Summary PPQC

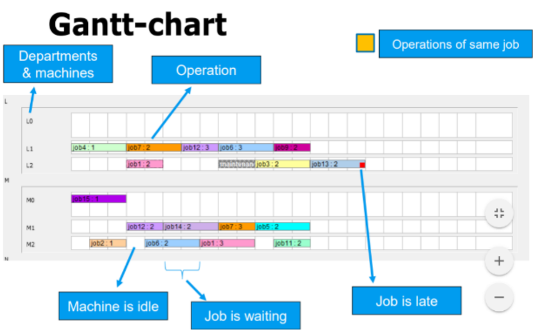
Slides

Lecture 1

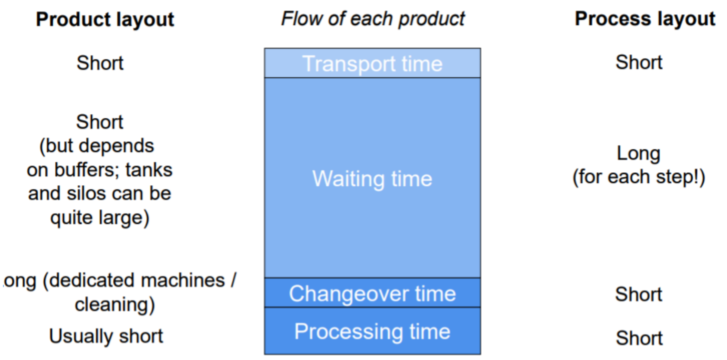
- Basic design decisions:
    - Direction of flow: Unidiretional & multidirectional
    - Management structure: product & process
    - Physical layout: product, dock, process, operator
    - Hierarchy: each unit can have multiple internal units in any flow, management structure, and layout
- Unidirectional flow: products flow through line without disruptions.
- Multidirectional flow: products flow through multiple departments. Coordination between departments needed.

Product		Process
	Performance criteria	
~	Quality	~
+	Speed	-
+	Dependability	-
-	Flexibility	+
+	Cost	-

- Physical layout:
    - Product
    - Process
    - Production sequence (flow)
    - Operator
- Two main approaches:
    - Resource / capacity / machine oriented (100% machine utilization)
    - Product (machine is waiting until product arrives, starts immediately)



- How to create schedule
    - First come, first serve
    - Shortest processing time (SPT)
        - Many customers served
        - Long jobs keep waiting
    - Earliest Due Date (EDD)
        - Less due date violations
        - Perhaps may small due date violations instead of a single large one



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- Batching (combine similar products): less setups, more efficient. Longer waiting time.
- Scheduling: Theory → optimization, practice → problem solving

Lecture 2

- Lean: integrated socio-technical system. Eliminate waste by reducing/minimizing variability

