CIVIL ENGINEERING

Construction Practice, Planning and Management

Comprehensive Theory
with Solved Examples *and* Practice Questions

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Elements of a Network

2.1 INTRODUCTION

Network
- Network is the flow of diagram consisting of activities and events connected logically and sequentially.
- Network diagram are of two types:
    (i) Activity-on-Arrow Network (A-O-A)
    (ii) Activity-on-Node Network (A-O-N)
- They are called by various names such as PERT, CPM, UNETICS, LESS, TOPS and SCANS.
- However all these have emerged from the two major network systems viz.:
    1. PERT
    2. CPM

Advantages of network method over bar chart and milestone chart (discussed further):
1. Inter-relationships between activities and events of a project are clearly shown.
2. The project can be treated as an integrated whole with all its sub-activities clearly related with each other. It helps in controlling the project.
3. Network method is useful for very complicated projects having large number of activities.
4. It indicates the time required in between two activities in which rescheduling of a project is possible.
5. Time uncertainty is accounted for and so it is also useful for research and development projects.

2.2 ELEMENTS OF A NETWORK

2.2.1 Event
- An event is either start or completion of an activity.
- Events are significant points in a project which act as control points of the project.
- An event is an instant of time and it does not require time or resources, for its completion.

Following are examples of an event :

1. All parts assembled
2. A budget prepared
3. Construction completed

Following can not be events :

1. Prepare budget   2.   Assemble parts   3.   Excavate trench

*   Events are represented by nodes in a network. It may have any of the following shapes.

(i) Circular   (ii) Square   (iii) Rectangular   (iv) Oval

Fig. Different Shapes for Events

Most commonly adopted shape for events is circular shape.

*   **Tail event or the start event:**

    It marks the beginning of an activity.

    If it is the first event of a project then it is also known or
    "initial as start event".

    It has only outgoing arrow.

    e.g: Event 10 is a tail event. Arrows represent job or activity
    of the project.

Activity A
Activity B
10
Activity C
Tail Event
(C)
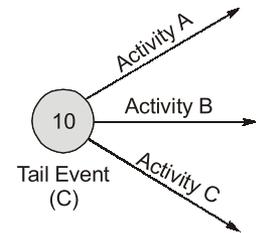
Fig. Tail Event

*   **Head event or the final event :**

    The event which marks the completion of an activity is
    known as "head event".

    If this event represents the completion of entire project
    then it is called as "Finish event".

    It has only incoming arrows.

    e.g.: Event 20 is a head event.

Activity A
Activity B
20
Activity C
Head Event
(C)

Fig. Head Event

NOTE
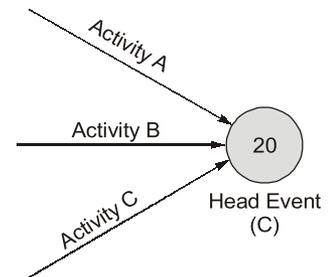
*   When a tail event represents beginning of more than one activity, then the event is
    said to occur when the first activity starts from it.
*   Similarly, when a head event occurs at end of more than one activity, the event is
    said to have occurred only when all the activities leading to it are completed.

*   **Dual role events** : All events except the first and the last event of a project are dual role events.
    They have both incoming as well as outgoing arrows.

1
3
4
5
2
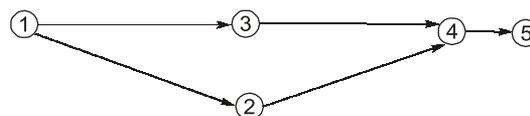
Fig. Dual Role Events

e.g.: Events 2, 3 and 4, are dual role events.

- **Successor events :** The event or events that follow another event are called successor events to that event.
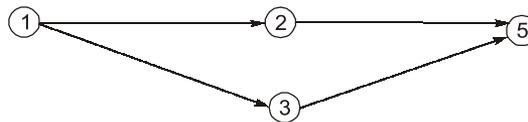
Fig. Successor and Predeassor Events

e.g.: Event 2 and 3 are successor events of event 1.

- **Predecessor events :** The event or events that occur before another event are called predecessor event to that event.

In above figure, events 2, 3 are predecessor to event 5.

> **NOTE:** There can be only one tail event and one head event in a project.

2.2.2 Activity

Activity is the actual performance of a job. It requires time and resources for its completion.

Following are examples of an activity:

1. Excavate trench   2. Mix concrete   3. Prepare budget

> **NOTE** In A-O-A system (Activity On Arrow network system), activity is represented by arrows between events while in A-O-N (Activity On Node system), activities are represented by nodes. In A-O-N system, events have no places.
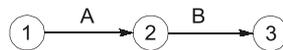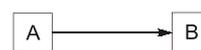
Fig. A-O-A system   **Fig.** A-O-N system

Here *A* & *B* activities are represented in two different systems.

