# Calculation

# Estimating Activity Duration

Time Interval

- Time Interval is selected according to the nature of the activity (seconds - minutes…)
- It is common practice in construction industry to use calendar day.
- Use one and only one time unit for any schedule.

# Estimating Activity Duration

1. From company's record
2. From standard estimating guide
3. Interviewing field personnel.

# Weather and Contingency Allowance

- Two approaches for assignment of weather allowance:

1. Add the Weather Allowance at the end of the project as a separate activity.
2. Add Weather Allowance to those affected by the weather.
3. Add weather allowance at the end of each construction segment (site preparation, foundation, … etc.)

## Contingency items

- Other activities can be added to allow for contingency such as strikes

## Time Zero

The close of the work period immediately preceding the start of the project.

# Scheduling Computation for Arrow Diagram

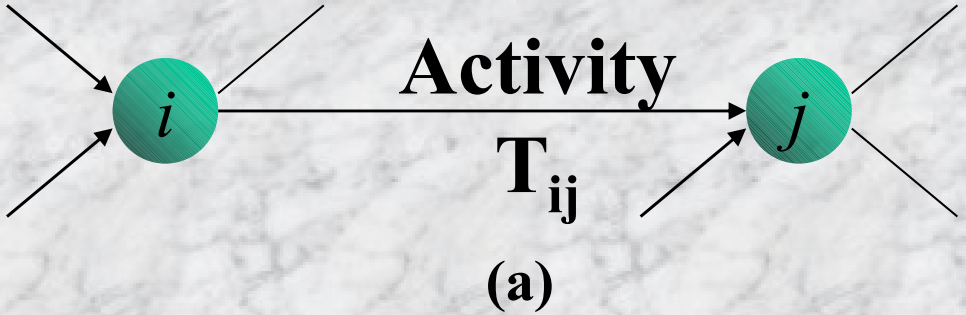
Four time values associated with each activity:

1. ESD Early Start Date
2. EFD Early Finish Date
3. LSD Late Start Date
4. LFD Late Finish Date

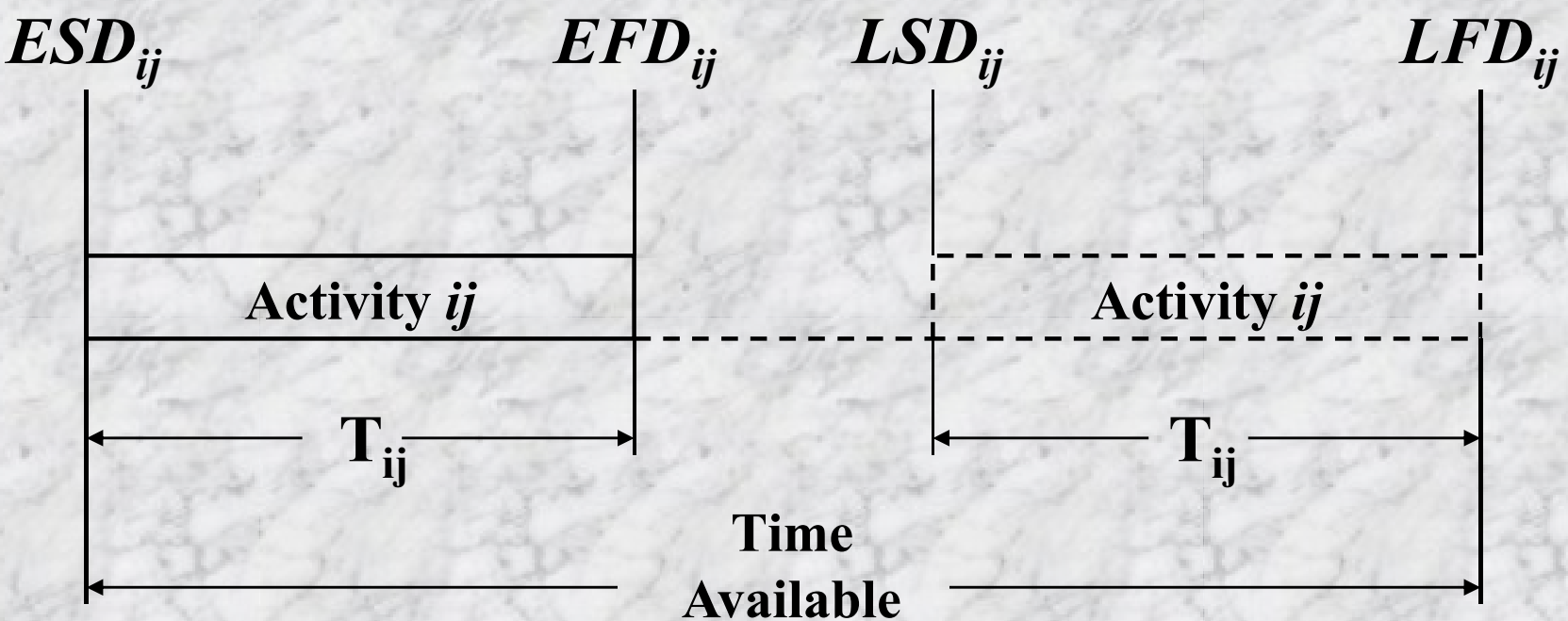
**Early Start Date** for an activity is the earliest point in time that any activity bursting from its beginning node can start.