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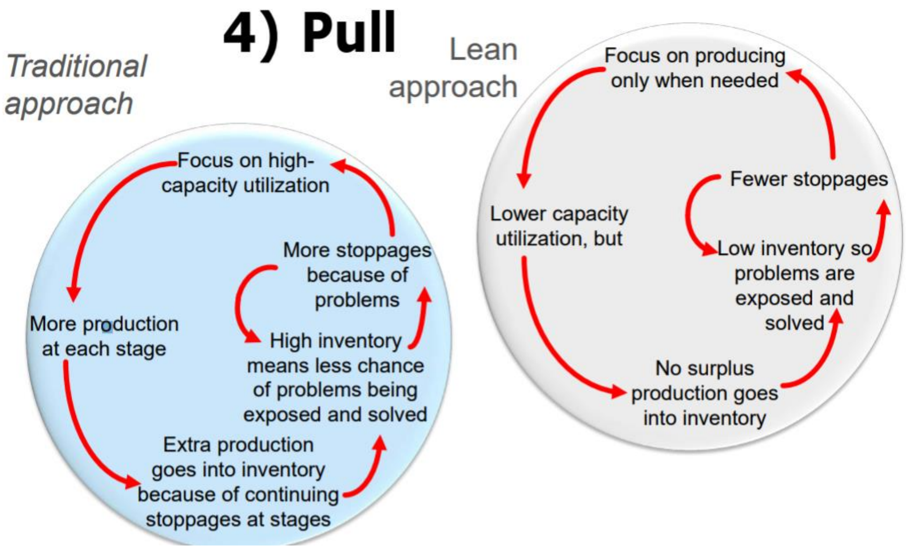
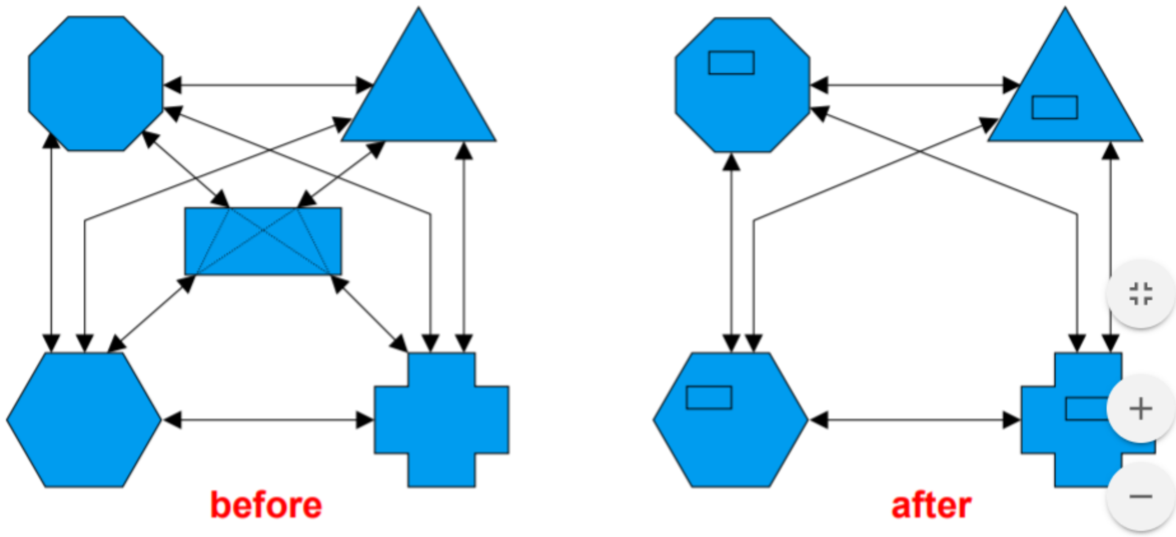
- 1. Identify (non) value: 7+1 wastes (ezelsbrug: DOWNTIME)
  - Defects
  - Overproduction
  - Waiting
  - Not using all available human potential
  - Transport
  - Inventory
  - Motion
  - Extra processing
- 2. Map the value stream
- 3. Create flow
  - Stability and predictability disrupted by:
    - Job shops
    - High setup times
    - Machine disruptions
    - Defects in products / rework
    - Individual differences in processing times
    - Unreliable suppliers
  - Efficiency disrupted by unnecessary activities
  - Avoid/reduce:

        - Muri : overburden
        - Mura: unevenness – variability
        - Muda: waste
- 4. Pull



    - **Push** → MRP: system computes production schedules based on forecasts of sales. Subassemblies are pushed to next level
    - **Pull** → Just-in-time (JIT) : production at one level only happens when initiated by request at the higher level.
- 5. Seek perfection : Kaizen
- Variability is the root of all evil
    - Inventory is just a symptom
    - How to handle → buffer
        - Products (inventory)
        - Capacity (overcapacity)
        - Time (lead time)
    - Might be a choice or prerequisite:
        - Offer different products, provide meaningful jobs, be agile
- Lean as collection of methods: The Lean Toolbox
    - Investigate, design, control
- Design: 5 S
    - Seiri Sort
    - Seiton Set in order
    - Seiso Shine
    - Seiketsu Standardize
    - Shitsuke Sustain
- Lean Production
    - Basic design of production system: as much as possible
        - Unidirectional flow
        - Process bases management
        - Flow based layout
    - Reduce waste → continuous improvement (Kaizen)
- How to get unidirectional flow:
    - Focused factories

