply, demand or lead time. It prevents stockouts
- Lot-sized inventory are items purchased or manufactured in quantities greater than needed immediately. This is done to take advantage of shipping discounts or minimize setup costs. This is also called cycle stock
- Transportation inventories exist due to the time needed to move inventories. They are also called pipeline or movement inventories. The average amount = (transit time in days) * annual demand / 365
- Hedge inventory (usually done with commodities) is done if prices fluctuate and buyers expect prices to rise, so they buy more now
- Inventory management objectives include 1) maximum customer service (orders shipped on schedule, stockouts) 2) operating efficiency (build seasonal inventories, larger production runs, but in larger quantities). Balance this against costs, and tied up $$ in assets
- Item cost is the price paid for a purchased item (includes direct costs like transportation, customs and insurance) also called landed price. Can also be determined in house including direct material, direct labor and factory overhead
- Carrying costs include all expenses incurred by the firm due to volume. 1) capital costs or opportunity cost of $$ tied up in inventory 2) storage costs including space workers, and equipment 3) risk costs include obsolescence, damage, theft and deterioration. Typically 20%-30% of inventory costs are carrying costs
- Ordering costs are associated with placing an order either with the factory or a supplier. Does not depend on quantity ordered. 1) production control costs 2) setup and teardown costs 3) lost capacity cost 4) purchase order costs
- Average cost = (fixed cost / number of orders) + variable cost
- Stockout costs expensive due to back order costs, lost sales and lost customers
- Inventory turns = annual cost of goods sold / average inventory
- ABC inventory determines the relative importance of items and then has different levels of controls

1. A items – 20% of items account for 80% of dollars
2. B items – 30% of items account for 15% of dollars
3. C items – 50% of items account for 5% of dollars

- To calculate ABC use 1. determine annual usage 2) multiple annual usage by cost to get total dollars 3) list items by annual usage 4) calculate cumulative annual dollar usage and percentages 5) group ranked items into A, B and C categories
- ABC rules are 1) have plenty of low-value "C" items (order a years at a time and carry plenty of safety stock) 2) use money and control effort saved to reduce inventory of high-value items (A items)
- A items – high priority – tight control and frequent review, expedite when needed
- B items – medium priority – good controls with normal attention and processing
- C items – low priority – use simple controls and order many items
- Summary – need to balance cost of carrying inventory against 1) customer service 2) operating efficiency (longer production runs and fewer setups) 3) cost of placing orders (decrease with less orders) 4) transportation and handling costs (smaller orders cost more per item)

Chapter Ten – Order Quantities

- Main question - Decision rules to determine **how much** should be ordered at one time
- Stock keeping unit (SKU) are individual items in a particular inventory
- Lot or batch is a quantity produced together and sharing the same production costs and specifications
- Lot for lot says order exactly what is needed – used in just-in-time environment, also for "A" inventory items
- Fixed order quantity rules say exactly how many should be ordered each time an order is placed (i.e. 500 units). This is a simple system
- Min-max system – orders made when quantity available hits order point. At that point order the difference between the quantity on hand and the maximum (i.e. if you have a maximum or 500 units, and you order at 100 units, your order would be placed for 400 units)
- Order "n" periods supply – demand for a number of future periods (months, days or weeks)
- Economic Order Quantity (EOQ) is the decision method to minimize the cost of ordering and the cost of carrying inventory
- Assumptions of EOQ 1) demand is constant 2) item purchased or produced in lots 3) order preparation costs and inventory costs are known 4) replacement occurs all at once
- Average inventory = order quantity / 2
- Number of orders per year = annual demand / order quantity
- A = # of units annually S = ordering costs I = annual carrying costs (percentage) c = unit cost Q = order quantity
- Annual ordering costs = number of orders * cost per order
- Annual carrying cost = average inventory * cost of carrying one unit for one year
- Total annual costs = annual ordering costs + annual carrying costs
- EOQ occurs where the ordering costs = the carrying costs. EOQ increases as the annual demand (A) and the cost of ordering (S) increases, and will decrease as the cost of carrying inventory (i) and unit cost (c) increase.
- Quantity discounts include 1) purchase costs 2) ordering costs 3) carrying costs (saving on purchase and ordering costs, increase in carrying costs)
- Period order quantity (POQ) calculated an economic time between orders. Divide EOQ / average weekly usage. Ordering costs are the same but carrying costs are reduced
- EOQ issues
    1. lumpy demand – EOQ assumes demand is uniform and that replenishment occurs immediately. When not true use period – order quantity
    2. anticipation inventory –when you need to build ahead
    3. minimum orders – may be a rule from suppliers – for C items, order plenty, not an EOQ
    4. transportation inventory can reduce cost per unit for large orders
    5. multiples (ship in skid-load lots)