**Late Finish Date** is the latest point in time that any activity which merges at the activity's ending node can finish.

# The Four Activity Times - Arrow Diagram Notation




(a)




(b)

# Forward Pass Rules

Rule 1

The initial project event is assumed to occur at time zero

Rule 2

All activities are assumed to start as soon as possible, that is , as soon as all the predecessor activities are completed.

Rule 3

The early finish time of an activity is merely the sum of its early start date and the estimated activity duration.

$EFD_{ij} = ESD_{ij} + T_{ij}$

# Forward Pass Rules (cont.)

## Rule 4

The late start date $LSD_{ij}$ is found by subtracting the activity duration $T_{ij}$ from the late finish date $LFD_{ij}$

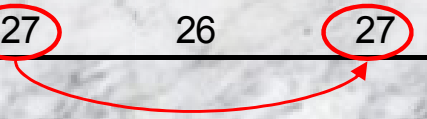
$$LSD_{ij} = LFD_{ij} - T_{ij}$$

*Forward Pass Computations - Remodeling Chemical Laboratory*

| i | j | Activity Description | T (Days) | ESD | EFD |
|---|---|---|---|---|---|
| 2 | 4 | Strip room | 3 | 0 | 3 |
| 2 | 12 | Obtain fume hood | 10 | 0 | 10 |
| 2 | 14 | Obtain cabinet | 10 | 0 | 10 |
| 2 | 20 | Obtain chemical sink | 10 | 0 | 10 |
| 2 | 24 | Painter availability | 20 | 0 | 20 |
| 2 | 28 | Obtain vinyl floor covering | 5 | 0 | 5 |
| 4 | 6 | Rough-in plumbing and electrical | 5 | 3 | 8 |
| 4 | 8 | Replace existing fume duct | 3 | 3 | 6 |
| 6 | 8 | Dummy | 0 | 8 | 8 |
| 6 | 10 | Repair floor | 1 | 8 | 9 |
| 8 | 10 | Repair walls and ceiling | 4 | 8 | 12 |
| 10 | 12 | Dummy | 0 | 12 | 12 |
| 10 | 14 | Dummy | 0 | 12 | 12 |
| 12 | 16 | Install new fume hood | 1 | 12 | 13 |
| 14 | 16 | Dummy | 0 | 12 | 12 |
| 14 | 22 | Install wall cabinets | 5 | 12 | 17 |
| 16 | 18 | Install 1/3 base cabinets | 1 | 13 | 14 |
| 18 | 20 | Dummy | 0 | 14 | 14 |
| 18 | 22 | Install 2/3 base cabinets | 2 | 14 | 16 |
| 20 | 22 | Install chemical sink | 1 | 14 | 15 |
| 22 | 24 | Finish plumbing and electrical | 2 | 17 | 19 |
| 24 | 26 | Dummy | 0 | 20 | 20 |
| 24 | 28 | Paint cabinets | 6 | 20 | 26 |
| 26 | 28 | Paint walls and ceiling | 3 | 20 | 23 |
| 28 | 30 | Lay vinyl floor | 1 | 26 | 27 |

