Basics of Scheduling - Exercises

1.1 At a family-house construction a group of workers is performing the tasks below – seven days a week:

Task	Duration [days]	Working-days							
Erecting the masonry wall	3								
Lifting and spacing slab elements	1								
Formworking the ring-beam	1								
Reinforcing and concreting the ring-beam	2								

1.2 At a construction site two groups of workers are performing the tasks below. One of the groups is performing earthwork and concreting, while the other is doing the carpentry works – five days a week.
The concrete of foundation should be at least a day (twenty-four hours) old before placing any formwork on it.

Task	Duration [days]	Calendar days													
		M	T	W	Th	F	Sa	Su	M	T	W	Th	F	Sa	Su
Excavating the foundation	3														
Formworking foundation	3														
Concreting the foundation	3														
Formworking the walls	3														
Concreting the walls	3														

1.3 A sewer-line is being constructed in a synchronized-belt performance system (progression of tasks are even and alike).
Succeeding jobs are launched a day after the preceding ones had started (minimum succession time is a day).

Task	D [days]	Working-days																				
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Excavation	15																					
Timbering	15																					
Pipe-laying	15																					
Timb. removal	15																					
Trench refilling	15																					

1.4 A sewer-line similar to the preceding one above is being constructed. Timber works are performed by the only group of carpenters. Minimum succession time is two days. Which days could the carpenters have days-off having no job at the site?

Task	D [days]	Working-days																										
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
Excavation	18																											
Timbering	12																											
Pipe-laying	18																											
Timb. removal	6																											
Trench refilling	18																											

2.1 At an access-road construction a 300 m-s long hollow (cut-through) excavation is to be performed. Due to the varying depth the site engineer estimated the likely duration of processes for three sections (I, II, III) within it, separately. Durations of mass excavation performed by heavy equipment are estimated to be 2, 6 and 1 days – respectively. Duration of refinery excavation (progression of which is less effected by the depth and is to be performed by live labour) is estimated as 9 days for the total of 300 m-s. When should the refinery excavation be started for to provide at least a day succession time after the mass excavation and the labourers performing it with no break.
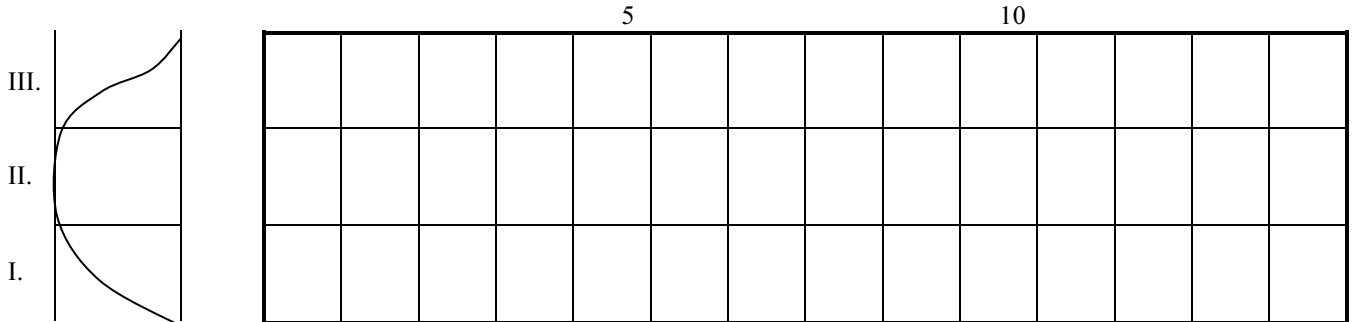
2.2 A retaining wall is to be constructed. According to the varying height the site engineer divided the overall length of it into two sections (I, II). Foundation is not changing along the wall. Minimum succession time should be at least one day. There are specialized groups (workers and/or equipment) assigned to the tasks to be performed, listed below, one for each.
Do prepare a schedule of performances in form of a Gantt-Chart and of a two-dimensional time-route chart („Cyclogram") too.

