ORDRE DES INGÉNIEURS DU QUÉBEC
November 2017 SESSION

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

14-BA-A3 Construction Project Management

Question 1 (5 points)

Briefly discuss the problems encountered in establishing the levels 4 to 6 of the WBS.

Question 2 (5 points)

Describe a method used by the estimators to calculate the volumes of excavation and backfill for the earth moving of road projects. Use illustrations if needed.

Question 3 (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	7	None
N	12	M
O	8	N
P	5	M
Q	5	P
R	8	O, Q
S	9	M
T	3	S
U	8	T
V	8	O, Q, U
W	8	T
X	8	U, W

Question 4 (15 points)

The following network, **Figure 1**, shows the schedule of a project using the PDM method, also called AON diagram (Activity-On-Node).

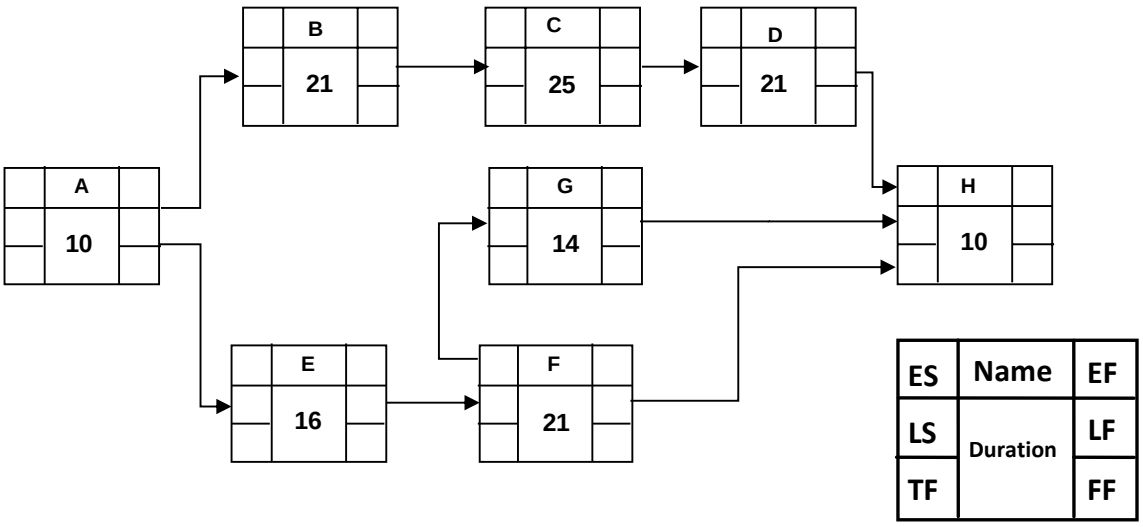


Figure 1. PDM Network

Table 2 shows the optimistic, the pessimistic and the most likely durations for each activity. You have to:

a. Calculate and indicate in Table 2, the expected duration TE, the variance σ^2 and the standard deviation σ for each activity. (3 points)
b. Calculate the project duration. (2 points)
c. Calculate the project variance. (2 points)
d. Calculate the probability to complete the project within 90 days. (4 points)
e. Calculate the probability to complete the project within 80 days. (4 points)

Table 2

Activity	Optimistic Duration	Most Likely Duration	Pessimistic Duration	Te	σ^2	σ
A	10	10	10			
B	16	20	30			
C	22	25	28			
D	16	20	30			
E	13	15	23			
F	18	20	28			
G	8	15	16			
H	8	10	12			

Question 5 (20 points)

Your company is committed to implement the following project according to the schedule shown in **figure 2**, which 23 days that represent the normal duration of the project.

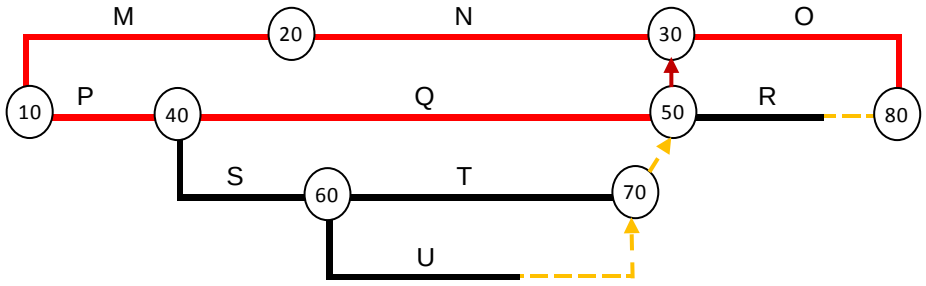


Figure 2. Project schedule

The project includes fixed overhead costs of $ 5 000 to be spent at the beginning (1rst day) of the project. It also includes variable overhead of $ 2 000 / day. The project data are in Table 3 below:

Table 3

Activity	Predecessors	Normal		Compressed	
		Duration	Cost	Duration	Cost
M		7	12 000	5	14 000
N	M	10	8 000	7	8 900
O	N, Q	6	10 000	3	12 100
P		4	5 000	3	6 000
Q	P	13	16 000	10	16 900
R	Q, T, U	4	1 500	3	3 000
S	P	4	3 000	4	3 000
T	S	8	12 000	5	13 200
U	S	5	3 000	4	3 800
	Total		**70 500**		

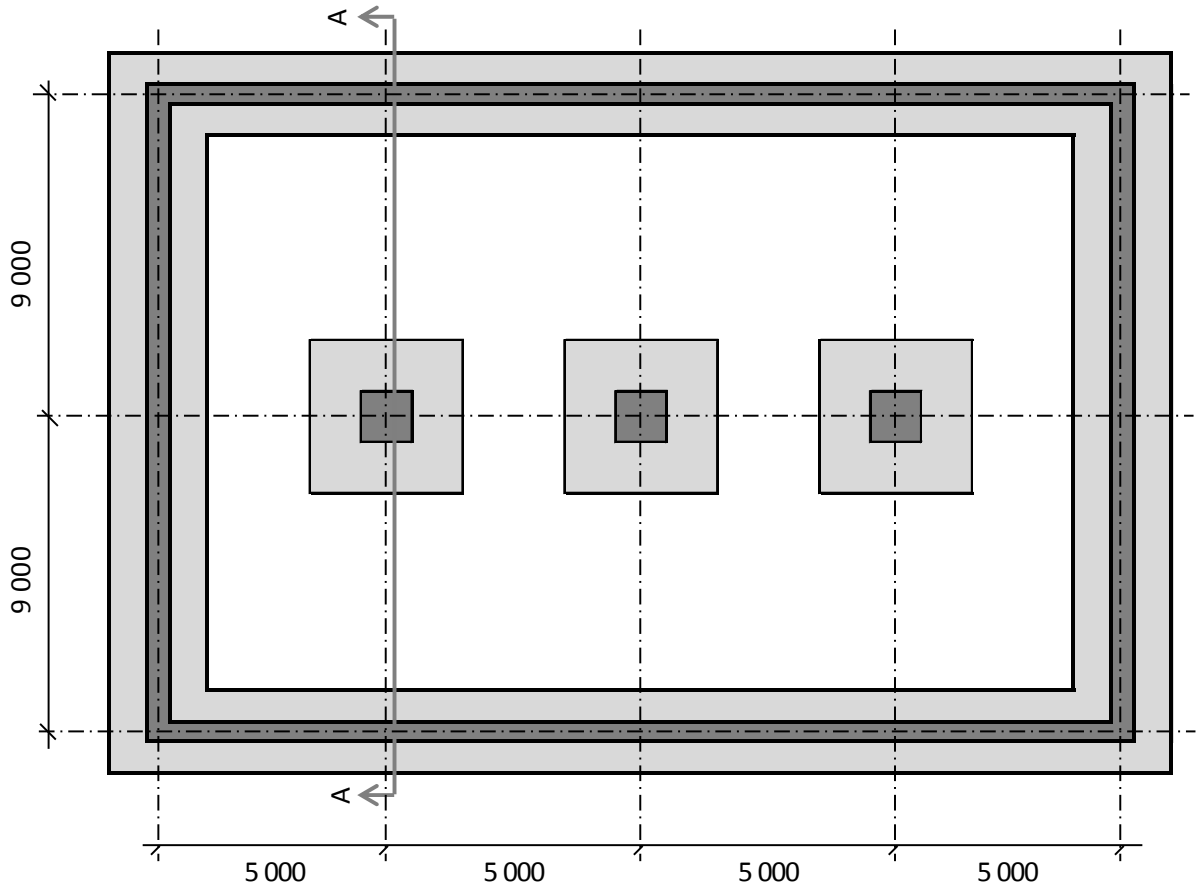
We ask you to:

- Calculate the minimum duration of the project after compression (12 points);
- Draw the CPM direct costs-duration curve for the project (2 points);
- Draw the CPM indirect costs-duration curve for the project (2 points);
- Taking into account the indirect and direct costs establish the total cost-duration curve (2 points);
- Calculate the optimum duration to complete this project and the relative cost (2 points)