    - Group technology
    - Cellular manufacturing
- Defunctionalisation:

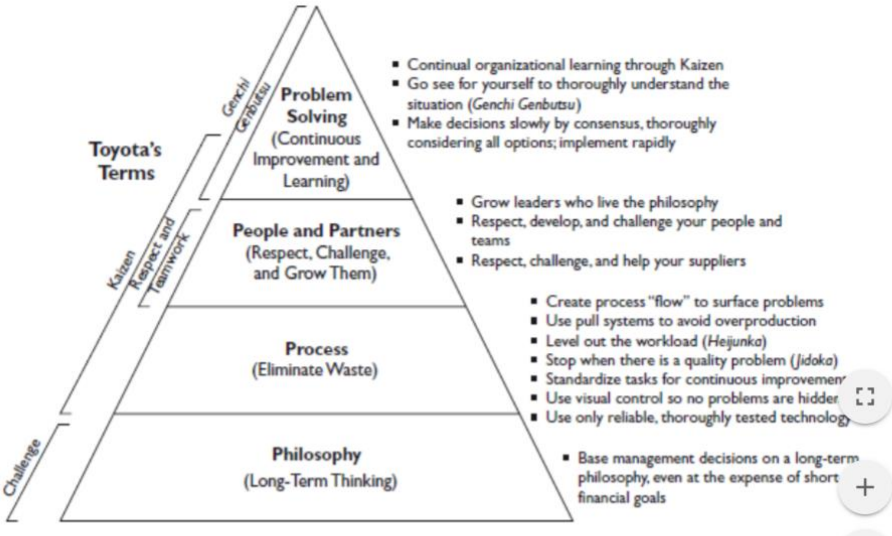


- Group technology: exploiting similarities between products in processing and operations
- Focused factory: plant within a plant. Autonomously creating a product or subassembly
    - Focused flowline: product layout
    - Focused workcenters: physical process layout, but certain machines dedicated to families
    - Workcell: small job/flowshop, able to produce small batches efficiently
- Batchflow because:
    - Purchase large machine to get economies of scale
        - Long complex set-ups
        - Solution 1: dedicated machines -> no setup
        - Solution 2: reduce setup
            - Single Minute Exchange of Dies (SMED)
                - Distinguish internal from external activities
                - Convert internal to external
                - Improve setup activities
                - Abolish setup

Lecture 3

- Human capital: traits that people bring to the workplace
- Management: process designed to coordinate and control productive activity
- Human resource management; requires the coextistence of **control** and **cooperation**.
- HRM
    - Theory x (Control):
        - Employees effort must be directed because people are lazy, lack ambition, prefer to be led and dislike responsibility.
    - Theory y (cooperation)
        - Management responsible for organizing elements of productive enterprise
        - People made passive by organizations
        - Management should make it possible for people to recognise and develop
        - Task management: arrange organizational conditions and methods of operation.
- Scientific management (Taylorism) (1950s)

    - Division of tasks and responsibilities between management and workers
    - Control-based, economic incentives
    - Higher productivity
        - At cost of workers' well being
    - Ignorance of non-financial aspects of motivation
    - Ignorance group psychology and motivation
- Motivation theories: general principles
    - Employees know expected level of performance. Give accurate and timely feedback
    - Positive rewards for good performance = more effective in motivating
    - Perceived fairness or equity
    - Increase sense of 'self-efficacy'
- Job enlargement: recombination of tasks
- Job enrichment: giving employees more control and responsibility
- Autonomous work group
    - Individual jobs should provide:
        - Variety
        - Meaningful task
        - Optimum work cycle
        - Worker's control over work standards
        - Feedback of results
        - Perceived contribution to end product
- Toyota Production System (TPS): Taylorism, motivational theories :& autonomous work group