Chapter Eleven – Independent Demand Ordering Systems

- Main question – **when** to place a replacement order? Three basic systems 1) order point system (for independent demand) 2) periodic review system (for independent demand) 3) material requirements planning (for dependent demand)
- Order point system – when quantities fall to a predetermined level, an order is placed. Must be when there is stock available to satisfy demand until the new stock arrives (lead time). 1) quantities are fixed 2) order point is determined by average demand during the lead time 3) timing of reorders depend on actual demand not on a constant schedule
- Order point = demand during the lead time + safety stock
- Safety stock is a calculated extra amount of stock ordered to protect against uncertainty. Calculation depends on 1) variability of demand during lead time 2) frequency of reorder 3) service level desired 4) length of lead time (longer the time, the more safety stock that has to be carried)
- Safety lead time protects against timing uncertainty by planning order releases and order receipts earlier than required
- Safety factor – service level is directly related to the number of standard deviations provided as safety stock and is usually called the safety factor. The service level is the percentage of order cycles without a stockout
- Safety stock = sigma * safety factor (sigma = 1 standard deviation)
- The only time a stockout occurs is when stock is running low and this happens whenever an order is placed.
- If lead time is zero, the standard deviation of demand (during lead time) is zero. As lead time increases, the standard deviation increases at a slower rate. Sigma for lead time interval = sigma for forecast interval * square root of (lead time interval/forecast interval)
- Two bin system – a quantity of an item equal to the order point quantity is set aside (in a second bin) and not used until main quantity is gone. When the main quantity is gone, an order is placed, and manufacturing continues out of the safety stock
- Perpetual inventory record system is an up to date record of transactions. Contains permanent (header record) and variable information (quantities, balances, etc…)
- Target level demand is the quantity equal to the demand during the lead time plus the demand during the review period plus safety stock is the maximum level inventory (for periodic review system, which doesn't automatically reorder)
- Distribution inventory includes all the finished goods held anywhere in the distribution system (central supply facility and distribution centers)
- Unless a firm delivers directly from factory to customer, demand on the factory is created by the distribution centers (served from central supply). Thus even if demand is uniform it won't appear that way at the center because it depends on when the distribution centers place their replenishment orders
- Decentralized system – each distribution center determines what it needs and when and places orders on central supply. Local control is better but has negative impact on production. Stock is "pulled" through the system
- Centralized system – all forecasting and order decisions are made centrally. Distribution centers have no say in what they receive. Stock is "pushed" through the system. Generally stock that has been sold is replaced with extra inventory for promotions. Results in lower level of customer service

- Distribution requirements planning forecasts when the distribution centers will demand product from central supply. Then the factory can plan for production and respond to customer demand

