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MTH 214 - Introduction to Operations Research

Definition of Operation Research

Operation research is concerned with scientifi-
-cally deciding how to best design and
operate man-made systems.

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Classifications of Operations Research Models

1. Iconic Models
2. Analog Model
3. Symbolic Model

1. Iconic Model:

This represents the real system by something that looks like what is being represented. Examples are: Photographs, Globes and 3D models etc. An advantage of the iconic model is that it is useful for studying conditions which prevail at a given time. However iconic models are not particularly useful for the study of dynamic situations, or helpful in discovering relationships between the variables in a system.

2. Analog Model:

This is a model that establishes a relationship between a variable in a system and an analogous variable in the model. Examples are graphs, maps, flowcharts and building

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plans. Unlike iconic models analog models are useful for the study of dynamic situations. One disadvantage of the analog model is that it may over simplify the real life system.

3. Symbolic Model:

This is a model that replaces components or variables in a real lify system with symbols, and the systems are generally related mathematically and is therefore often called mathematical models

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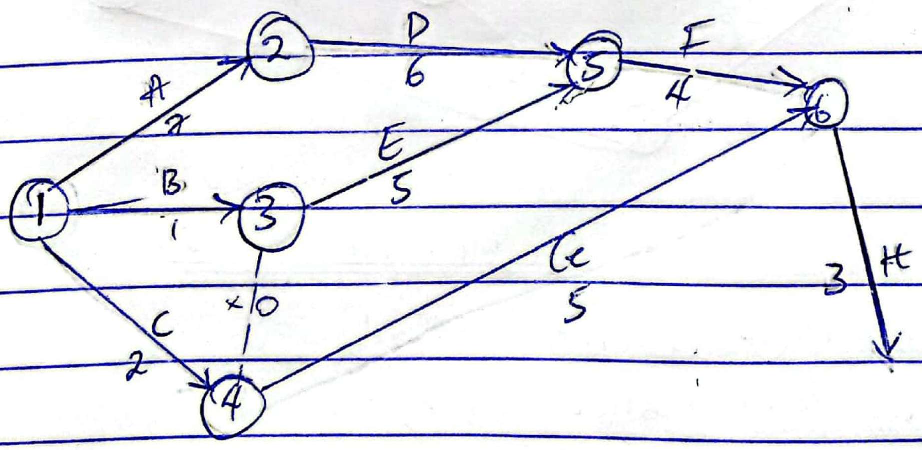
Network Analysis and Project Management

I.D	Activity	Duration (days)	Immediate predecessors
A	Type-set Manuscript	7	None
B	Procure Plates	1	None
C	Procure Papers	2	None
D	Paste and Film	6	A
E	Plate	5	B
F	Run Impression	4	D and E
G	Produce Cover	5	B and C
H	Bind and Trim	3	F and G



Network 1.

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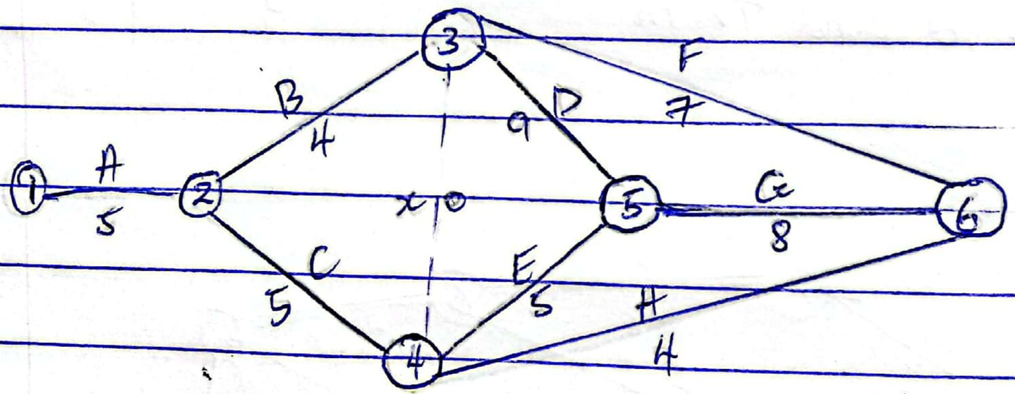
I.D	Activity	Duration (Days)	Immediate Predecessors
A		5	None
B		4	A
C		5	A
D		9	B
E		5	C
F		7	C, B
G		8	D, E
H		4	C



Title: Network2.

Project Management Method

Critical Path Method (CPM):

An activity is said to be critical if a delay in it starts will cause a delay in the completion date of the entire project.

