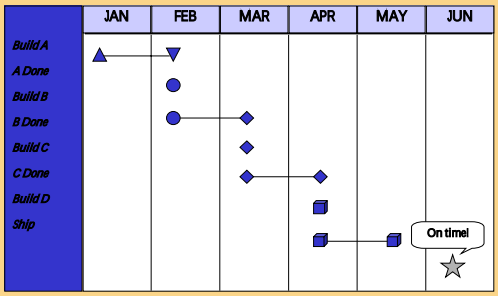
Scheduling

Scheduling

- برنامه ريزي كارگاهي : تعيين زمان استفاده از ماشين , ابزارآلات و تجهيزات و نيروي انساني در يک سازمان است تا
  - بهره برداري بهينه از منابع حاصل شود
  - زمان توقف , موجودي و زمان عمليات كاهش يابد

مفهوم اجرايي برنامه ريزي كارگاهي چيست؟

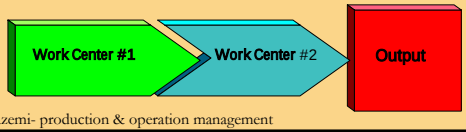


سيستم توليد انبوه
High-Volume Systems

- Characterized by standardized equipments and activities that provide identical or highly similar operations on customers or products as they pass through the system.
- Goal: high utilization of labor and equipment.
  - Many of the loading and sequence decisions are determined during the design of the system.

سيتمهاي توليد انبوه
High-Volume Systems

- *Flow system*: High-volume system with Standardized equipment and activities
- *Flow-shop scheduling*: Scheduling for high-volume flow system
  - Line balancing
  - Flow system design



High-Volume System Success Factors

- Process and product design
  - cost, manufacturability, and smooth flow
- Preventive maintenance
  - minimize breakdowns
- Rapid repair when breakdown occurs
  - require specialists as well as stocks of critical spare parts
- Optimal product mixes
  - achieve desired outputs at minimal costs
- Minimization of quality problems
  - production shutdown, loss of output, waste of labor, material, time, and other resource
- Reliability and timing of supplies
  - shorten supply lead times, develop reliable supply schedules, and carefully project needs

سيستمهاي با توليد متوسط
Intermediate-Volume Systems

- Outputs are between standardized high-volume systems and made-to-order job shops.
- Three basic issues:
  - *run size* of jobs, the *timing* of jobs, and the *sequence* in which jobs should be processed.

سيستمهاي با توليد كم يا سفارشي
Low-Volume Systems

- Products are made to order.
- Orders usually differ considerably in terms of
  - processing requirements, materials needed, processing time, and processing sequence and setups.
- Impossible to establish firm schedules priori to receiving the actual job orders.

سیستمهاي برنامه ريزي توليد اندک
Scheduling Low-Volume Systems

- *Loading* - how to distribute the workload among work centers
- *Sequencing* - what job processing sequence to use

Job Shops

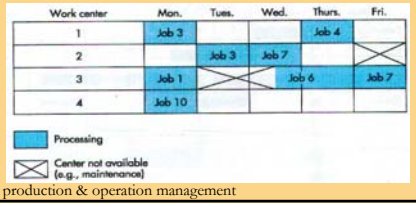
Gantt Load Chart

- *Gantt chart* - used as a visual aid for loading and scheduling
  - Load chart
  - Schedule chart

ایستگاه	شنبه	یکشنبه	دوشنبه	سه شنبه	چهارشنبه
1	Job 3			Job 4	
2		Job 3	Job 7		
3	Job 1			Job 6	Job 7
4	Job 10				

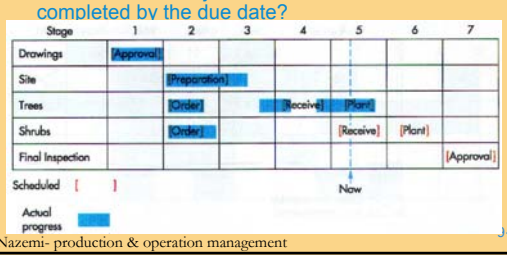
Load Chart

- Depict the loading and idle times for a group of machines or a list of departments.
  - Infinite loading
    - Vertical loading
  - Finite loading
    - Horizontal loading



Schedule Chart

- Forward scheduling
  - How long will it take to complete this job?
- Backward scheduling
  - When is the latest job can be started and still be completed by the due date?