Chapter Twelve – Physical Inventory and Warehouse Management

- Warehousing management objectives are to 1) minimize cost 2) maximize customer service
- Elements include 1) provide fast customer service 2) track items 3) minimize the total cost of moving goods in and out of storage 4) communicate with customers
- Capital costs are space and materials handling equipment (based on peak demand). Operating costs include labor, and productivity of labor is measured in # of units that can be moved each day (which depends on capital investment)
- Warehouse activities include the following elements:
    1. Receive goods 1) check vs. order and bill of lading 2) check quantities 3) check for damage 4) inspect goods if required
    2. Identify the goods (put SKU on them)
    3. Put goods in storage
    4. Hold goods (protect and keep in good condition)
    5. Pick goods (select from stock and bring to dock)
    6. Marshal the shipment (select goods that comprise a single order, check, update order records)
    7. Dispatch the shipment (package orders, prepare documents, load on vehicle)
    8. Operate an information system (maintain records, may be manual or computer based)
- Best warehouse practices 1) maximize use of space (largest capital cost) 2) use labor and equipment effectively (largest operating cost, more productive)
- Cube Utilization and Accessibility – goods are stored on the floor and above the floor. Space is also required for aisles, receiving, shipping, offices, order picking and assembly
- <u>Accessibility</u> means that you can get to the goods you want with a minimum amount of effort (if you don't have to move anything else, it is 100% accessible)
- <u>Cube utilization</u> can be increased by putting in racks or tiers (additional capital cost to reduce handling costs)
- Basic stock locating systems 1) group functionally related items together (all hardware) 2) group fast-moving items together 3) group physically similar items together (i.e. items that need to be frozen) 4) locate working stock and reserve stock separately (working stock used for order picking)
- <u>Fixed location system</u> assigns an SKU a permanent location. Minimize record keeping (only uses 50% of cube space)
- <u>Floating location system</u> stores goods where ever a location can be found. Improves cube utilization but must be computer based
- <u>Point of use storage</u> puts inventory close to where it will be used (on the assembly line)
- <u>Central storage</u> puts all inventory in a central location to improve control and maintain records
- Methods of order picking and assembly
    1. <u>Area system</u> – the order picker walks thru the aisle like a supermarket (used for small places)
    2. <u>Zone system</u> – the warehouse is broken into zones, and order pickers work only in their own area. Each picker sends them to the marshaling area where they are assembled for shipment (only one order at a time)

3. Multi-order system – same as zone system except that a number of orders are aggregated before sending to marshaling area

- Reserve stock and working stock may be separated – a separate work force is used to replenish the working stock from the reserve stock
- To maximize control, use a good part numbering system. Use a simple, well-documented transaction system 1) identify item 2) verify quantity 3) record the transaction 4) physically execute the transaction. Limit physical access (lock). Train your work force well
- Accurate inventory records allow you to 1) operate an effective materials management system 2) maintain satisfactory customer service (don't promise what you don't have) 3) operate effectively and efficiently 4) analyze inventory
- Poor inventory records will result in 1) lost sales 2) shortages 3) excess inventory 4) low productivity 5) poor delivery performance 6) excessive expediting
- Causes of inventory errors include 1) unauthorized transactions 2) unsecured access 3) poor training 4) inaccurate transactions 5) poor system 6) lack of audit capability (cycle counting)
- Measuring inventory accuracy is done through tolerance (amount of permissible variation between inventory records and physical count) – may be 100% or less
- Important to audit records to have accurate inventory and to audit the system to find causes of errors and eliminate them (cycle counts track flaws, periodic audits do not)
- Primary purpose of periodic (annual) inventory is for financial auditing. Needs 1) housekeeping (sort inventory) 2) identification 3) training
- Process of physical inventory 1) count items and record on a ticket 2) verify count by recounting or sampling 3) when verification is complete collect tickets 4) reconcile results to systems
- Cycle counting counts inventory continually during the year. 1) allows for timely detection of problems 2) reduces "down time" for facility 3) uses trained personnel. Count frequency should increase based on value or ABC system
- Cycle counts can occur 1) when order is placed (ensure order is correct) 2) when order is received 3) when inventory record reaches zero 4) when a specified # of transactions has occurred 5) when an error occurs

Chapter Thirteen – Physical Distribution

- Physical distribution is the movement of materials from the producer to the consumer. It is the responsibility of the distribution department. Objective is to design and operate a system that meets customer service needs at a minimum cost
- Physical supply is the movement and storage of goods from suppliers to manufacturing
- Physical distribution is the movement and storage of finished goods from the end of production to the consumer
- Transaction channel is concerned with the transfer of ownership (negotiate, sell and contract)
- Distribution channel is concerned with the transfer or delivery of goods and services
- Specific way a firm moves materials depends on 1) channel of distribution in use (retailer to consumer or producer to wholesaler) 2) types of markets served (dispersion, # of customers, size of orders) 3) characteristics of the product (weight, density, fragility) 4) type of transportation available (planes, trains or trucks)
- Six inter-related activities of physical distribution:
    1. Transportation – moving goods outside the firm's buildings – about 30%-60% of distribution costs – adds "place value" to the product
    2. Distribution inventory – all finished goods at any point in the distribution system. Accounts for 25% - 30% of total distribution costs – add "time value" to the product
    3. Warehouses (distribution centers) – used to store inventory
    4. Materials handling – movement and storage of goods inside the distribution center. Trade off between capital (costly) and operating (efficiency) costs
    5. Protective packaging – must be protected and identified, and fit into storage and vehicles
    6. Order processing and communication – an important part to communicate among intermediaries
- Objective of distribution management is to minimize the least total system cost, not just transportation or distribution inventory, while meeting the service level required. In general, increasing customer service results in an increase in costs
- Marketing is responsible for transferring ownership through selling, promotions, etc… and physical distribution gets the customer the goods. Physical distribution also helps create demand through prompt delivery and product availability
- Physical supply of materials into production must be reliable with a high service level because the cost of interrupted production may be huge
- Location of factory is often decided based on access to supply (plants near coal or trains, steel plants near water, etc.)
- Costs of carriage are ways, terminals and vehicles
    1. ways – paths over which the carrier operates (roads, tracks) can be self provided or by gov't
    2. terminals – areas where carriers load and unload goods to and from vehicles and make connections between local and long haul
    3. vehicles are used except in the case of pipelines
- Railways provide their own ways, terminals and vehicles (large capital investment). Speed is good, and prices are cheap, best over long distances
- Roads – do not provide their own ways but do provide vehicles. Most costs are operating in nature. Requires extensive road net – best for small volume goods to a dispersed market

