ORDRE DES INGÉNIEURS DU QUÉBEC
May 2020 SESSION

All documentation is permitted
Calculators: allowed models only
Exam duration: 3 hours

14-CI-A7 Construction Project Management

Question 1 (20 points)

Using the data in Table 1, **draw the AOA diagram** (Activity On Arrow) and indicate the **critical path**.
Indicate, for each activity, the Early Start (**ES**), the Early Finish (**EF**), the Late Start (**LS**), the Late Finish (**LF**), the total Float (**TF**), and the Free Float (**FF**).

Table 1

Activity	Duration	Predecessor
M	5	none
N	8	M
O	4	N, Q
P	9	O, V, W
Q	7	M
R	3	Q
S	8	R
T	5	O, S, W
V	3	R
W	7	N, Q
X	4	W
Y	4	X

Question 2 (20 points)

Resolve the resource conflicts for the following project, knowing that you can use up to 5 resources at the same time. The activities must be carried out on an ongoing basis (This means that once an activity has started it must continue to run until it is completed without any interruption).

Figure 1, indicates the network, critical path and for each activity, the duration, the number of resources per day, the Early Start (ES), the Early Finish (EF), the Late Start (LS), the Late Finish (LF), the total Float (TF), and the Free Float (FF).

The **calculation steps must be demonstrated**. This means that you have to redraw the network and make a new Gantt chart every time an activity is delayed because of a conflict. New resource links must also be demonstrated (this means new constraints between activities to resolve resource conflicts).

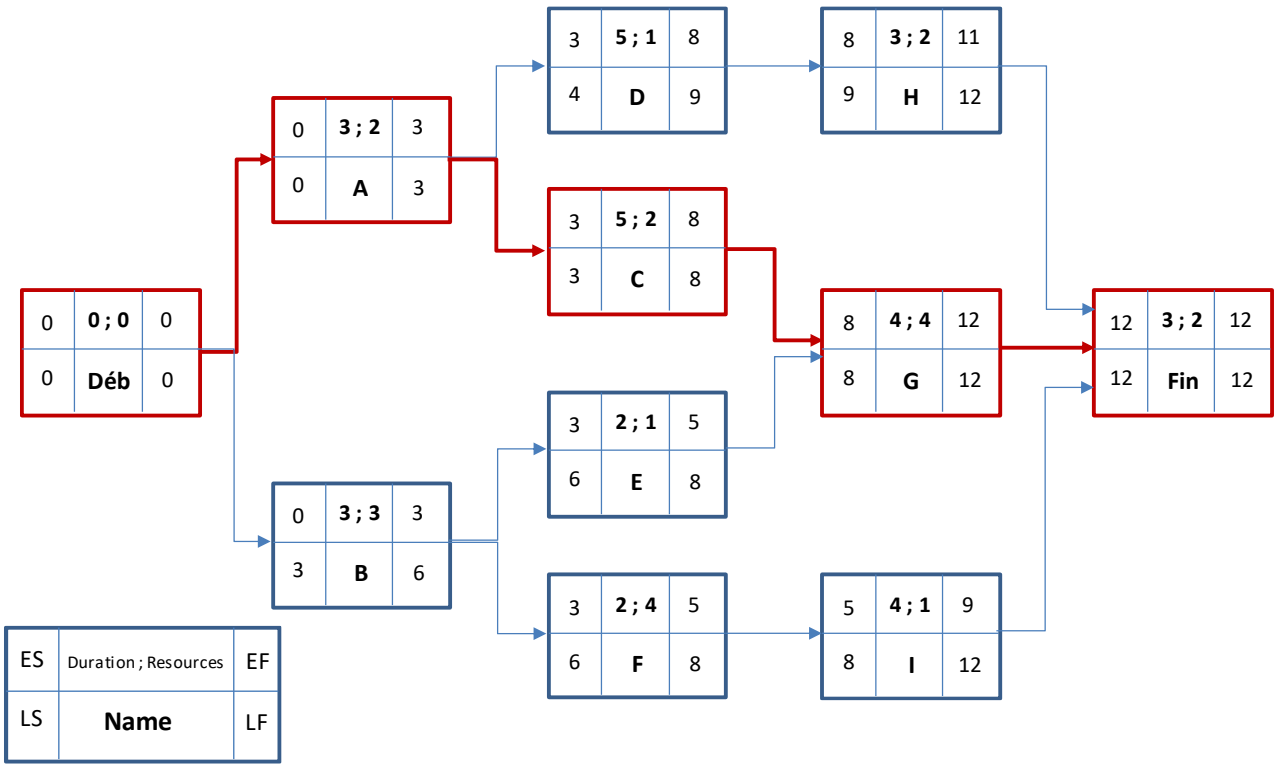

Figure 1 – Resource conflicts

Question 3 (20 points)

Using the two following tables (2 and 3), please:
1 - Calculate the **planned and actual costs;** the **earned value** and **draw the Planned, the Actual and the Earned Value progress curves**.
2 - Calculate the **variances** and **draw a histogram** to show the cost and the schedule variances.
3 - Calculate the **performance indexes** and **draw curves to show the cost and the schedule performance indexes**.