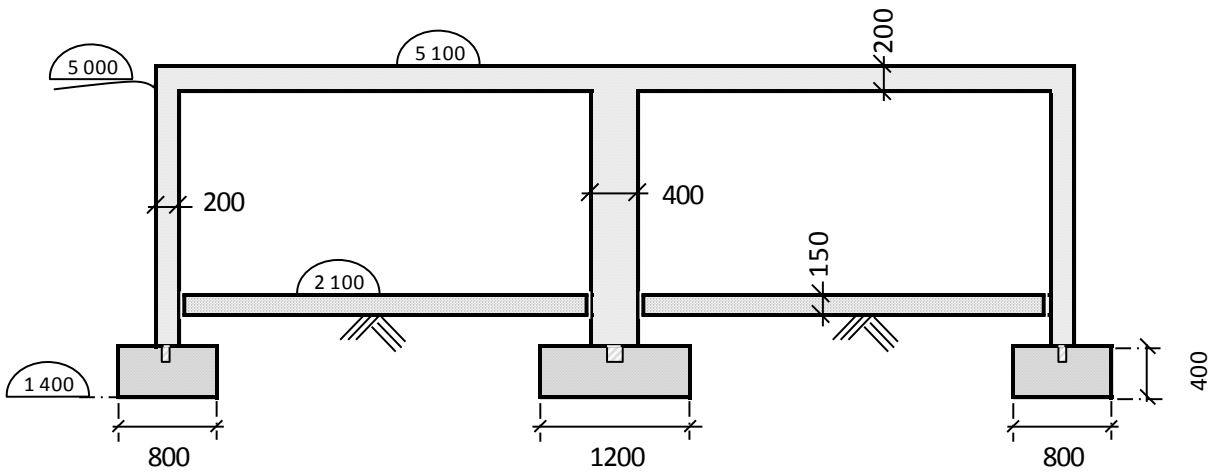
Question 6 (15 points)

As an estimator you have to make, for the construction of the basement shown in **Figure 3**, the quantities take-off of the following materials:

1. The surface area of the formwork in square meter (m^2) for the footings, columns and foundation walls and for the slab at level 5 100;
2. The volume of 30MPA concrete in cubic meter (m^3) for the footings, columns and foundation walls and for the slab at level 5 100;
3. The weight of the reinforcing steel in kg. Knowing that the rate of steel is 70 kg / m^3 for the footings; 120 kg / m^3 for the columns; 100 kg / m^3 for the foundation walls; and 140 kg/m^3 for the slab at level 5 100;
4. The volume of the 20MPA concrete in cubic meter (m^3) for the slab-on-grade at level 2 100;
5. The surface area of the wire mesh in square meter (m^2) for the slab-on-grade at level 2 100.



a) Plan view



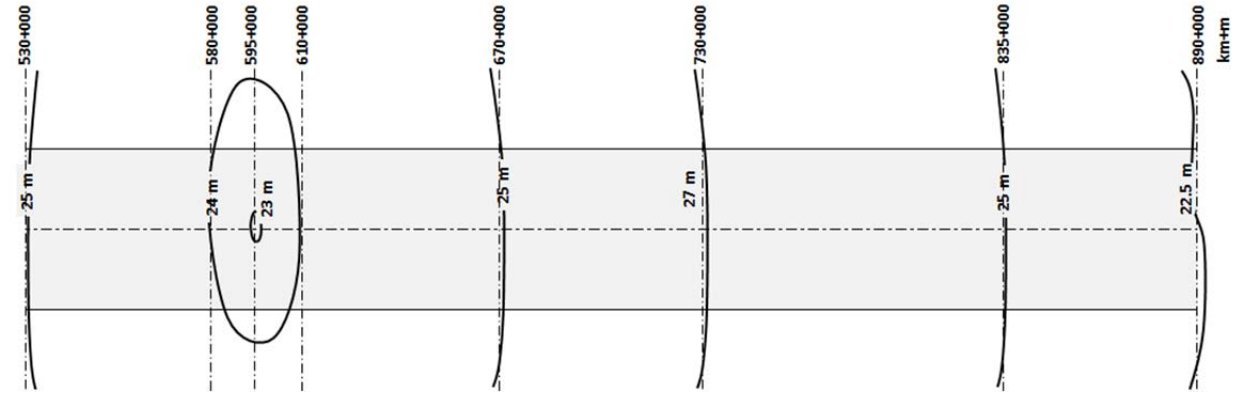
Section A-A

Figure 3. Plan and Section A-A of the basement

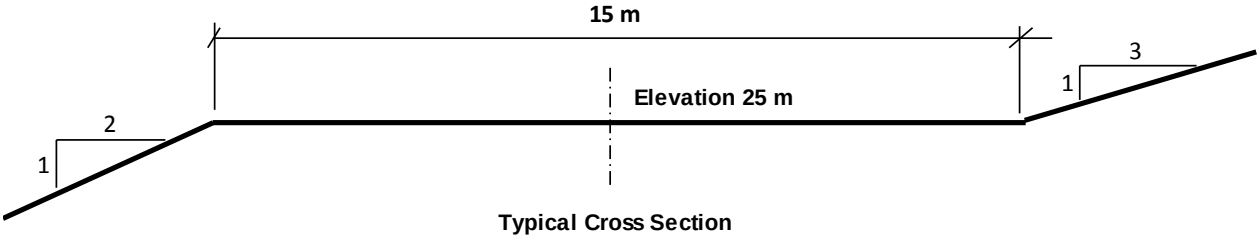
Question 7 (20 points)