گانت چارت

- نياز به بروز رساني مداوم نمودار دارد
- هزينه هاي مرتبط با فعاليتها را مورد پردازش قرار نميدهد
- زمان هر عمليات بستگي به عوامل مختلف دارد و لذا با روش ساده خطا در كار وجود دارد
  - برخي از ايستگاهها قابليت توليد سريعتري از ساير ايستگاهها دارند

توالي عمليات

- *Sequencing*: Determine the order in which jobs at a work center will be processed.
- *Workstation*: An area where one person works, usually with special equipment, on a specialized job.

قواعد توالي عمليات
Sequencing: Priority Rules

- FCFS: first come, first served
- SPT: shortest processing time
- EDD: earliest due date
- CR: critical ratio of time(remaining until due date to processing time remaining)
- S/O: slack time per operation
- Rush: emergency

فرضيات پايه

- مجموعه دستور كارها از قبل مشخص است
- زمان راه اندازي اوليه مستقل از توالي دستور كارها است
- زمان راه اندازي مقدار مشخص و قطعي است
- زمان عمليات مشخص و قطعي است
- پس از شروع هر فعاليت , وقفه در آن مجاز نيست

معيارهاي اندازه گيري در توالي عمليات

- زمان کل کار : زمان از شروع دستور کار تا زمان خروج از کارگاه
  - Job flow time: The length of time that begins when a job arrives a shop and ends when it leaves the shop.
- تاخیر کار : مدت زماني که خاتمه کار از موعد تحویل بیشتر شود
  - Job lateness: The length of time the job completion date is expected to exceed the due date.
- زمان یک سفارش کلي : مدت زمان تا خاتمه تمام کارهاي یک سفارش
  - Makespan: The total time needed to complete a group of jobs.
- متوسط تعدا دکار : متوسط زمان یک کار / سفارش
  - Average number of jobs: flow time / makespan.

Sequencing: Priority Rules, Example 1

Processing times (including setup times) and due dates for six jobs waiting to be processed at a work center are given in the following table. Determine the sequence of jobs, the average flow time, average days late, and average number of jobs at the work center, for each of these rules:

- FCFS
- SPT
- EDD
- CR

Job	Processing Time (Days)	Due Date (days)
A	2	7
B	8	16
C	4	4
D	10	17
E	5	15
F	12	18

Sequencing: Priority Rules, Example 1, FCFS

The FCFS sequence is simple A-B-C-D-E-F. The measures of effectiveness are (see table below):

- Average flow time: 120/6 = 20 days.
- Average tardiness: 54/6 = 9 days.
- The makespan is 41 days. Average number of jobs at the work center: 120/41=2.93.

Seq.	PT	FT	DD	Tard.
A	2	2	7	0
B	8	10	16	0
C	4	14	4	10
D	10	24	17	7
E	5	29	15	14
F	12	41	18	23
	41	120		54

Sequencing: Priority Rules, Example 1, SPT

Using the SPT rule, the job sequence is A-C-E-B-D-F (see the following table). The resulting values for the three measures of effectiveness are

- Average flow time: 108/6 = 18 days.
- Average tardiness: 40/6 = 6.67 days.
- The makespan is 41 days. Average number of jobs at the work center: 108/41=2.63.

Seq.	PT	FT	DD	Tard.
A	2	2	7	0
C	4	6	4	2
E	5	11	15	0
B	8	19	16	3
D	10	29	17	12
F	12	41	18	23
	41	108		40

Sequencing: Priority Rules, Example 1, EDD

Using earliest due date as the election criterion, the job sequence is C-A-E-B-D-F. The measures of effectiveness are (see table):

- Average flow time: 110/6 = 18.33 days.
- Average tardiness: 38/6 = 6.33 days.
- The makespan is 41 days. Average number of jobs at the work center: 110/41=2.68.