Table 2

Planning	Quantity	Unit price	Unit	Total	Month				
					1	2	3	4	5
					%				
Site organization									
Mobilization	1	$15 000	Lump sum	**$15 000**	100%				
Site Installation	1	$8 000	Lump sum	**$8 000**	100%				
Foundation									
Topsoil stripping	350	3 $ / U	m²	**$1 050**	100%				
Excavation	400	10 $ / U	m³	**$4 000**	80%	20%			
Foundation soles	20	350 $ / U	m³	**$7 000**		100%			
Foundation walls	50	500 $ / U	m³	**$25 000**		100%			
backfill	120	12 $ / U	m³	**$1 440**			100%		
Superstructure									
columns	15	800 $ / U	m³	**$12 000**			100%		
Floor slab	80	700 $ / U	m³	**$56 000**			40%	60%	
Slab on ground	200	45 $ / U	m²	**$9 000**			100%		

Table 3

Actual	Quantity	Unit price	Unit	Total	Month				
					1	2	3	4	5
					%				
Site organization									
Mobilization	1	$15 000	Lump sum	**$15 000**	100%				
Site Installation	1	$9 000	Lump sum	**$9 000**	100%				
Foundation									
Topsoil stripping	350	3 $ / U	m²	**$1 050**	100%				
Excavation	420	11 $ / U	m³	**$4 620**	60%	40%			
Foundation soles	22	350 $ / U	m³	**$7 700**		100%			
Foundation walls	45	480 $ / U	m³	**$21 600**		80%	20%		
backfill	130	12 $ / U	m³	**$1 560**			100%		
Superstructure									
columns	15	800 $ / U	m³	**$12 000**				100%	
Floor slab	82	720 $ / U	m³	**$59 040**				40%	60%
Slab on ground	200	45 $ / U	m²	**$9 000**			100%		
Amendment 1		1	Lump sum	**$12 000**			100%		

Question 4 (20 points)

You have to draw a **LINEAR SCHEDULE** for the replacement of the infrastructure of an existing railway line 2.7 kilometers long.
This means you **MUST NOT USE EITHER the GANTT diagram or the CPM networks** to draw the schedule.

The work will be carried out between the **two chaining (0 + 000 and 1 + 500)** and the t**wo chaining (1 + 800 and 3 + 000).**
The chains (1 + 500) and (1 + 800) are occupied by the "Notre-Dame" station, whose railways **must not be replaced.**

You have three (3) Lots which carry out the work **in the following order:**

Lot 1 - responsible for the **removal of the old railway**. This lot consists of three (3) teams to carry out, in order, the following three activities:

A. A team for the removal of old rails which performs the work with a production rate of 6 linear meters of track per hour (for the two lines of rail);
B. A team for the removal of old railroad sleepers who performs the work with a production rate of 6 linear meters of track per hour;
C. A team for the removal and deposit of the ballast for reuse. This team performs the work with a production rate of 10 linear meters of track per hour.

Lot 2 - responsible for the **installation of the railway.** This lot consists of two (2) teams to carry out, in order, the following two activities:

D. The first team to install the new railroad sleepers with a production rate of 4 linear meters of track per hour;
E. The second team for the installation of the new rails with a production rate of 4 linear meters of track per hour (for the two lines of rail).

Lot 3 - responsible for **installing the ballast** on the new rails installed and for leveling these rails. This lot consists of two (2) teams each carrying out, in order, one of the following two activities:

F. A team for the installation of ballast on the installed rails with a production rate of 6 linear meters of track per hour;
G. A team for leveling the rails. This team performs the work with a production rate of 10 linear meters of track per hour.

You have to :

- Work 50 hours a week.
- Maintain a distance of at least a week between the different teams. You can only start a new activity at the start of a new week, i.e. you cannot start an activity in the middle of the week.
- Draw a space-time diagram: i) the timescale uses the week and starts at week 0; ii) the distance chaining is between the two chaining 0+000 and 3+000.
- Plan the work with a **LINEAR SCHEDULE** so that all the teams work continuously (no work stoppage is allowed).