*Forward Pass Computations - Remodeling Chemical Laboratory*

| i | j | Activity Description | T (Days) | ESD | EFD | LSD | LFD |
|---|---|---|---|---|---|---|---|
| 2 | 4 | Strip room | 3 | 0 | 3 | 1 | 4 |
| 2 | 12 | Obtain fume hood | 10 | 0 | 10 | 4 | 14 |
| 2 | 14 | Obtain cabinet | 10 | 0 | 10 | 3 | 13 |
| 2 | 20 | Obtain chemical sink | 10 | 0 | 10 | 7 | 17 |
| 2 | 24 | Painter availability | 20 | 0 | 20 | 0 | 20 |
| 2 | 28 | Obtain vinyl floor covering | 5 | 0 | 5 | 21 | 26 |
| 4 | 6 | Rough-in plumbing and electrical | 5 | 3 | 8 | 4 | 9 |
| 4 | 8 | Replace existing fume duct | 3 | 3 | 6 | 6 | 9 |
| 6 | 8 | Dummy | 0 | 8 | 8 | 9 | 9 |
| 6 | 10 | Repair floor | 1 | 8 | 9 | 12 | 13 |
| 8 | 10 | Repair walls and ceiling | 4 | 8 | 12 | 9 | 13 |
| 10 | 12 | Dummy | 0 | 12 | 12 | 14 | 14 |
| 10 | 14 | Dummy | 0 | 12 | 12 | 13 | 13 |
| 12 | 16 | Install new fume hood | 1 | 12 | 13 | 14 | 15 |
| 14 | 16 | Dummy | 0 | 12 | 12 | 15 | 15 |
| 14 | 22 | Install wall cabinets | 5 | 12 | 17 | 13 | 18 |
| 16 | 18 | Install 1/3 base cabinets | 1 | 13 | 14 | 15 | 16 |
| 18 | 20 | Dummy | 0 | 14 | 14 | 17 | 17 |
| 18 | 22 | Install 2/3 base cabinets | 2 | 14 | 16 | 16 | 18 |
| 20 | 22 | Install chemical sink | 1 | 14 | 15 | 17 | 18 |
| 22 | 24 | Finish plumbing and electrical | 2 | 17 | 19 | 18 | 20 |
| 24 | 26 | Dummy | 0 | 20 | 20 | 23 | 23 |
| 24 | 28 | Paint cabinets | 6 | 20 | 26 | 20 | 26 |
| 26 | 28 | Paint walls and ceiling | 3 | 20 | 23 | 23 | 26 |
| 28 | 30 | Lay vinyl floor | 1 | 26 | 27 | 26 | 27 |



# 1. Total Float

- Total float may be defined as that time span in which the completion of an activity may occur and not delay the termination of the project.

$$TF_{ij} = LFD_{ij} - EFD_{ij}$$
$$= LSD_{ij} - ESD_{ij}$$

# 2. Free Float

- Free float may be defined as the time span in which the completion of an activity may occur and not delay the finish of the project nor delay the start of any following activity.

$$FF_{ij} = ESD_{jk} - EFD_{ij}$$

# 3. Interfering Float

- That part of the total float which remains after free float has been deducted is the interfering float.
- It may be defined as: the time span in which the completion of an activity may occur and not delay the termination of the project but within which completion will delay the start of some other following activity.

$$INTF_{ij} = TF_{ij} - FF_{ij}$$

# 4. Independent Float

- The fourth float, independent float, is the amount of scheduling leeway of an activity that is independent of the early starts and late finishes of any other activity. It may be formally defined as:

  The time span in which the completion of an activity may occur and not delay the termination of the project, not delay the start of any following activity, and not be delayed by any preceding activity.