Task	Durations		Working-days																					
	I.	II	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
Excavation	12																							
Foundation	12																							
Formwork	4	8																						
Concreting	3	6																						
Formw. removal	2	4																						
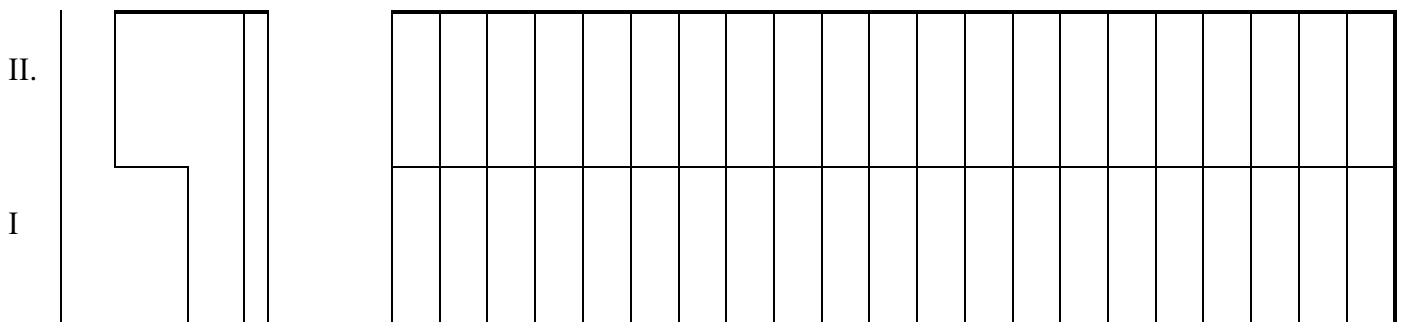
2.3 At installing a new telecommunication centre a complex task of parallel processes is to be performed by a subcontractor. Volumes of processes are: $V_A=280m^2$; $V_B=380m$; $V_C=22pcs$; $V_D=510hs$. Experienced standard performances are: $n_A=4h/m^2$; $n_B=1.35h/m$; $n_C=45h/pc$; $N_D=30h/d$; Available resources: $C_A=6ws$; $C_B=2ws$; $C_C=5ws$. What kind of counter-action should be made if the originally contracted one month duration got be reduced to 20 days?

2.4 At an embankment construction it is necessary to build a sheet-wall barrier. To keep up with the deadline it is necessary to apply two sets of equipment (two pile-driver machines and their staffs). Do develop as many variants in starting location and in progress direction for the two machines working simultaneously as you can.

3.1 How many steel-fitters would you command to perform the reinforcement works in the cases below? (10 hours are a shift)

Task	Working-days
	1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30
Formwork	░░░░░░░░░░░░░░░░░░░░ (days 1–20)
Reinforcement	
Concrete	░░░░░░░░░░░░░░░░░░░░ (days 5–24)

a/ Quantity of reinforcement is 25 ton, the time-standard of a steel-fitter is 40 hour/ton;

b/ Budgeted cost of the reinforcement is 24000 €, and standard daily performance of a steel-fitter is 200 €.

3.2 At a sewer system construction a trench of 6000 m^3 is to be excavated. Due to crossing existing public services at most 90 % of the work can be performed by the excavator (which has the experienced hourly output of 135 m^3) while the rest must be performed by live labour (time standard of which is 1.2 hour/m^3 per worker). The workers and the machine should work together (simultaneously, on a safe distance from each other). How many workers would you assign to the job?

3.3 Do develop a time schedule and associating resource usage charts for constructing a flat foundation including 160 pcs of monolithic foundation blocks.

Quantities per block: excavation: 25 m^3, formwork: 12 m^2, concreting: 9 m^3, refill: 16 m^3.

Time standards of works: formworking: 0.2 hour/m^2, removing formwork (striking): 0.1 hour/m^2, concreting: 1.5 hour/m^3, ditch refilling (+compacting): 1.0 hour/m^3;

Experienced hourly output of the backhoe excavator: 25 m^3.

Avoiding exposure of sensitive conditions are of high preference. 10 hours are a shift.

Task	W [h]	C	Working-days (shifts)
			1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25
Excavation			
Formwork			
Concreting			
Formw. removal			
Refill			

4.1 At a construction site the main tasks are organized into four succeeding processes (A, B, C, D). Assigned resources and estimated durations of each are listed below:

process A	5 workers	14 days,
process B	10 workers	24 days,
process C	8 workers	12 days,
process D	6 workers	24 days.

Minimum succession time is a day. Do plot a schedule for the performances.

Prepare a proposal for shortening the overall execution time keeping in mind that neither more working hours (shifts) in a day nor more workers for any of the processes are available? (Minimum capacity to be assigned to any process is 2 workers.)

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

4.2 In case of building a retaining wall the refill behind is to be performed in four layers. The soil for fill is excavated at a near-by pit, and transported by trucks to the foot of the wall. There the dumped soil is manipulated by a loader-excavator and is poured behind the wall, where rollers are used for compacting. Do plot the progression curves (cyclograms) of excavation and of fill.