- Air – requires an air system – gov't provides terminals but you must provide own planes. Best advantage is time, disadvantage is cost
- Water – no cost for using waterway, costs are low but time is long
- Pipelines – have high capital costs and low operating costs
- For Hire – carrier may carry goods for the public as a common carrier or under contract to a shipper
- Common carriers – standing offer to serve the public. They can only carry the goods they are authorized to carry
- Contract carriers haul only for those with a contract, not the general public.
- Private carriers own or lease their equipment and operate it themselves. Companies normally only do this when they have sufficient internal volume
- Transportation cost elements 1) line haul 2) pickup and delivery 3) terminal handling 4) billing and collecting
- Line-haul costs – the carrier has costs to move the truck and they vary directly with distance (not weight). There is a cost per mile and a distance move. Lin-haul cost per hundred weight varies with the cost per mile, the distance moved, and the weight moved. The limitations are the weight and cubic volume of the vehicle. If shippers want to reduce transportation costs, they should 1) increase the weight shipped 2) maximize density
- Pickup and delivery costs – similar to line-haul costs except cost depends on time spent (charge for each pickup) – less expensive if load is consolidated
- Terminal handling costs depend on the # of times a shipment must be loaded, handled and unloaded. If full truckloads are shipped, they can go straight to their destination
- Billing and collecting costs can be reduced by consolidating shipments and reducing the pickup frequency
- To decrease transportation costs 1) decrease line haul costs by increase weight shipped 2) decrease pick up and delivery by reducing the # of pickups (consolidate) 3) decrease terminal handling costs by consolidating shipments 4) decrease billing costs by consolidating shipping
- Rate charged by carrier will vary by 1) value (increase their liability) 2) density (carry more weight is good) 3) perishability (requires special handling) 4) packaging (risk of damage). Rate structures are TL (truck load) or LTL (less than truckload). LTL can be up to 100% higher than TL rates
- General warehouse is where goods are stored for a long time and goal is to protect goods until needed (document depository, furniture)
- Distribution warehouse receives goods in large lots, stores briefly, and then breaks them down into smaller orders. Emphasis on movement and handling rather than storage. Measured by throughput, not volume of storage
- Warehouses fill three needs 1) transportation consolidation 2) product mixing 3) service
- Product mixing deals with grouping of different items into an order and the economies that warehouses can provide in doing this (receive TL, ship LTL). Service improves by placing goods near customers
- Shipping cost / service depends on 1) number of customers 2) geographic distribution of the customers 3) customer order size 4) number and location of plants and distribution centers (have control over this item)
- Laid-down cost (LDC) is the delivered cost of a product to a particular geographic point. Includes all costs of moving the goods. LDC = product cost + (transportation costs per mile * distance)
- Market boundary is the line between two or more supply sources where the laid-down cost is the same