*Forward Pass Computations - Remodeling Chemical Laboratory*

| i | j | Activity Description | T (Days) | ESD | EFD | LSD | LFD | TF | FF | INTF | INDF |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | 4 | Strip room | 3 | 0 | 3 | 1 | 4 | 1 | 0 | 1 | - |
| 2 | 12 | Obtain fume hood | 10 | 0 | 10 | 4 | 14 | 4 | 2 | 2 | 2 |
| 2 | 14 | Obtain cabinet | 10 | 0 | 10 | 3 | 13 | 3 | 2 | 1 | 2 |
| 2 | 20 | Obtain chemical sink | 10 | 0 | 10 | 7 | 17 | 7 | 4 | 3 | 4 |
| 2 | 24 | Painter availability | 20 | 0 | 20 | 0 | 20 | 0 | - | - | - |
| 2 | 28 | Obtain vinyl floor covering | 5 | 0 | 5 | 21 | 26 | 21 | 21 | 0 | 21 |
| 4 | 6 | Rough-in plumbing and electrical | 5 | 3 | 8 | 4 | 9 | 1 | 0 | 1 | - |
| 4 | 8 | Replace existing fume duct | 3 | 3 | 6 | 6 | 9 | 3 | 2 | 1 | 1 |
| 6 | 8 | Dummy | 0 | 8 | 8 | 9 | 9 | 1 | 0 | 1 | - |
| 6 | 10 | Repair floor | 1 | 8 | 9 | 12 | 13 | 4 | 3 | 1 | 2 |
| 8 | 10 | Repair walls and ceiling | 4 | 8 | 12 | 9 | 13 | 1 | 0 | 1 | - |
| 10 | 12 | Dummy | 0 | 12 | 12 | 14 | 14 | 2 | 0 | 2 | - |
| 10 | 14 | Dummy | 0 | 12 | 12 | 13 | 13 | 1 | 0 | 1 | - |
| 12 | 16 | Install new fume hood | 1 | 12 | 13 | 14 | 15 | 2 | 0 | 2 | - |
| 14 | 16 | Dummy | 0 | 12 | 12 | 15 | 15 | 3 | 1 | 2 | 0 |
| 14 | 22 | Install wall cabinets | 5 | 12 | 17 | 13 | 18 | 1 | 0 | 1 | - |
| 16 | 18 | Install 1/3 base cabinets | 1 | 13 | 14 | 15 | 16 | 2 | 0 | 2 | - |
| 18 | 20 | Dummy | 0 | 14 | 14 | 17 | 17 | 3 | 0 | 3 | - |
| 18 | 22 | Install 2/3 base cabinets | 2 | 14 | 16 | 16 | 18 | 2 | 1 | 1 | 0 |
| 20 | 22 | Install chemical sink | 1 | 14 | 15 | 17 | 18 | 3 | 2 | 1 | 0 |
| 22 | 24 | Finish plumbing and electrical | 2 | 17 | 19 | 18 | 20 | 1 | 1 | 0 | 0 |
| 24 | 26 | Dummy | 0 | 20 | 20 | 23 | 23 | 3 | 0 | 3 | - |
| 24 | 28 | Paint cabinets | 6 | 20 | 26 | 20 | 26 | 0 | - | - | - |
| 26 | 28 | Paint walls and ceiling | 3 | 20 | 23 | 23 | 26 | 3 | 3 | 0 | 3 |
| 28 | 30 | Lay vinyl floor | 1 | 26 | 27 | 26 | 27 | 0 | - | - | - |

# Critical Path Computations on the Network

# The Two Event Approach

- Early Start Event

  In the forward pass, the maximum of the EFD values for all activities merging at a node is taken as ESD value for all the activities that burst from the same node.