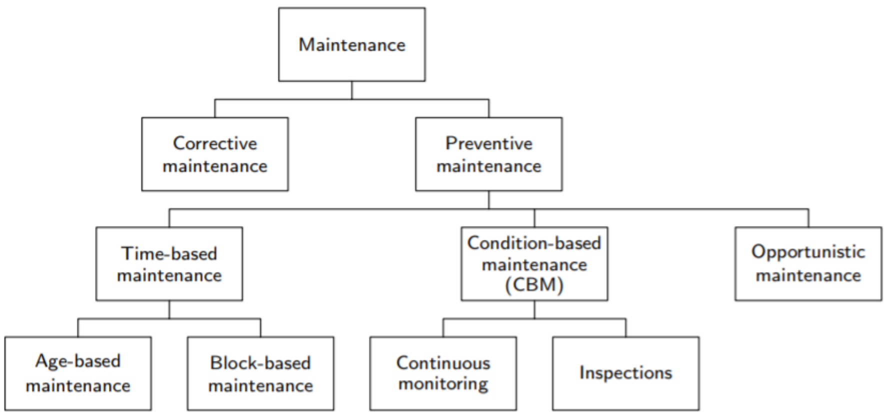
- TPS as control
    - Process: standardized tasks as in scientific management
        - Workers have responsibility for improvements
    - All work highly specified
    - Methods → disciplined workplace
    - Instant information about performance
    - Show whether process is in control
- TPS as cooperation
    - People and Partners

Internal Motivation Theories	Concept	Toyota Approach
Maslow's Need Hierarchy	Satisfy lower level needs and move employees up the hierarchy toward self actualization.	Job security, good pay, safe working conditions satisfy lower level needs. Culture of continuous improvement supports growth toward self actualization.
Herzberg's Job Enrichment Theory	Eliminate "dissatisfiers" (hygiene factors) and design work to create positive satisfiers (motivators).	5S, ergonomics programs, visual management, human resource policies address hygiene factors. Continuous improvement, job rotation, and built-in feedback support motivators.

    - Teamwork as for autonomous work group:
        - Balance individual and group work
        - Employee empowerment
        - Work groups focal point for solving problems
        - Rest of hierarchy support associates
    - People must be helped to develop skills and knowledge (technical, interperspnal, presentational and communication)
- TPS as culture
    - Everyone is striving for continuous improvement
- Negative aspects of lean
    - Failure → superficial approach
    - Too much stress due to pressure to do better than before
    - Measurement system and psychological triggers make worker a slave
    - Prod. Targets key and identification of failure as well

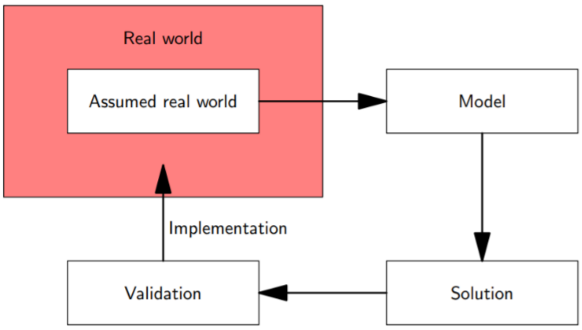
Lecture 4

- Maintenance: all activities necessary to restore equipment to, or keep it in, a state in which it can perform its designated functions.
- Overview:



- Corrective maintenance
    - Consequences: safety, machine damage, quality issues, unplanned unavailability (downtime), unplanned maintenance, long repair times
- Preventive maintenance

  - Costs PM < costs CM
  - Failures to be expected
  - Functional machine is repaired
  - Decision problem
- Time-based PM (TBM)
  - Age-based: PM performed when unit reaches age T (from failure)
  - Block-based: PM performed at fixed times T (2T, 3T) (failure out of scope)
- Condition-based PM (CBM)
  - Advantage: most effectively planned, just-in-time maintenance (ideal)
  - Conditions/cons:
    - Conditions related to moment of failure
    - Technically possible to measure conditions
    - Condition monitoring should not be too expensive
    - More difficult to plan then TBM
- Opportunistic maintenance: maintenance action on unit is used as an opportunity to also maintain other units
- OR perspective