If you need to **speed up the project** and you can only increase the productivity of the two teams in Lot 2, for how many days the duration of the project could be reduced and what would be the productivity rates per hour required for each of these two teams.

Question 5 (20 points)

Using the method of parallelepipeds (méthode des parallélépipèdes), calculate the required volumes of excavation and backfill. The final level of the site (shown in Figure 2) should be 10 000.

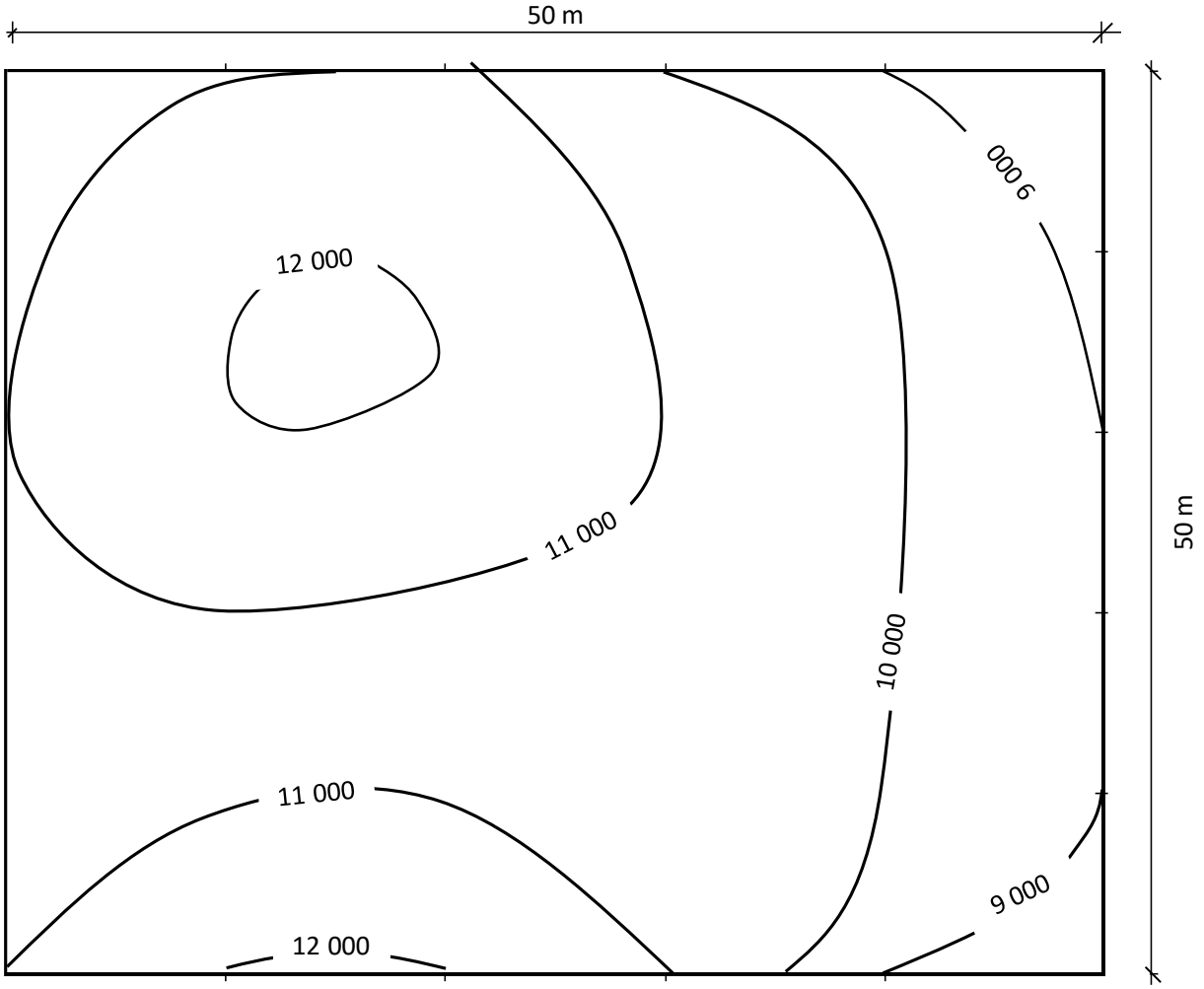

Figure 2 – The site map