  $TE_j = Max_{\forall I} (TE_i + T_{ij})$

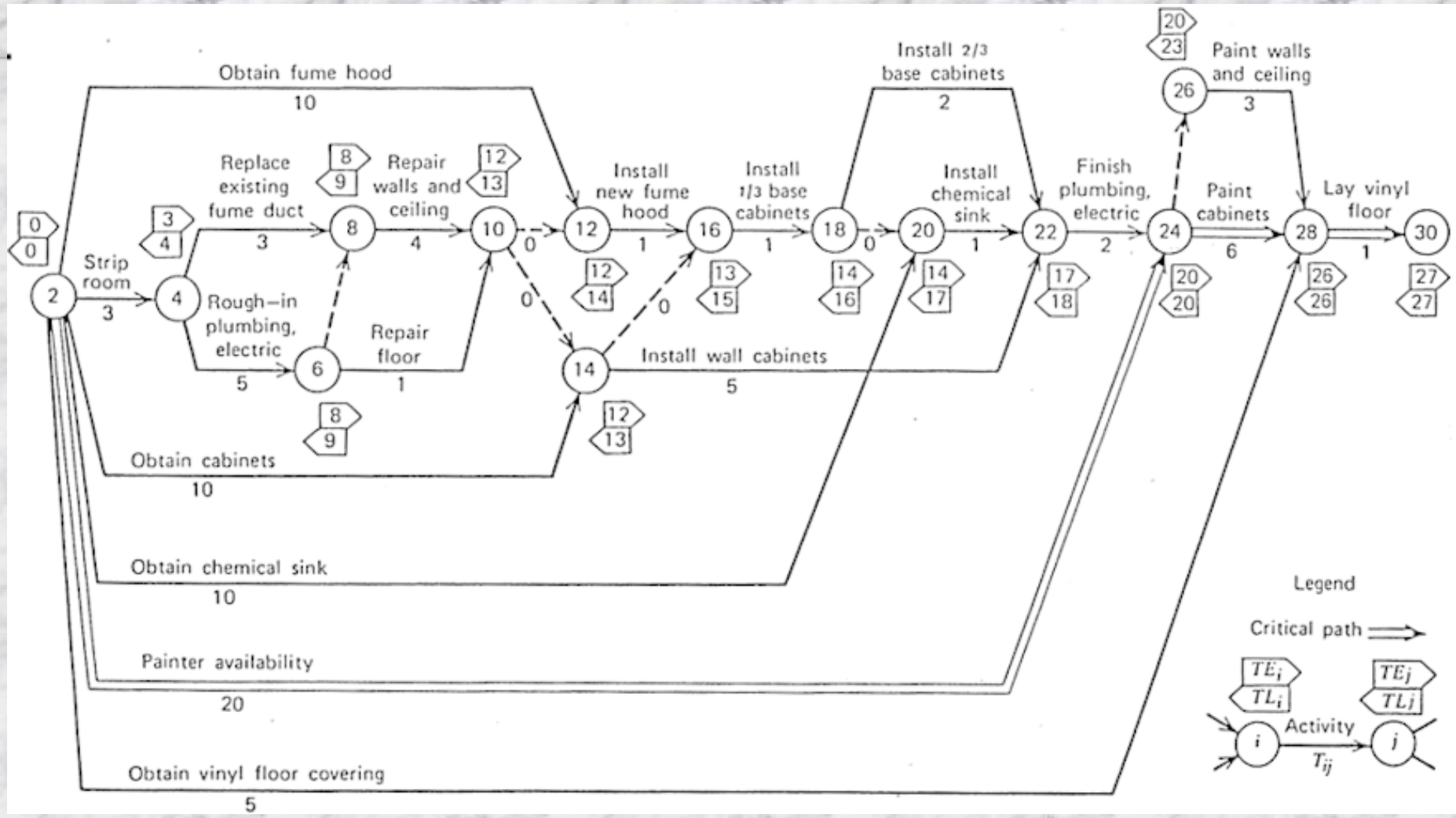
- For all activities entering node j, $TE_j$ is taken as the greatest sum of all activities merge to the node

## Late Finish Event

- In the backward computations, the minimum of LSD valves is taken as the latest finish time for all activities that enter the node.

$TL_j = Min_{\forall I} (TL_i + T_{ij})$

- Start by the last activity, the TL for the next earlier node is taken as the minimum value of the late time event minus activity duration.


Obtain fume hood
10
Replace existing fume duct
3
Repair walls and ceiling
4
Install new fume hood
1
Install 1/3 base cabinets
1
Install 2/3 base cabinets
2
Install chemical sink
1
Finish plumbing, electric
2
Paint walls and ceiling
3
Paint cabinets
6
Lay vinyl floor
1
Strip room
3
Rough–in plumbing, electric
5
Repair floor
1
Install wall cabinets
5
Obtain cabinets
10
Obtain chemical sink
10
Painter availability
20
Obtain vinyl floor covering
5
0
0
3
4
8
9
12
13
12
14
13
15
14
16
14
17
17
18
20
20
26
26
27
27
Legend
Critical path
$TE_i$
$TL_i$
$TE_j$
$TL_j$
Activity
$T_{ij}$
i
j

# Float Calculations From Event Times

**Total Float**

$TF_{ij} = TL_j - TE_i - T_{ij}$

Example

$TF_{2\text{-}20} = TL_{20} - TE_2 - T_{2\text{-}20}$

$= 17 - 0 - 10 = 7$

## Free Float

$FF_{ij} = TE_j - TE_i - T_{ij}$

Example

$FF_{2\text{-}20} = TE_{20} - TE_2 - T_{2\text{-}20}$

$= 14 - 0 - 10 = 4$

## Interfering Float

$INTF_{ij} = TL_j - TE_j$

Example

$INTF_{2-20} = TL_{20} - TE_{20}$

$= 17 - 14 = 3$

## Independent Float

$INDF_{ij} = TE_j - TL_i - T_{ij}$

Example

$INDF_{2-20} = TE_{20} - TL_2 - T_{2-20}$

$= 14 - 0 - 10 = 4$