For the earthworks (volume of cut and fill) of the road St-Paul illustrated in **Figure 4**, you should perform the following tasks:

1 - Draw the longitudinal section (2 pts)
2 - Draw the cross sections for all the demonstrated chaining (7 pts)
3 - Calculate the areas of the cross sections for all the demonstrated chaining (5 pts)
4 - Using the cross sections method (sections en travers), calculate the volumes of excavation and backfilling required for the road earthworks (6 pts)



Plan View



Typical Cross Section

Figure 4. Plan and cross section of the road

Annexe : Table Z

z	*00*	*.01*	*.02*	*. 03*	*.04*	*.05*	*.06*	*.07*	*.08*	*.09*
.0	.5000	.5040	.5080	.5120	.5160	.5199	.5239	.5279	.5319	.5359
.1	.5398	.5438	.5478	.5517	.5557	.5596	.5636	.5675	.5714	.5753
.2	.5793	.5832	.5871	.5910	.5948	.5987	.6026	.6064	.6103	.6141
.3	.6179	.6217	.6255	.6293	.6331	.6368	.6406	.6443	.6480	.6517
.4	.6554	.6591	.6628	.6664	.6700	.6736	.6772	.6808	.6844	.6879
.5	.6915	.6950	.6985	.7019	.7054	.7088	.7123	.7157	.7190	.7224
.6	.7257	.7291	.7324	.7357	.7389	.7422	.7454	.7486	.7517	.7549
.7	.7580	.7611	.7642	.7673	.7704	.7734	.7764	.7794	.7823	.7852
.8	.7881	.7910	.7939	.7967	.7995	.8023	.8051	.8078	.8106	.8133
.9	.8159	.8186	.8212	.8238	.8264	.8289	.8315	.8340	.8365	.8389
1.0	.8413	.8438	.8461	.8485	.8508	.8531	.8554	.8577	.8599	.8621
1.1	.8643	.8665	.8686	.8708	.8729	.8749	.8770	.8790	.8810	.8880
1.2	.8849	.8869	.8888	.8907	.8925	.8944	.8962	.8980	.8997	.9015
1.3	.9032	.9049	.9066	.9082	.9099	.9115	.9131	.9147	.9162	.9177
1.4	.9192	.9207	.9222	.9236	.9251	.9265	.9279	.9292	.9306	.9319
1.5	.9332	.9345	.9357	.9370	.9382	.9394	.9406	.9418	.9429	.9441
1.6	.9452	.9463	.9474	.9484	.9495	.9505	.9515	.9525	.9535	.9545
1.7	.9554	.9564	.9573	.9582	.9591	.9599	.9608	.9616	.9625	.9633
1.8	.9641	.9649	.9656	.9664	.9671	.9678	.9686	.9693	.9699	.9706
1.9	.9713	.9719	.9726	.9732	.9738	.9744	.9750	.9756	.9761	.9767
2.0	.9772	.9778	.9783	.9788	.9793	.9798	.9803	.9808	.9812	.9817
2.1	.9821	.9826	.9830	.9834	.9838	.9842	.9846	.9850	.9854	.9857
2.2	.9861	.9864	.9868	.9871	.9875	.9878	.9881	.9884	.9887	.9890
2.3	.9893	.9896	.9898	.9901	.9904	.9906	.9909	.9911	.9913	.9916
2.4	.9918	.9920	.9932	.9925	.9927	.9929	.9931	.9932	.9934	.9936
2.5	.9938	.9940	.9941	.9943	.9945	.9946	.9948	.9949	.9951	.9952
2.6	.9953	.9955	.9956	.9957	.9959	.9960	.9961	.9962	.9963	.9964
2.7	.9965	.9966	.9967	.9968	.9969	.9970	.9971	.9972	.9973	.9974
2.8	.9974	.9975	.9976	.9977	.9977	.9978	.9979	.9979	.9980	.9981
2.9	.9981	.9982	.9982	.9983	.9984	.9984	.9985	.9985	.9986	.9986
3.0	.9987	.9987	.9987	.9988	.9988	.9989	.9989	.9989	.9990	.9990
3.1	.9990	.9991	.9991	.9991	.9992	.9992	.9992	.9992	.9993	.9993
3.2	.9993	.9993	.9994	.9994	.9994	.9994	.9994	.9995	.9995	.9995
3.3	.9995	.9995	.9995	.9996	.9996	.9996	.9996	.9996	.9996	.9997
3.4	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9997	.9998