Summary

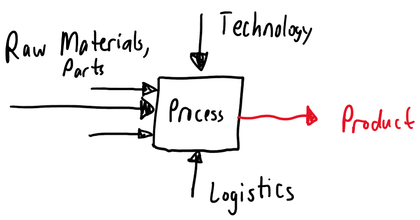
Wednesday, April 10, 2024 3:20 PM

Tools available to the Industrial Engineer

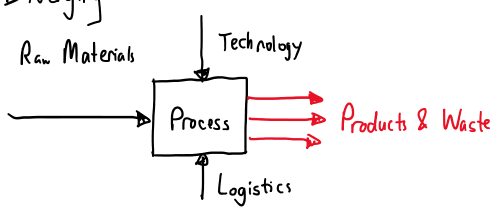
- Management
- Logistics
- Timing
- Quantity
- Quality
- Information
- Technology

Systems

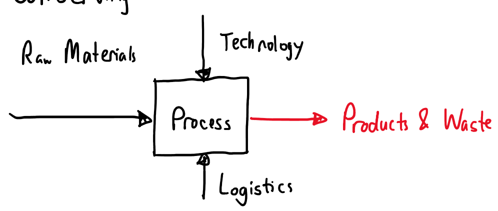
Mass converging



Mass Diverging



Mass Conserving



Industrial Engineer — Requires more management than other engineering disciplines

Organisations

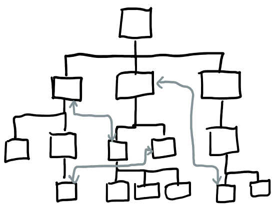
- General Guidelines
  - > Clear Objectives
  - > Logical Work Division
  - > Unitary Command
  - > Work Delegation
  - > Well-Defined Responsibilities
  - > Two-Way Communications

Vision & Purpose

- Vision — Ultimate goal
- Purpose — Plans to achieve the vision

Informal Organisation

- must exist in a formal situation



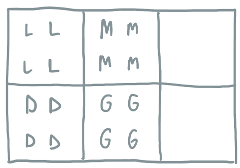
Manufacturing Systems

- Job-Shop (J) — rely on technician's skill, machine shop, general machinery
- Batch (B) — higher production rate, for 'seasonal' companies
- Mass (M) — One product produced en-masse

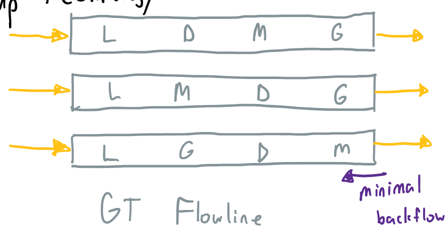
	J	B	M
Production quantity	Low	High	Higher
Production rate	Low	High	Higher
Workforce skill	Very High	High	Lower
Equipment	General-purpose	General-purpose	Special-purpose
Tooling	General-purpose	Special-purpose	Special-purpose
Plant Layout	Functional	Functional/Group	Line
Automation	Low	High	Higher

Layouts

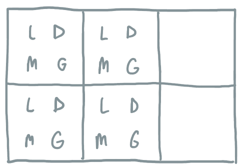
- Fixed Position
- Functional (Old System)
  - any part will be transported all over factory – increasing energy consumption



- Group Technology



GT Flowline



GT

	Functional	Group	Line
Specialisation	By process	By component	By component
Material flow b/w machines	In batches	In batches ~ nearly continuous	Continuous
Material throughput thru time	long	short	shorter
Stocks for work-in-progress	high	low	lower
Responsibility for quality	many persons/part	one person/part	one person/part
Responsibility for delivery by due date	many persons/part	one person/part	one person/part
Investment in special tooling	high: one set/operation/part	low: one set/tooling family	high: one set/line
Investment in buildings	high	low	lower
Control of material flow	complex	simple	simpler
Workforce Skill	high	high	low
Job satisfaction	medium-high	high	low
Flexibility	high	medium-high	very low

Sequencing & Scheduling

- Sequencing → A, B, C, D
- Scheduling → Item A at 2:00, Item B at 2:15, ...

