HIGHWAY CONSTRUCTION PROJECT — CPM/PDM EXERCISE

Problem

This is an exercise on how to schedule a highway construction project using the Critical Path Method (CPM) and the Precedence Diagram Method (PDM). The network contains 18 activities, details of which are given. Participants are also required to look into different ways of reducing project time by modifying the basic network. Approximate working time: 2 hours.

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A list of activities for the construction of a new highway project is given in Annex A. The activities are grouped under four main work functions, and time estimates for the execution of the activities are shown. The project consists of excavation along a proposed route with balanced cut and fill, the construction of a number of culverts at minor watercourses, construction of two road bridges over larger streams, road surfacing and other miscellaneous work. In the course of discussion with your engineering staff you have gathered the following additional information:

(a) Clearing and grubbing along the proposed route have to be done before any excavation can commence, but the contractor has first to mobilize and bring his men and equipment to the site.

(b) Culverts at minor watercourses have to be constructed before they can be filled over, but during their construction, some excavation can take place (begin excavation) at selected sections which has to be carried out before work can start for the construction of the embankments of the two bridges and the building of underdrains, storm sewers and miscellaneous drainage structures. The remaining excavation (complete excavation) can only be completed after the culverts are in place.

(c) After excavation is completed fine grading takes place and the sub-base is laid. However, prior to the fine grading the underdrains, storm sewers and miscellaneous structures have first to be installed.

(d) Construction of the pavement follows the placing of the sub-base, and the road shoulders and berms are constructed after the paving is done. This completes work on the road surfacing.

(e) The two bridges can be constructed at the same time. For the bridge construction the embankments are first constructed. This is followed by the construction of the substructures and then the superstructures.

(f) After the road surfacing and construction of the two bridges are completed, the guard rails and fences are erected and installation of street lights and traffic signs takes place, as is also the painting of road surface markings.

(g) Roadside improvement work involving slope trimming, sodding and seeding cannot commence until both the bridges and the road surfacing are completed.

(h) The contractor has to clean up the site for acceptance by the Highway Department after all construction work has ended.

Problem

1. Prepare a CPM (arrow diagram) or PDM network to illustrate the sequence of the work to be carried out.
2. Based on the time estimates given, locate the critical path for the project.
3. Calculate or enter the earliest and latest starting and finishing times for each activity and the float available on Worksheet No. 2 provided.

4. Draw a time scaled network diagram based on your findings.
5. What is the estimated project time? Discuss whether or nor this can be reduced, and if so, how this can be done.
6. What are the effects of your measures to reduce project time?

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Annex A

HIGHWAY CONSTRUCTION PROJECT—CPM/PDM EXERCISE

Activity	*Duration* (weeks)
Earthwork & Drainage	
Clearing & Grubbing	4
Begin excavation	6
Construct culverts	8
Complete excavation	10
Build underdrains storm sewers and miscellaneous drainage structures	6
Bridgework	
Construct Bridge A embankments	8
Construct Bridge A substructure	16
Construct Bridge A superstructure	14
Construct Bridge B embankments	6
Construct Bridge B substructure	14
Construct Bridge B superstructure	14
Roadwork	
Fine grade & place sub-base	12
Construct pavement	24
Construct shoulders & berms	12
Roadside improvement	3
Miscellaneous	
Contractor mobilization	3
Erect guard rails, fences, install lighting, signs and painting	4
Clean-up and acceptance	2

1. Construct the arrow diagram comprising activities A,B,C, ..., and P, which satisfies the following precedence relationships.

   (i) A, B, and C, the first activities of the project can start simultaneously.

   (ii) Activities D, E, and F start immediately after A is completed.

   (iii) Activities I and G start after both B and D are completed.

   (iv) Activity H starts after both C and G are completed.

   (v) Activities K and L suceed activity I.

   (vi) Activity J succeeds both E and H.

   (vii) Activities M and N suceed F but cannot start until E and H are completed.

   (viii) Activity O succeeds M and I.

   (ix) Activity P succeeds J, L and O.

   (x) Activities K, N, and P are the terminal jobs of the project.

2. Determine the critical path for project (a).

3. In Problem #2 compute the total and free floats and determine the critical path.

4. In Problem #2, using the results of Problem #3, construct the corresponding time charts assuming no limits on the resources.

5. Suppose in Problem #2 the following manpower requirements are specified for the different activities of project (a).
   Project (a)

Activity	*Number of men*	*Activity*	*Number of men*
1,2	5	3,6	9
1,4	4	4,6	1
1,5	3	4,7	10
2,3	1	5,6	4
2,5	2	5,7	5
2,6	3	6,7	2
3,4	7		

   Find the minimum number of men (as a function of the project time) required during the scheduling of the project. Using resource leveling estimate the maximum number of men required.

6. In Problem #2, given the following data for the direct costs of the normal and crash durations, find the different minimum cost schedules between the normal and crash points.

Project (a)

Activity (*i*, *j*)	*Normal* *Duration*	*Cost*	*Crash* *Duration*	*Cost*
1,2	5	100	2	200
1,4	2	50	1	80
1,5	2	150	1	180
2,3	7	200	5	250
2,5	5	20	2	40
2,6	4	20	2	40
3,4	3	60	1	80
3,6	10	30	6	60
4,6	5	10	2	20
4,7	9	10	5	90
5,6	4	100	1	130
5,7	3	140	1	160
6,7	3	200	1	240