- As more distribution centers are added to the system 1) cost of TL shipments IN to distribution centers increases 2) cost of LTL shipments to customers decreases 3) total cost of transportation to decrease
- Role of packaging is to carry the goods safely through a distribution system to a customer 1) identify the product 2) contain and protect the product 3) contribute to physical distribution efficiency
- Unitization is the consolidation of several units into large units, or unit loads, so that there is less handling
- Pallet is a platform measuring 48 by 40 by 4 and designed so it can be lifted by a forklift. Loaded with packages, it forms a cube that is a unit load.
- Materials handling is the short-distance movement in a plant or distribution center. Unloading and loading of transportation vehicles and dispatch and recall of goods from storage. Objectives include:
    1. increase cube utilization by using height of building and making aisles as small as possible
    2. reduce handling
    3. increase speed
- Three types of materials handling equipment. Conveyors move material between 2 fixed points (expensive). Industrial trucks are not gas powered (more flexible than conveyors). Cranes and hoists can move materials vertically or horizontally within their area of operation (make good use of vertical space)
- As distribution centers are added, distribution costs decrease, and inventory-carrying costs increase. With a constant sales volume, as the number of distribution centers increases, the demand on each decreases. This causes an increase in total safety stock in all distribution centers . Operating costs increase because they move with # of handles, not sales.
- System service capability can be measured by percentage of market served within a given period. It increases quickly as first and second distribution centers are built (in the top 1-2 markets) but then decline.

Chapter Fourteen – Products and Processes

- Product phases include 1) introduction phase (most expensive and risky) 2) growth phase (production increases and unit costs drop) 3) maturity phase (price competition severe) 4) decline phase (profits decline)
- 2 elements to consider with range of products 1) too narrow, lose customers 2) too broad, customers happy but costs increase due to loss of specialization
- <u>Simplification</u> is the process of making something easier to do or make (remove unnecessary products and variations)
- <u>Standardization</u> ensures that all products will be alike and interchangeable
- <u>Modularization</u> uses standardized parts for flexibility and variety – doesn't necessarily reduce the range of choice for the customer (use component parts)
- Specialization – a limited range of products provides benefits
    1. allow development of specially designed equipment
    2. reduce the number of setups
    3. labor develops speed and dexterity
- <u>Product and market focus</u> can be based on customer grouping (similar customers), demand characteristics (volume), or degree of customization
- <u>Process focus</u> is based on similarity of process
- Focused factory where factory specializes in a narrow product mix for a niche market
- Products must be designed to be 1) functional (perform as specified) 2) low-cost processing (made at least cost)
- <u>Simultaneous Engineering</u> coordinates between product design and process design (better chance of designing functional product at least cost). 1) reduce time to market 2) reduce cost due to less changes 3) improve quality 4) lower total system cost (involve field support in initial design)
- <u>Process –</u> a process is a method of doing something, generally involving a number of steps or operations. <u>Process design</u> is the developing and designing of the steps
- Five factors to be considered when designing a process
    1. product design and quality level – machines must be able to meet quality level
    2. Demand patterns and flexibility needed – if there is variation in demand process must be flexible enough to respond
    3. quantity / capacity considerations – use different process for one item than for 100,000 items
    4. customer involvement – more involvement with engineer to order than make to stock
    5. make or buy decision – purchase more than 50% of goods manufactured
- <u>General Purpose Machinery</u> can be used for a variety of operations. <u>Special purpose machinery</u> is designed to perform specific operations on one work piece or a small number of similar work pieces (i.e. a machine for sewing shirt collars)
- <u>Flow processes</u> move from one work station to the next at a nearly constant rate and with no delays. There is some sort of mechanical means of moving goods between workstations (can either be repetitive manufacturing for cars or continuous manufacturing for gasoline). Flow process is also called <u>product layout</u>
- Flow systems are efficient because
    1. workstations produce limited range of products so machinery is specialized
    2. very little build up of WIP

3. lead times are short (flow system and low WIP)
4. substitute capital for labor and standardize tasks