Seq.	PT	FT	DD	Tard.
C	4	4	4	0
A	2	6	7	0
E	5	11	15	0
B	8	19	16	3
D	10	29	17	12
F	12	41	18	23
	41	110		38

Sequencing: Priority Rules, Example 1, CR

Job	PT	DD	CR	
A	2	7	(7-0)/2=3.5	
B	8	16	(16-0)/8=2.0	
C	4	4	(4-0)/4=1.0	(lowest)
D	10	17	(17-0)/10=1.7	
E	5	15	(15-0)/5=3.0	
F	12	18	(18-0)/12=1.5	

Sequencing: Priority Rules, Example 1, CR

At day 4 [C completed], the critical ratios are:

Job	PT	DD	CR	
A	2	7	(7-4)/2=1.5	
B	8	16	(16-4)/8=1.5	
C	-	-	-	
D	10	17	(17-4)/10=1.3	
E	5	15	(15-4)/5=2.2	
F	12	18	(18-4)/12=1.17	(lowest)

Sequencing: Priority Rules, Example 1, CR

At day 16 [C and F completed], the critical ratios are:

Job	PT	DD	CR	
A	2	7	(7-16)/2=-4.5	(lowest)
B	8	16	(16-16)/8=0.0	
C	-	-	-	
D	10	17	(17-16)/10=0.1	
E	5	15	(15-16)/5=-0.2	
F	-	-	-	

Sequencing: Priority Rules, Example 1, CR

At day 18 [C, F, and A completed], the critical ratios are:

Job	PT	DD	CR	
A	-	-	-	
B	8	16	(16-18)/8=-0.25	
C	-	-	-	
D	10	17	(17-18)/10=-0.10	
E	5	15	(15-18)/5=-0.60	(lowest)
F	-	-	-	

Sequencing: Priority Rules, Example 1, CR

- At day 23 [C, F, A, and E completed], the critical ratios are:

Job	PT	DD	CR	
A	-	-	-	
B	8	16	(16-23)/8=-0.875	(lowest)
C	-	-	-	
D	10	17	(17-23)/10=-0.60	
E	-	-	-	
F	-	-	-	

Sequencing: Priority Rules, Example 1, CR

The job sequence is C-F-A-E-B-D, and the resulting values for the measures of effectiveness are:

- Average flow time: 133/6 = 22.17 days.
- Average tardiness: 58/6 = 9.67 days.
- The makespan is 41 days. Average number of jobs at the work center: 133/41=3.24.

Seq.	PT	FT	DD	Tard.
C	4	4	4	0
F	12	16	18	0
A	2	18	7	11
E	5	23	15	8
B	8	31	16	15
D	10	41	17	24
	41	133		58

Sequencing: Priority Rules, Example 1

Rule	Average Flow Time (days)	Average Tardiness (days)	Average Number of Jobs at the Work Center
FCFS	20.00	9.00	2.93
SPT	18.00	6.67	2.63
DD	18.33	6.33	2.68
CR	26.67	14.17	3.90

Sequencing: Priority Rules, Example 2

Use S/O (slack per operation) rule to schedule the following jobs. Note that processing time includes the time remaining for the current and subsequent operations. In addition, you will need to know the number of operations remaining, including the current one.

Job	Remain. PT	DD	Remain. OP
A	4	14	3
B	16	32	6
C	8	8	5
D	20	34	2
E	10	30	4
F	18	30	2

Sequencing: Priority Rules, Example 2

Determine the difference between the due date and the processing time for each operation. Divide the amount by the number of remaining operations, and rank them from low to high. This yields the sequence of jobs: C-B-A-E-F-D.