Fill

Transport

Excavation

4.3 At a public supply-line construction the refill of the trench of 1000 m-s is to be scheduled. Do plot the progression curves (cyclograms) of the performances in cases below. (In both cases the overall execution time should be 8 days.)

 a; The trench is refilled in four layers, one layer along the total length at a time.

 b; The trench is refilled in four layers, in four equal sections, one layer along a section at a time.

1	2	3	4	5	6	7	8

1	2	3	4	5	6	7	8

Do plot cyclograms for the cases above, but with two groups (of workers and/or machines) working simultaneously. The overall execution time should be 8 days in these cases too.
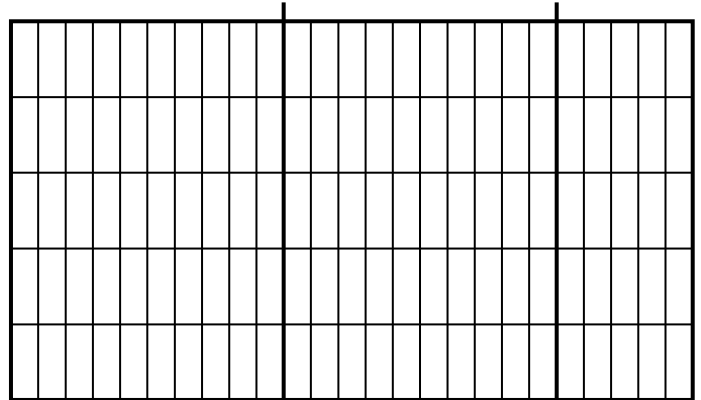
1	2	3	4	5	6	7	8

1	2	3	4	5	6	7	8

1	2	3	4	5	6	7	8

1	2	3	4	5	6	7	8

5.1 Develop a Schedule based on estimates below. (Illustrate your solution in a cyclogram.)

Process (In order)	Work [hour]	Capacity [Worker]
A	300	6
B	300	6
C	400	5
D	300	5
E	400	4

Conditions: - Processes "A" and "B" should be performed by the same group.
 - 10 working hours are a shift (One-shift days required).
 - Minimum succession time between succeeding processes is a day.

5.2 Develop a Schedule based on estimates below. (Illustrate your solution in a cyclogram.)

Process (In order)	Work [hour]	Capacity [Worker]
A	250	5
B	400	4
C	250	5
D	200	5
E	400	4
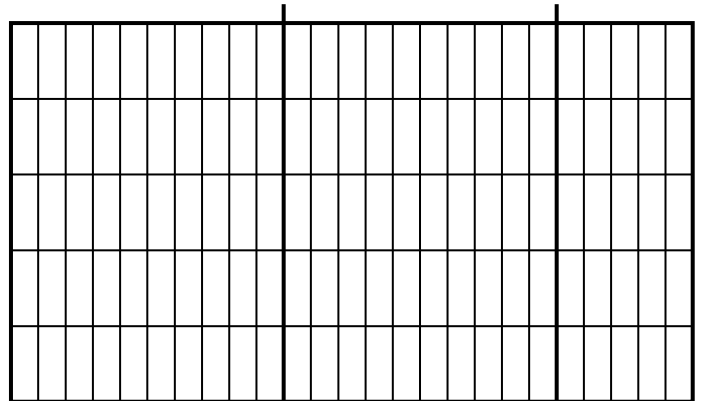
Conditions: - Processes "A" and "C" should be performed by the same group.
 - 10 working hours are a shift (One-shift days required).
 - Minimum succession time between succeeding processes is a day.

5.3 Develop a Schedule based on estimates below. (Illustrate your solution in a cyclogram.)

Process (In order)	Work [hour]	Capacity [Worker]
A	320	4
B	400	4
C	200	5
D	300	5
E	200	4
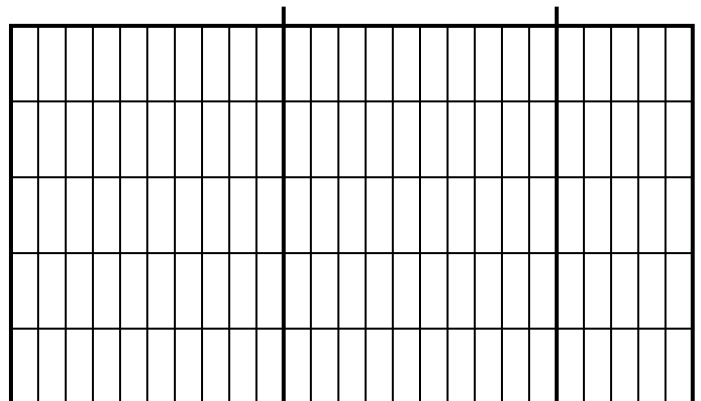
Conditions: - Processes "A" and "E" should be performed by the same group.
 - 10 working hours are a shift (One-shift days required).
 - Minimum succession time between succeeding processes is a day.