- Intermittent manufacturing – goods are not made continuously but are made in intervals in lots or batches. Work stations must be capable of processing many different parts and processes are flexible
- Project or fixed position manufacturing is used for large complex projects like ships or buildings because moving is too expensive
- Fixed costs – do not vary with volume being produced ($200 to set up a process). Variable costs vary with the quantity produced (direct labor and direct material)
- Total cost = fixed cost + (variable cost per unit) * (units produced)
- Unit cost = total cost / number of units produced
- Cost equalization point is where the cost of one process equals the cost of another process (i.e. one with different fixed or variable costs)
- Continuous process improvement (CPI) consists of a logical set of steps and techniques used to analyze processes and to improve them. Three common elements 1) improving productivity, usually through capital investment 2) people involvement and motivation 3) teams working together for common objectives. Six steps of CPI are as follows
    1. select the process to be studied
    2. record the existing method to collect necessary data in a useful form
    3. analyze the recorded data to generate alternative improved methods
    4. evaluate the alternatives and select
    5. install the method and train operator
    6. maintain the new method
- Pareto diagrams – the 80 / 20 rule (a few items account for most of the costs or problems)
- Cause and effect diagram (Ishikawa diagram) – identifies root causes (materials, machines, people, methods, measurement, or environment)
- Recording defines the process. You need to know
    1. the process boundaries
    2. process flow
    3. process inputs and outputs
    4. components (resources to change inputs to outputs)
    5. customer
    6. suppliers (provide inputs)
    7. environment (beyond control)
- Classes of activity include 1) operation 2) inspection 3) movement 4) storage 5) delay 6) decision
- Operations process charts record in sequence only the main operation and inspections
- Process flow diagram shows graphically and sequentially the various steps, events and operations that make up a process
- Developing solutions 1) eliminate all unnecessary work 2) combine operations wherever possible 3) rearrange the sequence 4) simplify
- Principles of motion economy 1) locate materials, tools and workplace within normal working areas and pre-position tools and materials 2) locate everything within maximum grasp areas 3) Arrange work so that motions are balances by being made simultaneously in opposite directions 4) minimize factors that cause fatigue
- Human and environmental factors include 1) job design – an attempt to provide more satisfying meaningful jobs and to use the workers mental and impersonal skills 2) job enlargement – include similar or related tasks in the workers job 3) job enrichment – adds more fulfilling tasks 4) job rotation (cross training)

- Learning curve – as operator does tasks repetitively, speed increases and errors decrease

Chapter Fifteen – Just-in-Time Manufacturing

- Just in time manufacturing can be defined as the elimination of all waste and continuous improvement in productivity. This means there should be no safety stocks, and lead times are minimal
- Adding value to a product does not mean adding cost. Waste can be caused by poor product specification and design. Component standardization can also minimize waste
- Seven important sources of waste in manufacturing (per Toyota):
    1. the process – best process makes the product with a minimum of scrap, in quantities needed, with least cost added
    2. Methods – waste is added if operators have wasted movement, time for effort
    3. Movement – moving and storing components adds cost but not value
    4. Product defects – they interrupt the flow of work, also reworking defects is waste
    5. waiting time – ideally material passes from one work center to the next and is processed without waiting in queue
    6. overproduction – production beyond what is needed for immediate use
    7. inventory – costs money to carry, and excess inventory adds cost to the product
- Just in time elements include 1) flow manufacturing 2) process flexibility 3) total quality management 4) total productive maintenance 5) uninterrupted flow 6) continuous process improvement 7) supplier partnerships 8) total employee involvement
- Flow manufacturing systems (repetitive manufacturing) are often very cost effective, but system is not suitable for making a variety of different products
- If you can't justify flow manufacturing, work cells group machines on a functional basis. The layout can be improved based on product flows by using miniature flow lines or work cells. Parts now pass one by one, or in very small lots. This reduces lead times and queue times, simplifies production activity control, reduce needed floor space, and get immediate feedback for defects
- Process flexibility allows the company to react to changes in the volume and mix of their product (flexible machines and quick changeovers). Short setup times reduce economic order quantity by reducing the lot size. Reductions of up to 90% in setup time can occur by organizing the preparation, streamlining the setup, and eliminating adjustments.
- Benefits of a good quality program are less scrap, less rework, less inventory, better on-time production, timely deliveries, and more satisfied customers. Quality at the source means doing it right the first time and stopping the process and fixing it if something does go wrong
- Traditional maintenance fixes machines when they break down. Use preventive maintenance with inspections and other maintenance tasks. Total productive maintenance is preventative maintenance plus continuing efforts to adapt, modify and refine equipment to increase flexibility, reduce material handling, and promote continuous flow
- Uninterrupted flow occurs when material flows smoothly from one operation to the next with no delays. Requires 1) uniform plant loading 2) pull system 3) valid schedules 4) linearity
- Uniform plant loading means that the work done at each workstation should take about the same time (also called balancing the line). The result will be no bottlenecks and no build up in WIP
- Pull system – the demand on each workstation should come from the next workstation. The pull system starts at the end of the line. Kanban is a pull system (a 2 bin, fixed order quantity, order point system)