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The time between the earliest start and the latest completion date of a non-critical activity is longer than its actual duration. Hence a non-critical activity is said to have slack or float time. A critical path defines a chain of activities that connect the start and end event of the network. To determine the critical part of a project, we must:

1. Calculate the earliest possible times $T_i(E)$ for each event.
2. Calculate the latest allowable times $T_i(L)$ for each event.
3. Determine the slack times for event i (S_i) as $S_i = T_i(L) - T_i(E)$

The event which has 0 slack times are one the critical paths.

Earliest Time. (Earliest Possible Start time)

The earliest time of an event i denoted by $T_i(E)$ is the earliest time at which event i can occur and is given by:

$$T_j(E) = \underset{i,j}{Max}\{T_i(E) + t_{ij}\}$$

Where t_{ij} are the completion times of job i, j
An i ranges over all nodes to which i, j exist.

Note: 1. The earliest time of the first node (event) is always set to be 0. $T_i(E) = 0$

2 Earliest Time of the Last event in the project network gives the earliest time of completing the project.

The Latest Time (Latest Allowable Start Time)

The latest time of event i denoted by $T_i(L)$ is the latest time at which event i can occur without delaying the completion of the project. To determine the latest time of any event we note the following:

(i) Start with event n, proceed backward through each preceeding event.

(ii) Set the latest allowable time for the last (Terminal) event equal to the earliest possible completion time. i.e $T_n(L) = T_n(E)$.

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(iii) To compute the latest time for any event i $(i < n)$. Consider all activities leading from event i. The latest time is obtained by using

$$T_i(L) = \begin{cases} \min\limits_{j>i} \{T_j(L) - t_{ij}\} & \text{for } 1 < i < n-1 \\ T_n(E) & \text{for } i = n \end{cases}$$

Consider this project network one.
Consider this project network and calculate
(a) The earliest possible time.
(b) The latest possible time.
(c) Critical path

Using Network Diagram Pg. 193

Solution.

(a) Using the formula: $T_j(E) = \max\limits_{i,j} \{T_i(E) + t_{ij}\}$

$T_1(E) = 0$ {will always be 0}

$T_2(E) = T_1(E) + t_{1,2} = 0 + 7 = \underline{7}$

$T_3(E) = T_1(E) + t_{1,3} = 0 + 1 = \underline{1}$

$T_4(E) = \text{Max}(T_1(E) + T_{14},\ T_3(E) + T_{34})$
$= \text{Max}(0 + 2,\ 1 + 0) = 2$

$T_5(E) = \text{Max}(T_2(E) + t_{2,5},\ T_3(E) + t_{3,5})$
$= \text{Max}(7 + 6,\ 1 + 5) = \max(13, 6) = 13$

$T_6(E) = \text{Max}(T_4(E) + t_{4,6},\ T_5(E) + t_{5,6})$
$= \text{Max}(2 + 5,\ 13 + 4) = \max(7, 17) = 17$

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$$T_7(E) = T_6(E) + t_{6,7}$$
$$= 17 + 3 = \underline{\underline{20}}$$

(b) $T_i(L) = \text{Min}\left(T_i(L) - t_{i,j}\right)$

$T_n(L) = T_n(E)$

$\Rightarrow T_7(L) = 20$

$T_6(L) = T_7(L) - t_{6,7} = 20 - 3 = 17$

$T_5(L) = T_6(L) - t_{5,6} = 17 - 4 = 13$

$T_4(L) = T_5(L) - t_{4,5} = 17 - 5 = 12$

$T_3(L) = \text{Min}\left(T_4(L) - t_{3,4},\ T_5(L) - t_{3,5}\right)$

$= \text{Min}(12 - 0,\ 13 - 5) = \text{Min}(12, 8) = 8$

$T_2(L) = T_5(L) - t_{2,5} = 13 - 6 = 7$

$T_1(L) = \text{Min}\left(T_2(L) - t_{1,2},\ T_3(L) - t_{1,3},\ T_4(L) - t_{1,4}\right)$

$= \text{Min}(7 - 7,\ 8 - 1,\ 12 - 2)$

$= \text{Min}(0,\ 7,\ 10)$

$T_1(L) = 0$

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(c)

Events	$T_i(E)$	$T_i(L)$	$S_i = T_i(L) - T_i(E)$	Remark
1	0	0	0	Critical
2	7	7	0	Critical
3	1	8	7	Non-Critical
4	2	12	10	Non-Critical
5	13	13	0	Critical
6	17	17	0	Critical
7	20	20	0	Critical

Critical Path

$= 1 \xrightarrow{A} 2 \xrightarrow{D} 5 \xrightarrow{F} 6 \xrightarrow{H} 7$

What is the total completion time? : A + D + F + H.

Practice Assignments [Part of CA]

1(a) Construct the network diagram

Job	Predecessors	Duration (days)
A	None	4
B	A	8
C	A	8
D	B; C	3
E	A	10

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F	D, E
G	C

(i) Earliest possible time.

(ii) Latest allowable time.

(iii) Critical Path

(iv) Total Completion Time

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