6.1 As part of a city revitalization 3 smaller units are to be reconstructed („Treasury circus", „Celebration square", „Oak alley").
In preliminary estimates the works are scheduled in three succeeding processes („Levelling", „High quality Pavement", „Plantation"). There are specialized groups assumed to perform processes in 10 hours-a-day shifts. To provide smooth performance 1 day (shift) minimum succession times are predicted between succeeding processes.

According to *works* listed site-by-site below and in accordance with *preliminary (master) schedule* do elaborate detailed schedule in form of a cyclogram.

Nº	ID	Activity (process)	Work by Site		
			Treasury circus	Celebration sqr.	Oak alley
1	"L"	Levelling	240 h	400 h	80 h
2	"H"	High quality Pavement	100 h	250 h	100 h
3	"P"	Plantation	240 h	120 h	180 h

Nº	ID	Activity (process)	C	Shift (day)
1	"L"	Levelling	8	
2	"H"	High quality Pavement	5	
3	"P"	Plantation	6	

6.2 How many processes are in a synchronized belt-system schedule if: overall execution time is 30 days; step-time is 3 days; technological break (over the step-time) between the second and the third process is 3 days; number of sections (units) is 6. Plot the schedule in form of a cyclogram.

7.1 Do prepare a schedule in form of a cyclogram for the maintenance works of a 4000 m long linear structure (e.g.: retaining wall, road, canal, etc.). Tasks would be performed by 3 teams of subcontractors in a strict technological order ("A", "B", "C"). Providing safe performance necessitates at least 2 days succession time between succeeding processes. Minimizing the length of the section under progress at a time has high preference.

According to the preliminary and preparatory negotiations we know that:

At task "A":   Total works to be performed by live labour is 2000 hours;
Available capacity during the first five days is 20 workers that falls down to 10 workers later on;
10 hours make a shift. (One-shift days predicted.)

At task "B":   Total amount of works is 12000 m^3;
To perform the job the supplier (subcontractor) offers more choices:
a.,   1 big machine of 120 m^3/h standard output, working 10 hours a day;
b.,   1 middle-range machine of 80 m^3/h standard output, working 8, 10 or 12 hours a day;
c.,   2 small machines, 20 m^3/h standard output of each, working 1 or 2 shifts (10 or 20) hours a day.