Job	Remain. PT	DD	Slack	Remain. OP	Ratio	Rank
A	4	14	10	3	3.33	3
B	16	32	16	6	2.67	2
C	8	8	0	5	0.00	1
D	20	34	14	2	7.00	6
E	10	30	20	4	5.00	4
F	18	30	12	2	6.00	5

Sequencing: Priority Rule Summary

- SPT is superior in minimizing the average number of jobs at the work center and completion time.
  - *Truncated* SPT: After waiting for a given time period, any remaining jobs are automatically moved to the head of the line.
- For service systems, the FCFS rule is by far the dominant priority rule.
- EDD and CR rules minimize lateness.
- S/O rule requires re-evaluating the sequence after each operation.

Two Work Center Sequencing

- قاعده جانسون
  - تکنیکي است براي حداقل نمودن زمان یک گروه از کارها که بایستي از دو ماشین یا دو ایستگاه کار عبور کنند
- این قاعده مورد زیر را بهینه میکند
  - کل زمان بیکاري ماشینها را حداقل میکند

Johnson's Rule Conditions

- ~~Job time must be known and constant~~
- Job times must be independent of sequence
- Jobs must follow same two-step sequence
- Job priorities cannot be used
- All units must be completed at the first work center before moving to second

الگوریتم روش جانسون

1. لیست کارها را با زمان در هر ایستگاه مشخص کنید
2. کار با کمترین زمان را تعیین نمایید
   1. اگر کار مربوط به ایستگاه اول باشد در اولین دستورکار قرار دهید
   2. اگر کار مربوط به ایستگاه دوم باشد آن را در آخرین لیست قرار دهید
   3. دستور کارهاي زمانبندي شده را جذف کنید
3. گامهاي دوم وسوم را تکرار کنید

Johnson's Rule Example

A group of six jobs is to be processed through a two-machine flow shop. The first operation involves cleaning and the second involves painting. Determine a sequence that will minimize the total completion time for this group of jobs. Processing times are as follows:

	Processing Time (Hours)	
Job	Work Center 1	Work Center 2
A	5	5
B	4	3
C	8	9
D	2	7
E	6	8
F	12	15

Johnson's Rule Example

a. Select the job with the shortest processing time. It is job D with a time of 2 hours.
b. Since the time is at the first center, schedule job D first. Eliminate job D from further consideration.
c. Job B has the next shortest time. Since it is at the second work center, schedule it last and eliminate job B from further consideration. We now have

1st	2nd	3rd	4th	5th	6th
D					B

Johnson's Rule Example

d.

	Processing Time (Hours)	
Job	Work Center 1	Work Center 2
A	5	5
C	8	9
E	6	8
F	12	15

1st	2nd	3rd	4th	5th	6th
D				A	B

Johnson's Rule Example

e. The shortest remaining time is 6 hours for job E at work center 1. Thus, schedule that job toward the beginning of the sequence (after job D). Thus,

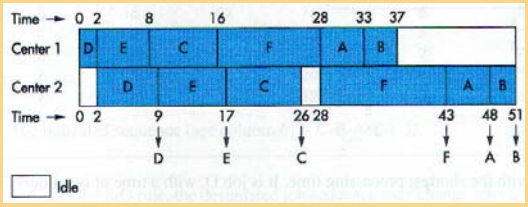
1st	2nd	3rd	4th	5th	6th
D	E			A	B

f. Job C has the shortest time of the remaining two jobs. Since it is for the first work center, place it third in the sequence. Finally, assign the remaining job (F) to the fourth position and the result is

1st	2nd	3rd	4th	5th	6th
D	E	C	F	A	B

Johnson's Rule Example

g. One way to determine the throughput time and idle times at the work centers is to construct a chart:



Thus, the group of jobs will take 51 hours to complete. The second work center will wait 2 hours for its first job and also wait 2 hours after finishing job C. Center 1 will be finished in 37 hours.

Service Operation Problems

- Cannot store or inventory services
- Customer service requests are random
- Scheduling service involves
  - Customers
  - Workforce
  - Equipment

Scheduling Service Operations

- Appointment systems
  - Controls customer arrivals for service
- Reservation systems
  - Estimates demand for service
- Scheduling the workforce
  - Manages capacity for service
- Scheduling multiple resources
  - Coordinates use of more than one resource