- Valid schedule – to maintain an even flow, the schedule must be level (produce the same amount every day). The company will have to make multiple products since inventories are at a minimum. Mixed-model schedule uses a level schedule in terms of total production but shifts among different models
- Linearity – JIT focuses on meeting the plan and it happens by scheduling less that at full capacity (so there is some slack left)
- Partnering is a commitment between two or more organizations to achieve specific goals. 1) long term commitment 2) trust (shared information) 3) shared vision. Benefits to purchasing organization should include 1) meeting quality goals 2) make frequent or JIT deliveries 3) work to improve performance, quality and cost. Benefit to supplier should include 1) more business and long-term security 2) ability to plan better 3) more competitive as JIT supplier
- Supplier selection criteria should include 1) supplier has stable and committed management 2) supplier will keep confidential information 3) supplier has an effective quality system 4) share same view of the customer
- Just in time is not a planning and control system. It is a philosophy and a set of techniques for designing and operating a manufacturing plant. Impacts of JIT 1) forecasting – shortened lead time (match production rates to sales rates and forecasting becomes less important) 2) production planning – environment where supplier and buyer can work together to plan the flow of material 3) master production scheduling – level schedule based on capacity and material flow (also move to daily from weekly time buckets)
- Material requirements planning has the following changes 1) daily not weekly budget 2) pure JIT environment has no inventory, so production occurs in the same time bucket as the gross requirement, and no offsetting is needed 3) bills of material can be flattened because of the elimination of many inventory transactions
- Backflushing (post-deduct) – raw materials are recorded into WIP; when work is completed the WIP is relieved by multiplying the # of units completed by the components in the bill of material (this works if the BOM are accurate and lead times are short)
- MRP is a "push" system. The trigger for the whole plan is the final projected need. MRP may not be effective based on 1) changes to demand 2) supplier delivery problems 3) inaccurate demand 4) production problems
- Pull system – don't preplan and generate schedules, instead react to the final customer order and produce only what is needed to satisfy demand and then only when needed
- Reorder points typically do not work is that there is an assumption of constant demand. Also EOQ assumes that the holding cost and order cost are known and fixed. But if order cost is setup, a major JIT effort could reduce setup costs
- Kanban system – means card or ticket. The system is simple – the Kanban signal identifies the material to which it is attached. A card limits the inventory allowed (take a card, reorder). Kanban rules:
    1. every container with parts shall have one Kanban
    2. There are no partial container stores – every container will be filled, empty, or in the process of being filled or empty (inventory is easy – don't count parts, just containers)
    3. No production or movement unless there is an authorization in the form of an unattached Kanban card
- Kanban alternatives include:
    1. single card systems – single card is the production card, empty container is move signal
    2. color coding of containers
    3. designated storage spaces
    4. computer systems (bar coding)

- MRP (ERP)
    1. best – effective with variability or uncertainty. Good for product changes or process changes
    2. worst – high data burden – if system is stable , better to use a less data intensive system (Kanban)
- JIT (Kanban)
    1. best – highly stable and predictable environment
    2. worst – highly volatile environment in terms of demand, design or process
- Theory of constraints (drum – buffer – rope)
    1. best – assumes a constraint can be identified and managed
    2. worst – where constraint cannot be identified (product mix changes) – also needs more stable environment
- hybrid systems – Kanban and MRP – plan ahead using MRP but produce using Kanban. JIT and TOC – JIT does process improvement but TOC focuses on overall bottleneck