At task "C":   Total work to be performed by live labour is 1200 hours;
Total work to be performed by machine (parallel/synchronized with labourers) is 150 hours;
Specific amount of works between sections 0+000 – 2+000 is the double of that between sections 2+000 – 4+000.
(That is: 2/3 of works must be performed between sections 0+000 – 2+000.)
10 hours make a shift. (One-shift days predicted.)
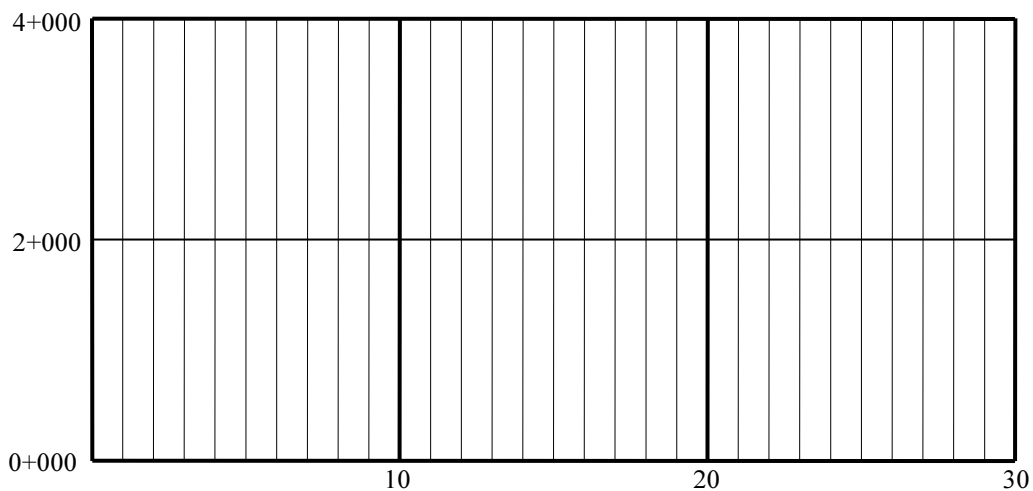
7.2 At a 400 m long gravity wall construction 4 main processes are to be performed. "A": sheet-wall piling by 2 machines: V_A=1600 m^2; N_A=10 m^2/h each. "B": excavation by 1 machine: V_B= 4000 m^3; N_B=50 m^3/h. "C": formworking by 1 or 2 teams (2 carpenters and a labourer make a team): V_C=800 m^2; n_{Clbr}=0.2 h/m^2; n_{Ccarp}= 0.4 h/m^2. "D": concreting by mixer truck and 2-4 labourers: V_D=600 m^3; n_D=0.4 h/m^3. 10 hours make a shift (one-shift days predicted). For smooth and safe performance distances between succeeding processes should be 100 to 200 m-s. Prepare the schedule of works in form of a cyclogram.
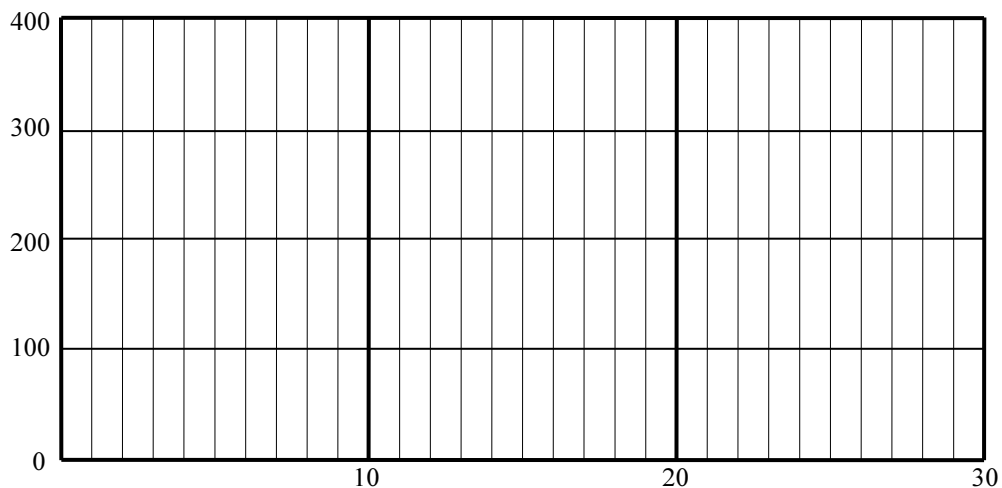
8. As part of a municipal development project a sewer line of HDPE pipe elements is to be constructed. Related tasks to be performed are defined below:

Quantities by section

Task	unit	Section I. 0+000 - 0+800	Section II. 0+800 - 2+000	Section III. 2+000 - 3+200
Excavating trench with no timbering	m³	-	1800	3000
Excavating trench with timbering	m³	1600	-	-
Grading + Pipe-bed (gravel layer)	m²	800	1200	1200
Pipe laying	m	800	1200	1200
Trench refill	m³	1600	1800	3000

Works by section [h]

Task	unit	Std. perform [h/unit]	Output of equipment [unit/h]	Section I. labour equip		Section II. labour equip		Section III. labour equip	
Excavating trench with no timbering	m³	0.2	30.0						
Excavating trench with timbering	m³	0.5	10.0						
Grading + Pipe-bed (gravel layer)	m²	0.3	-						
Pipe laying (by subcontractor)	m	-	8.0 - 15.0						
Trench refill	m³	0.1	60.0						

Calculate works section by section, determine durations with capacities needed. Do present your schedule proposal in form of a cyclogram. You also should consider conditions and expectations listed below.

- For excavation 1 excavator is available and should work with no break
- The subcontractor preforming pipe laying can progress with intensity of 80 to 150 m a day
- Number of workers in each teams should be 3 to 6
- Actual workplaces (fronts of performances) must not get closer to each other than 400 m
- Protection of sensitive conditions and the shortest overall execution time have high preference
- Do consider 10 hours a shift and 1 shift a day