- MTBF (mean time between failures)
  - Reliability measure
- Lifetime distribution function F(t): probability that machine breaks down before or at time t.
- Reliability function R(t): probability that machine does not break down before or at time t.
- R(t)= 1 – F(t)
- Empirical reliability function: estimate of reliability function
  - Easily determined. No assumptions to certain parametric lifetime distribution
  - Good impression
  - Unrealistic since it only assigns probabilities to discrete points in time
  - Difficult to determine maintenance policies
- Weibull lifetime distribution → continuous distribution
  - $$F(t;\lambda,k) = 1 - e^{-\left(\frac{t}{\lambda}\right)^k}, \quad t \geq 0.$$
  - Reliability function: $R(t;\lambda,k) = 1 - F(t;\lambda,k) = e^{-\left(\frac{t}{\lambda}\right)^k}, \quad t \geq 0.$

$$f(t;\lambda,k) = \frac{k}{\lambda}\left(\frac{t}{\lambda}\right)^{k-1} e^{-\left(\frac{t}{\lambda}\right)^k}, \quad t \geq 0.$$

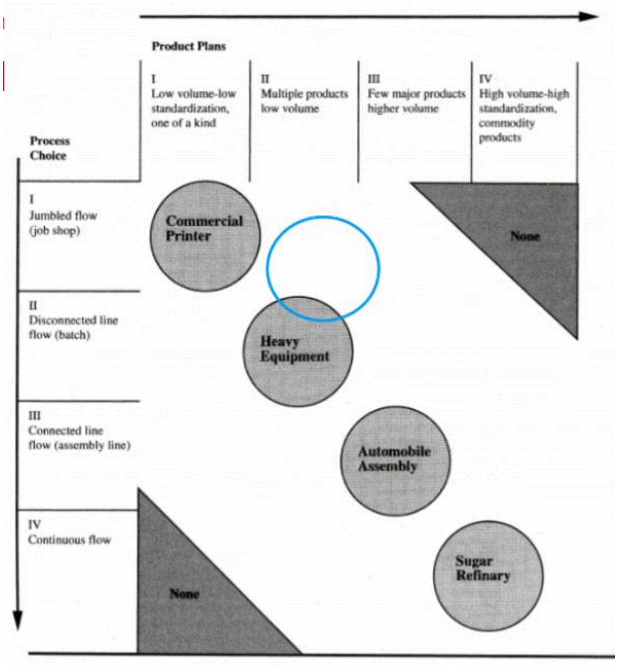
  - f(t; λ,k): likelihood of failure **at** a certain time t.
  - Finding λ and k: maximize product of f(t; λ,k) for every t. (use logsum for computational)
- Goodness-of-fit: compare empirical with fitted Weibull
- TBM – age based

- $\eta_{age}(T)$: cost rate as function of maintenance age T. calc: mean cost per cycle / mean cycle length
- Mean cost per cycle: $c_{cm}F(T) + c_{pm}(1 – F(T))$
- $\eta age(T) = \frac{CcmF(T)+CpmR(T)}{\int_0^T R(t)dt}$
  - The maintenance age T that minimizes $\eta_{age}(T)$ is optimal T_{age}