Chapter Sixteen – Total Quality Management

- Quality means user satisfaction – that goods or services satisfy the needs and expectations of the user
- Product designers must build the product to the quality level described in the general specification
- Quality for manufacturing is responsible for meeting the minimum specifications in the product design
- Quality is formed in the "loop" containing 1) product policy 2) product design 3) operations 4) the user
- Performance – quality dimension implies that the product or service is ready for the customer's use at the time of sale. 1) reliability – consistency of performance (use between failures) 2) durability – ability to continue functioning even when subjected to hard wear or frequent use 3) maintainability – able to return a product to operating condition after it has failed
- Conformance – meeting established standards or specifications (manufacturing's responsibility)
- Total Quality Management (TQM) – it is based on the participation of all members of an organization in improving processes, products, services and the culture they work in. The objective of TQM is to provide a quality product to customers at a lower price. TQM is both a philosophy and a set of guiding principles that lead to a continuously improving organization
    1. A committed and involved management – must be part of culture
    2. focus on the customer – listening to the customer, improving design
    3. involvement of the total workforce – training, empowering
    4. continuous process improvement
    5. supplier partnering
    6. performance measurement
- Management commitment includes establishment of a quality council
- Customers have 6 expectations of their suppliers 1) high quality level 2) high flexibility 3) high service level 4) short lead times 5) low variability 6) low cost
- Employee involvement includes 1) training (cross training) 2) organization (teams or customer contact) 3) local ownership (empowerment)
- Empowerment gives people authority to make decisions or take actions in their work area without getting prior approval

- Performance measures can be used to understand performance, compare actuals with targets, and show trends. They can be measured in terms of 1) quantity (production) 2) cost 3) time / delivery (on-time) 4) quality
- Possible measures include 1) customer (complaints, on-time delivery) 2) production (inventory turns, scrap) 3) suppliers (on time delivery, quality) 4) sales (new customers, sales per square foot)
- Cost of Failure (cost of failing quality control) include 1) Internal Failure costs (correcting problems while still in the facility) 2) External failure costs (after delivery to customer including warranty, service, etc…)
- Cost of controlling quality 1) prevention costs (doing the job right the first time) 2) appraisal costs (cost of audits in the organization)
- Chance variation is inherent in any manufacturing process and comes from six things
    1. people – poorly trained operators less consistent
    2. machine – well-maintained machines work better
    3. material – better raw materials
    4. method – improve method
    5. environment – changes in temperature, humidity
    6. measurement – bad tools
- Assignable variation is the specific reason for the cause of the variation
- Statistical control occurs when only chance variation is occurring
- Variability patterns include 1) shape (bell curve) 2) center (mean) 3) spread (variation)
- One standard deviation (68.3%), two standard deviations (95.4%), three standard deviations (99.7%)
- Lowest specification limit (tolerance) and upper specification limit
- Process capability index Cp = (upper specification limit - lower specification limit) / 6 standard deviation
- Cpk Index is the lower of (upper specification limit – mean) / 3 sigma or (mean – lower specification limit) / 3 sigma
- Cpk of less than one is unacceptable, Cpk 1 to 1.33 is marginal, Cpk greater than 1.33 good
- Run charts – gives a visible description of process (every ½ hour sample) but doesn't distinguish between chance variation and assignable cause variation
- X bar and R chart – take samples and put on a range and run between upper and lower control limit
- Control limits are set so that there is a 99.7% probability that the process is in control.
- Sample inspection 1) 100% inspection (every unit) 2) acceptance sampling (take a sample for the whole batch and then accept / reject)
- 4 reasons for sampling 1) sampling is destructive 2) not enough time 3) too expensive 4) human error is high
- Conditions necessary for sampling include 1) all items must be produced under similar conditions 2) a random sample 3) lot should be homogenous 4) batches should be large
- Consumers risk – probability of accepting a bad lot. Producers risk – probability of rejecting a good lot. Cost – balance consumers risk and producers risk
- ISO Certification (the international organization for standardization is based in Geneva, Switzerland). The standards are intended to prevent non-conformities during all stages of business functions. A third party (registrar) assesses the adequacy of the supplier's quality system
- ISO 9000 consists of 5 standards (explains the basic quality concepts, defines key terms, and provides guidelines for selecting, using, and modifying ISO 9001, 9002 and 9003.

- ISO 9001 provides a model for quality assurance in design, production, installation and servicing. ISO 9002 provides a model for quality assurance in production and installation. ISO 9003 provides a model for quality assurance in final inspection
- There are 20 ISO 9000 elements. All 20 are required for ISO 9001, but fewer are required for ISO 9002 and ISO 9003. ISO 9000 places emphasis on all internal processes, especially manufacturing, sales, administration and technical support
- Benchmarking – comparing yourself to best in class operations
    1. select process to benchmark
    2. identify best in class organization
    3. study the benchmarked organization
    4. analyze the data
- JIT and TQM should be considered 2 sides of the same coin – providing customers what they want at low cost. Both JIT and TQM are part of the MRP II environment