- The activities which can be performed simultaneously and independent of each other are called as **parallel activities**. In above figure, activities *A* & *B* are parallel activities.

- Activity or activities that can be performed after performance of other activity are known as **successor activities** to that activity. Activity *F* is successor activity to activity *C* in the figure shown.

Fig. Parallel and Successor activities

- Similarly activities that are required to be performed before another activity can begin are called predecessor activities to that activity. Activity A is a predecessor activity to activity D.

2.2.3 Dummy

- A dummy is a type of operation which neither requires time nor any resource, but it denotes dependency among the activities.

- It is represented by dashed arrow.
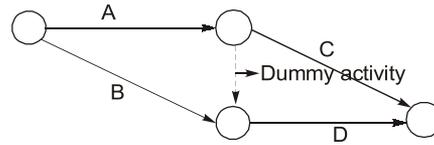
Fig. Dummy Activity

- Dummy is used to serve following purposes:
    1. *Grammatical purpose* : To prevent two arrows having common beginning and common end.
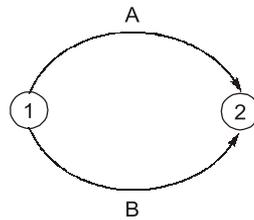

     (a) Ambiguous Representation   (b) Grammatically Clean Representation
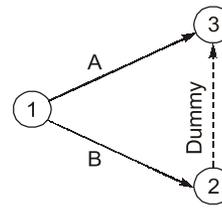
Fig. Grammatical purpose

    2. *Logical purpose* : To show relationship with the other activities.

Here dummy is required to show that activity D can start after the completion of activities A and B both.
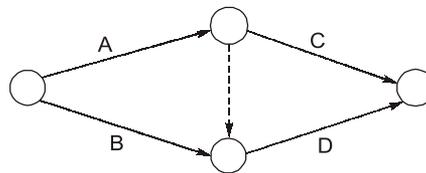
Fig. Logical purpose

- Unnecessary dummies should be avoided.

> **NOTE**
> - Dummies are used to show predecessor relation but if that relation is already established in the network, then that dummy is redundant and has to be removed.
> - If dummy is the only incoming/outgoing arrow to/from a node then it can be removed provided there is no logical or grammatical error.

2.3 RULES OF A NETWORK

1. There can be only one initial and one final event.
2. An event can not occur unless all preceding activities are completed.
3. An event can not occur twice.
4. Number of arrows should be equal to number of activities.
5. Time should always flow from left to right.
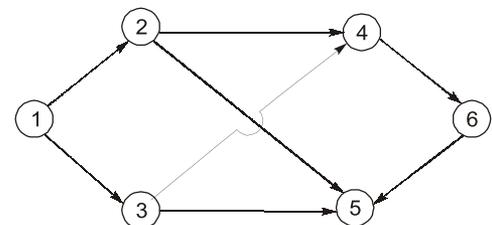
Fig. Network diagram

6. Length of arrow does not show any magnitude. Straight arrows should be taken as far as possible.
7. Arrows should normally not cross each other. If it is necessary to cross, one should be bridged over the other.
8. No activity can start until its tail event has occurred.

2.3.1 Fulkersons's rule for numbering the events

1. The single initial event is numbered as 0, 1, 10 etc.
2. All arrows emerging out of the initial event are neglected. Doing so, the created one or more new initial events are numbered as 2,3,4 or 20, 30, 40 etc.
3. Step - 2 is repeated unless all events are numbered.

2.4 ERRORS IN NETWORK

1. *Looping error* : Loops should not be formed.
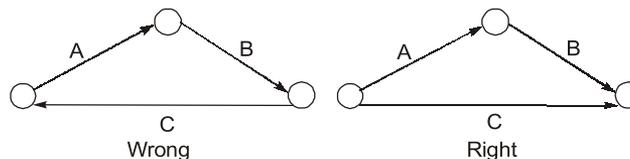
Fig. Looping Error

2. *Dangling error* : Project is complete only when all its activities are complete but the duration of activity 'R' has no effect on the project time as shown in figure. i.e., in a network, there should be only one final event.
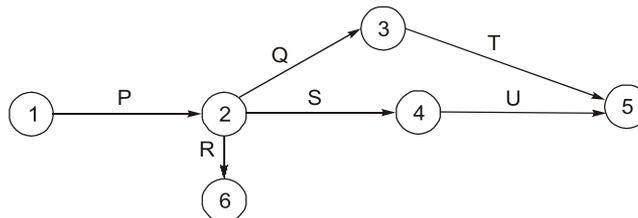
Fig. Dangling Error

To avoid dangling error, the network must be examined in such a manner that all events except initial and final events must have at least one activity entering and one activity leaving them.