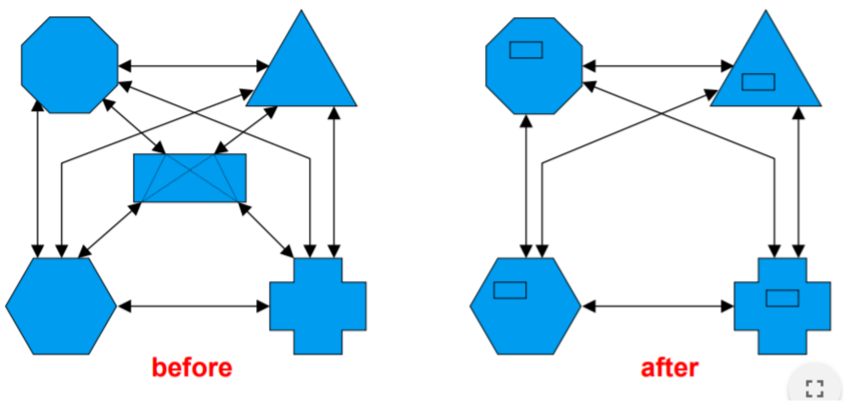
- TBM – block based
  - $\eta_{block}(T)$: cost rate as function of maintenance interval T. mean cost per cycle / cycle length T
  - m(T): number of breakdowns in between two consecutive preventive maintenance actions
  - $\eta block(T) = \frac{Cpm+Ccm*m(T)}{T}$
  - T that minimizes η_{block} is optimal maintenance interval T_{block}.
- CBM
  - Alert-alarm maintain model: condition parameter excees threshold value → alert signal. Another higher threshold value → alarm signal. Maintenance performed within certain period.
  - Only implemented when its benefit over TBM outweigh costs CBM
  - Slide 61
- $\sigma_p W(t)$: difference true level of deterioration and observed level of deterioration.
- Deterioration at which falure occurs is normally distributed with mean 1 and standard deviation σ_f.
- Normal distribution left truncated at 0, right truncated at 2
- Cost effective CBM in a multi-unit system
  - Maintenance on single unit or clustered
  - Maintenance policies:
    - No clustering: maintain single units
    - Alarm clustering: maintain units that have given an alarm signal if a unit needs to be maintained
    - Alers clustering: maintain units that have given an alert signal if a unit needs to be maintained
  - C fixed costs

Lecture 5

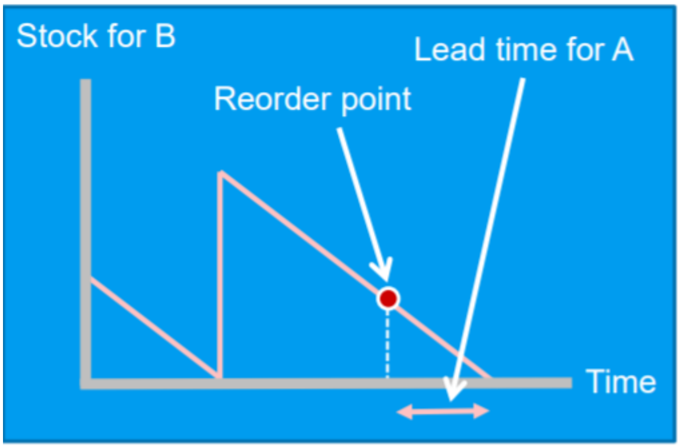
- Variability is root of all evil
  - inventory is symptom
  - need buffer:
    - products (inventory) → high invested work & holding cost
    - capacity → low efficiency
    - time (lead time) → high lead time
    - decreasing variability → decrease buffer
- Remedy buffer → perfect flow
  - No capacity: no idle time
  - No time: customer orders never wait
  - No product: no holding costs

- 

- How to get flow?
  - Product layout → group technology
  - Single piece / small lot production → transfer batches
  - Short setups → SMED (: single minute exchange of dies)
  - No intermediate stock → Pull production
  - Synchronized production → line balancing
- Process layout to cellular manufacturing: multiple simple structures instead of one complex
  - Some extra machines are preferred over buffers
  - Reduction of complexity
    - Shorter, more predictable lead time
    - more efficient
    - less coordination between departments required
    - less flexible → less product types
    - less efficient (duplications of machines)
- Defunctionalisation