- Heuristics Rules
  - Shortest Processing Time First (SPTF)
  - First Come First Serve (FCFS)

- Classification

N / M / A / B

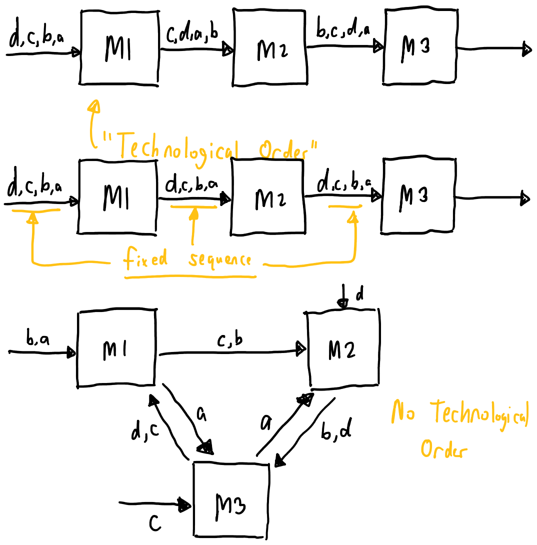
Tasks · # Machines · Shop type · Criteria

Shop Type: F flow shop
P permutation shop
G general shop

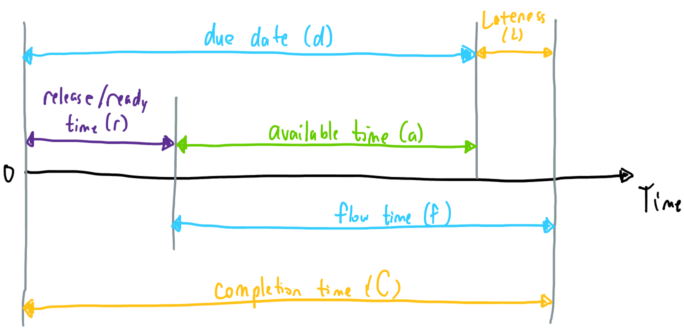
Jobs
Machines
Shop type
Criteria

P permutation shop
G general shop

- Shop Types
  - Flow (F)
  - Permutation (P)
  - General (G)



- Standard Scheduling Terms



- Johnson's n-job 2-machine algorithm ($n/2/P/C_{max}$)

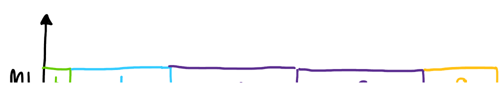
Processing Times

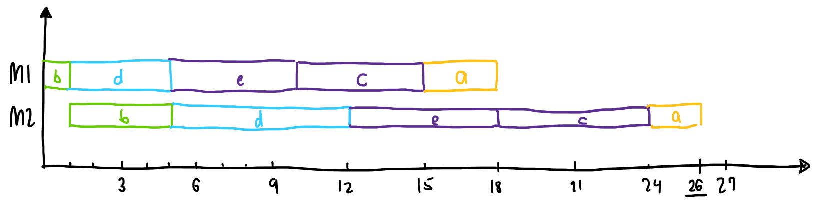
	M1	M2
~~a~~	~~3~~	~~2~~
~~b~~	~~1~~	~~4~~
c	5	6
~~d~~	~~4~~	~~7~~
e	5	6

2	4/5	4/5	3	1		
a	c	e	d	b	$\boxed{M1}$	$\boxed{M2}$

1. Shortest time. Front b/c M1 goes first
2. Next shortest. Back b/c M2 goes last
3. Next shortest. Second from front b/c value is for M1

4/5 A tie





→ $5/2/P/C_{max}$

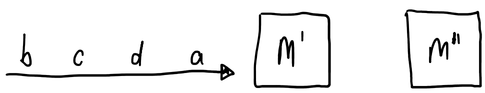
• Johnson's n-job 3-machine algorithm ($n/3/P/C_{max}$)

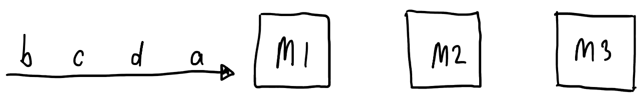
JobID	M1	M2	M3
a	3	1	6
b	5	4	5
c	4	2	8
d	2	3	7

→

Job ID	M' M1+M2	M'' M2+M3
a	4	7
b	9	9
c	6	10
d	5	10

• Apply Johnson's n-job 2-machine algorithm





* Condition :

> Smallest processing time on <u>M1</u> must be greater than or equal to processing times on M2

> " " " " <u>M3</u> " " " " " " " " " " " M2

• If either conditions not satisfied, solution may be sub-optimal, but still good

• Johnson's n-job 2-machine algorithm ($n/2/G/C_{max}$)

• Group jobs into 4 sets:

{AB} M1 → M2

{BA} M2 → M1

{AB}   M1 → M2

{BA}   M2 → M1

{A}   M1 only

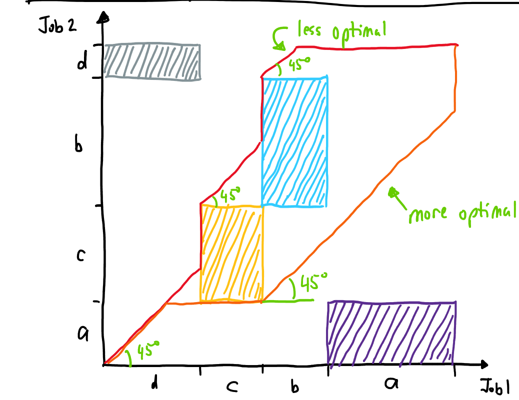
{B}   M2 only

- Apply Johnson's to {AB} and {BA}

{A} {AB} $\boxed{M1}$ → {BA} {A} $\boxed{M1}$ → o/p

{B} {BA} $\boxed{M2}$ → {AB} {B} $\boxed{M2}$ → o/p

- <u>Aker's Graphical Solution (2 / m / z / F_{max})</u>



- Completion Time

C = Total processing time of job 1 + time job 1 waits & job 2 is processed (sum of vertical lines)

C = " " " " 2 + " " 2 " " " 1 " " (sum of horizontal lines)

- <u>Number of Schedules by Brute Force</u>

Job Shop	# Schedules
G, no conditions	$>(n!)^m m!$
F, all machine orders	$(n!)^m m!$
F, one machine order	$(n!)^m$
P, all machine orders	$(n!)(m!)$
P, one machine order	$(n!)$

n = jobs

m = machines

- Assumptions
  - Each job is a single entity throughout passage through machines
  - No pre-emption
  - No cancellation
  - Processing times independent of sequence used
  - Machines don't break down
  - ⋮

Best Equipment Arrangement

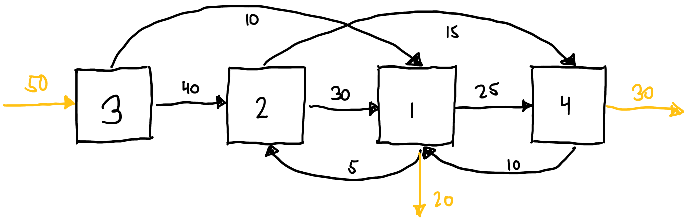
- To-From Ratio

From \ To	1	2	3	4	Sum
1	0	5	0	25	30
2	30	0	0	15	45
3	10	40	0	0	50
4	10	0	0	0	10
Sum	50	45	0	40	

	To-From Ratio	
1	50/30 →	1.67
2	45/45 →	1.00
3	0/50 →	0.00
4	40/10 →	4.00

lowest highest

$3 \rightarrow 2 \rightarrow 1 \rightarrow 4$



Forecasting

- Coefficient of Correlation

$$r = \sqrt{1 - \frac{\text{Regression sum of squares}}{\text{Total sum of squares}}} = \sqrt{1 - \frac{\sum_{i=1}^{n}(y_i - \hat{y}_i)^2}{\sum_{i=1}^{n}(y_i - \bar{y})^2}}$$

y_i = i^{th} observed point

$\hat{y}_i$ = regressed value for i^{th} data point

$\bar{y}$ = average of observed data point

- Analysis of Forecast Errors

$$e = y_t - \hat{y}_t$$

- Mean Squared Error (MSE)

$$MSE = \frac{\sum_{t=1}^{n}(y_t - \hat{y}_t)^2}{n}$$

- Mean Absolute Deviation (MAD)

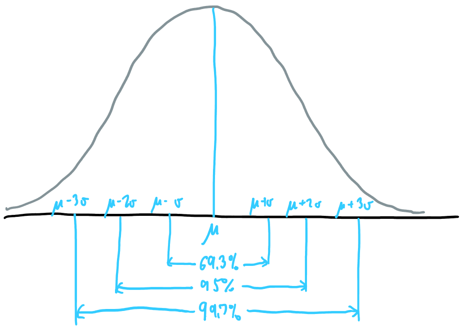
$$MAD = \frac{\sum_{t=1}^{n}|y_t - \hat{y}_t|}{n}$$

- Mean Absolute Percentage Error (MAP)

$$MAP = \frac{100}{n}\sum_{t=1}^{n}\left|\frac{y_t - \hat{y}_t}{y_t}\right|$$

Quality Control

- Normal Distribution



$$f(x) = \frac{1}{\sqrt{2\pi}} e^{\frac{-(x-\mu)^2}{2\sigma^2}}$$

$$\int_{-\infty}^{\infty} f(x)\,dx = 1 = 100\%$$

- Statistical Quality Control
  - Variables : anything that gives measurable quantity
  - Attributes
    - Defectives : A diode or two in a batch of 100 diodes
    - Defects : # scratches here & there, otherwise useable

$$\bar{\bar{X}} = \frac{\sum_{i=1}^{N} \bar{X}_i}{N} = \mu$$

$$\bar{R} = \frac{\sum_{i=1}^{N} R_i}{N} = d_2 \sigma$$

$$\sigma_R = d_3 \sigma \qquad \sigma_{\bar{X}} = \frac{\sigma}{\sqrt{n}}$$