3. *Wagon wheel error :* As shown in figure, each of the activities P, Q and R cannot start until all the three activities A, B and C are completed. But in reality, this may not be the situation. There is no error visible in the construction of diagram but logical error has crept into it.
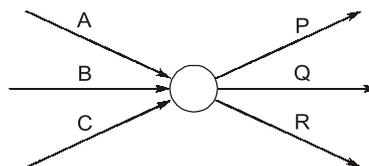
Fig. Wagon Wheel Error

OBJECTIVE BRAIN TEASERS

**Q.1** Consider the following statements:
1. A dummy activity is artificially introduced in a network when necessary.
2. A dummy activity consumes some time.
3. A dummy activity is represented by a dotted arrow.
4. A dummy activity must necessarily be introduced in every network.

Which of the above statements are correct?
(a) 1, 2 and 3   (b) 1 and 3
(c) 2, 3 and 4   (d) 1 and 2

Q.2 Consider the *AOA* diagram as shown below:
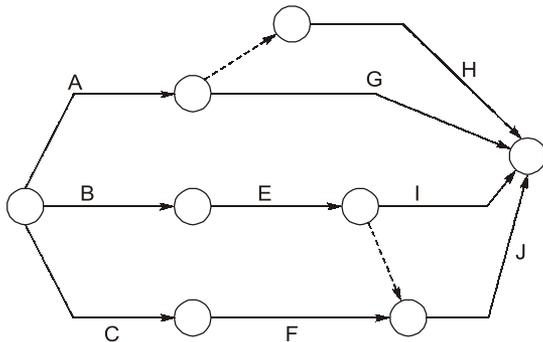
What is the number of dummy links required to convert it into the most concise *AON* diagram?
(a) 8   (b) 7
(c) 6   (d) 5

Q.3 Match **List-I** (Activity type) with **List-II** (Represented by) and select the correct answer:

List-I
A. Artificially introduced
B. Critical
C. Noncritical type
D. Dangler

List-II
1. A single thick arrow
2. A single arrow
3. An arrow emerging from and event and ending into an event which is not finish event and yet no emerging arrow from that event.
4. A dotted arrow

Codes:

	A	B	C	D
(a)	4	1	2	3
(b)	2	3	4	1
(c)	4	3	2	1
(d)	2	1	4	3

Q.4 Activity '*C*' follows activity '*A*' and activity '*D*' follows activities '*A*' and '*B*'. The correct network for the project is
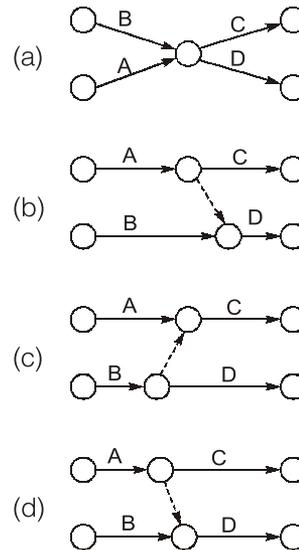
Q.5 Consider the *AON* diagram shown below:
What is the minimum number of dummy arrows required for conversion into *AOA* diagram?
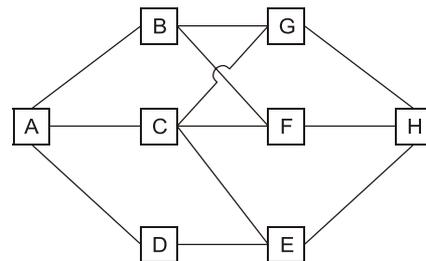


(a) 3   (b) 4
(c) 5   (d) 6

Q.6 Which of the following is the correct sequence to analyze a project for implementation?
(a) Time-cost study, Network, WBS, Scheduling with resource allocation

(b) Network, Time-cost study, Scheduling with resource allocation, WBS

(c) WBS, Network, Scheduling with resource allocation, Time-cost study

(d) WBS, Time-cost study, Network, Scheduling with resource allocation

Q.7 The total number of errors in the given *AOA* network is
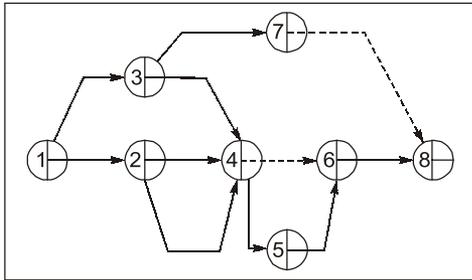
(a) 1   (b) 2

(c) 3   (d) 4

ANSWER KEY

1. (b)   2. (b)   3. (a)   4. (b)   5. (c)
6. (c)   7. (b)

HINTS & EXPLANATIONS

7. **(b)**

There is an extra dummy between events (7) and (8).

There are two arrows joining events (2) and (4).

The correct diagram will be

So there are two errors.

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