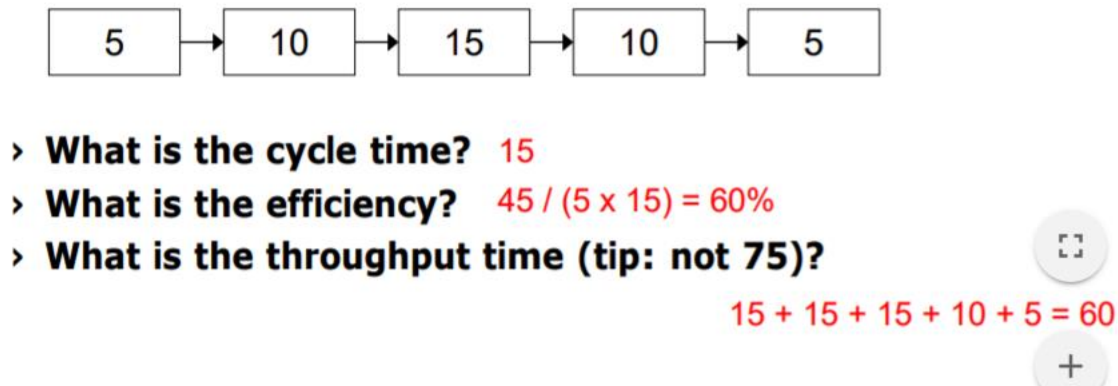


- Group Technology (GT): exploiting similarities between products in processing and operations
- GT leads to focused factories: a plant within a plant
  - Focused flowline: product layout
  - Focused workcenters: physical process layout, but certain machines dedicated to families
  - Workcell: small job/flowshop, able to produce small batches efficiently

- Group formation: machines + products/parts
  - Purpose
    - Minimize product flow between groups
    - Create flow within group
  - Steps
    - Match machines and product families
    - Compose groups from this (think about constraints)
- **Binary ordering algorithm → see book ! probably in the exam!**
- After BOA, organize group itself → job or flow shop → **book ch. 10**
- Transfer batch: send products to next process before whole batch is produced
- Pull production:
  - Never out of stock at any workstation
  - Not too much inventory
  - Only schedule final stage
  - System: 2-bin system: if one jar is empty, the second one will be enough until we go shopping
  - Reorder point: Demand rate * Lead time + Safety Stock
  - Lead time : waiting + setup time + processing + transport
  - 

- Kanban:
  - C-kanban: authorization to convey (transport)
    - C waiting in mailbox, C transported, C+b transported, C+b waiting at destination (c=card, b=bin)
  - P-Kanban: authorization to produce
    - Kc wainting at source, kc transported to destination, k waiting, production, move container to outbound buffer (kc = Kanban card, k = Kanban)
  - **Flow of cards explained in the book**
  - $K = D(P+C)(1+x)/Q$
    - K = kanbans, D = demand rate , P = production time, C = transport time, x = safety factor, Q = amount in one container
  - Express, temporary and emergency cards
- Rules for pull production **MEMORIZE**
  - Downstream only orders what is needed from upstream
  - Only produce what is indicated on the card
  - No production or transport without card
  - Defective items are not sent downstream
  - Demand variations are limited

- o Start with too many cards, but slowly reduce them
- Requirements pull production
  - Many tools lean toolbox
  - Each workstation has some buffer
  - Final assembly schedule, combined with local planning and control (no centralized detailed scheduling)
  - Final schedule uniform (stable demand)
- Flow line
  - Flow shop: all products need the same sequence of operations
  - Push instead of pull → demand determines activities <u>first</u> station
  - Synchronize all operations (instead of scheduling each operation to compensate for variety in processing times)
- Line balancing
  - Multiple tasks workstation. Minimizing idle time
  - Steps:
    - 1: determine the Takt Time (every X minutes a product must be finished (cycle time))
    - 2: find groups of activities ≤ X minutes
    - 3: assign those groups to workstations
  - Examples: see slide 89 – 102
- Unpaced line
  - Work will be given to the next station when it is finished



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- Mixed model line: different products made at multiple stations (slide 106)

Lecture 6

- Chapter 16 of the book → self-study!
- Life cycle analyses (LCA) in food

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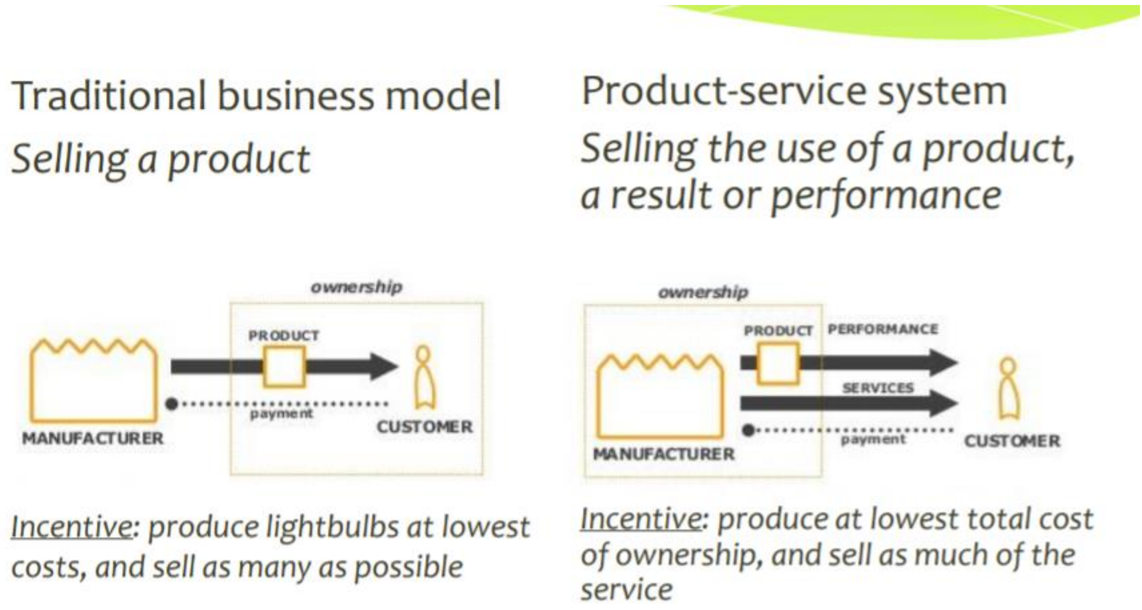
    - LCA: technique to asses environmental impacts associated with all the stages of a product's life (raw material → disposal/recycling)
    - It does not prescribe what is good or bad
    - Methodological and data challenges
    - Requires expertise
- Difference eco-efficiency and eco-effectiveness
    - Doing less worse ≠ sustainability
    - Jevons paradox: can even lead to worse situation
    - Lean: tendency to lean towards eco-efficiency
- Summary 1/3
    - Lots of challenges and uncertainties in what constitutes a green product/ green supply chain
        - Undermines many insights about GSCM and results achieved in practice
    - LCA should be used more
    - Better methods and measurements should be developed
- Consumers find sustainability more important
- Costs and benefits
    - Theory
        - Costs deduction (recycled materials) CE
        - Longer durability, higher quality
        - → lower production costs and lower total cos of ownership for customer
    - Practice
        - Innovation & learning investments
        - Higher costs across all life cycle stage
        - Risks too high
        - → firms do not want the risk
- Economic value ≠ ecological value
    - Ecological economics: market prices are blind to necessity of maintaining functional integrity of ecosystes.

- New business model



  - Does the customer want this?
    - New type of relationship with customer
  - Radical innovation and change
  - Market landscape for green products is fragmented (not one company can exert enough influence to move the industry in a particular direction).
  - Customers little understanding (urgency) green products
- Summary 2/3
  - Firms can make products greener
  - Status quo?
    - Economic tensions (greener products and production) → slow down progress
  - Solution → radical product, business model and supply chain innovation
- Porter hypothesis: strict environmental regulations can induce efficiency and encourage innovation that help improve commercial competitiveness
  - Weak (innovation) : empirical support
  - Strong (innovation → competitiveness): mixed empirical support
- Why eco-regulations?
  - Push companies to change/innovate to become greener
  - When improvements in resource productivity do not completely offset the cost of compliance
  - Give firms insights/guide firms to areas of improvement
  - Creation of demand (pull)
  - Create level playing field for firms to innovate
- Problems with regulation
  - Limited, sometime counterproductive
  - Anti lobby large and powerful firms
  - Green public procurement deficiencies
  - Unstable
  - Fragmented internationally
- Summary 3/3
  - Regulations are very important to stimulate greener production and products
  - Governments should do more according to the industry

    - Several problems exists with current eco-regulations
- Three main challenges
    - Tech-related: what is green, how to measure?
    - Market-related: how to sell with profit?
    - Law related: how to stimulate?
- Challenges affect:
    - GSCM in practice and in theory
- Critical relationship lean < - > green (there is synergy, doesn't come naturally)