# Linear Scheduling Method

# OUTLINE

- Review Lecture 8
- Introduction
- Definition
- Characteristics
- Advantages of LSM
- Implementation of LSM
- Elements of the LSM
- Time
- Exercise

# Review Lecture 8

# Introduction

Scheduling methods also differ depending on the type of project they are serving.

- Bar charts are generally good for small, simple projects.
- CPM networks are used for medium-size to large projects that consist of large numbers of small activities.
- LSM is used to plan or record progress on multiple activities that are moving continuously in sequence

# Linear Scheduling Method

## Definition

A simple diagram to show location and time at which a certain crew will be working on a given operation.

# Characteristics

- Shows repetitive nature of the construction.
- Progression of work can be seen easily.
- Sequence of different work activities can be easily understood .
- Have fairly high level of detail.
- Can be developed and prepared in a shorter time period than other formats.

# Advantages of LSM

- Provides more information concerning the planned method of const. than a bar chart.
- In certain types of projects, LSM offers some advantages over the network approach.

# Implementation of LSM

1. Can be used to continuous activities rather than discrete activities.
2. Transportation projects; highway const., highway resurfacing and maintenance, airport runway const. and resurfacing, tunnels, mass transit systems, pipelines, railroads.
3. High-rise building construction
4. Repetitive building units

# Elements of the LSM

- ✓ Axis Parameters
- ✓ Location
- ✓ Measure of progress.
- ✓ In high-rises and housing const., measures may be stories, floors, subdivisions, apartments, housing units
- ✓ In Transportation projects, distance (ft. or mile can be used.

# Time

- Hours, days, week, or month - depends on the total project time and level of detail desired in the schedule.
- Preferable to prepare the schedule based on working days and convert to calendar days only at the end.

# Example

a project to lay down 5,000 linear feet (LF) of an underground utility pipe. The basic activities are:

1. Excavation,
2. Prepare Sub-base,
3. Lay Pipe,
4. Backfill, and
5. Compact

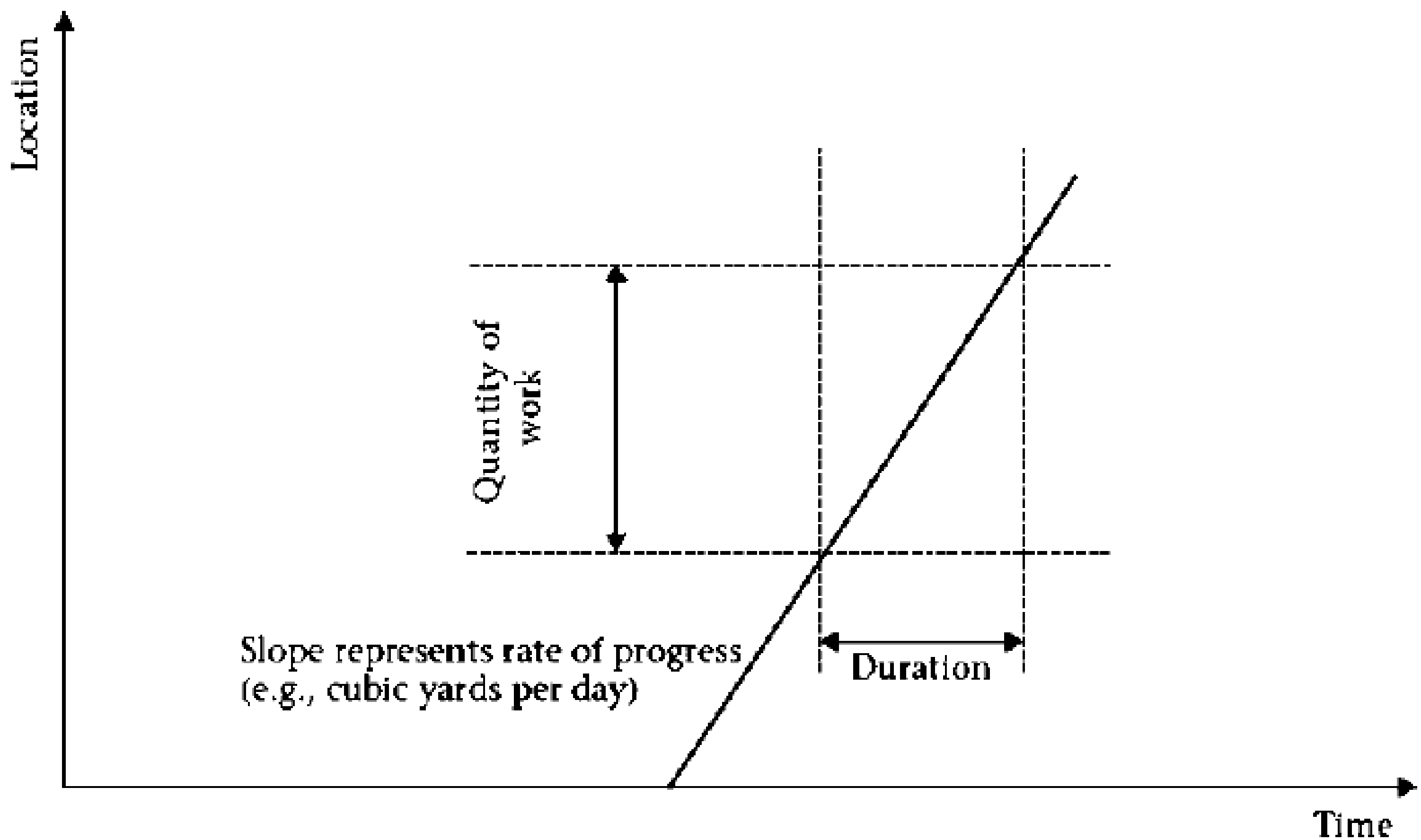
If we are to use CPM networks for this project, we can take one of the following two approaches:

1. Create a project with only five large activities. Connect these activities with start-to-start (with lags) and finish-to-finish relationships.
2. Divide each major activity into a number of activities (e.g., 50 sub activities) in which each represents a distance of 100 LF and connect them with finish-to start relationships with no lags.

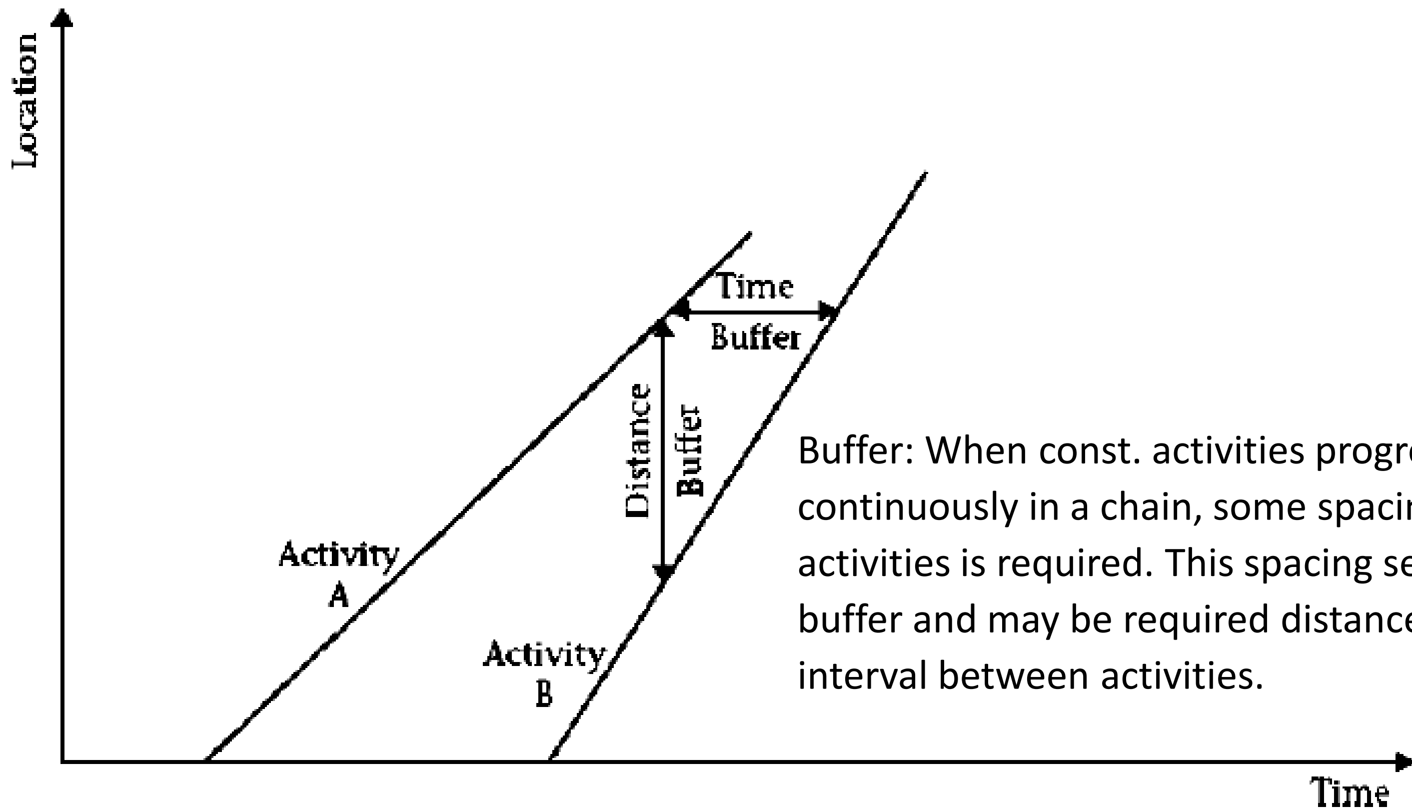
Three simple steps (similar to the first three steps in the CPM discussed in lecture 5) are necessary to build a schedule by using the LSM:

1. Determine the work activities. As mentioned previously, we expect only a few activities in LSM schedules.
2. Estimate activity production rates. Such estimation is similar to determining durations. We still estimate durations, but we are more concerned with production rates.
3. Develop an activity sequence, similar to determining logical relationships. All relationships are start to start (with lags) with finish to finish. Before applying the LSM, we must make sure it is the most appropriate method.

In the LSM, the x-axis represents time and the y-axis represents distance, the slope represents the ‘‘speed,’’ or rate, of production (Figure below).



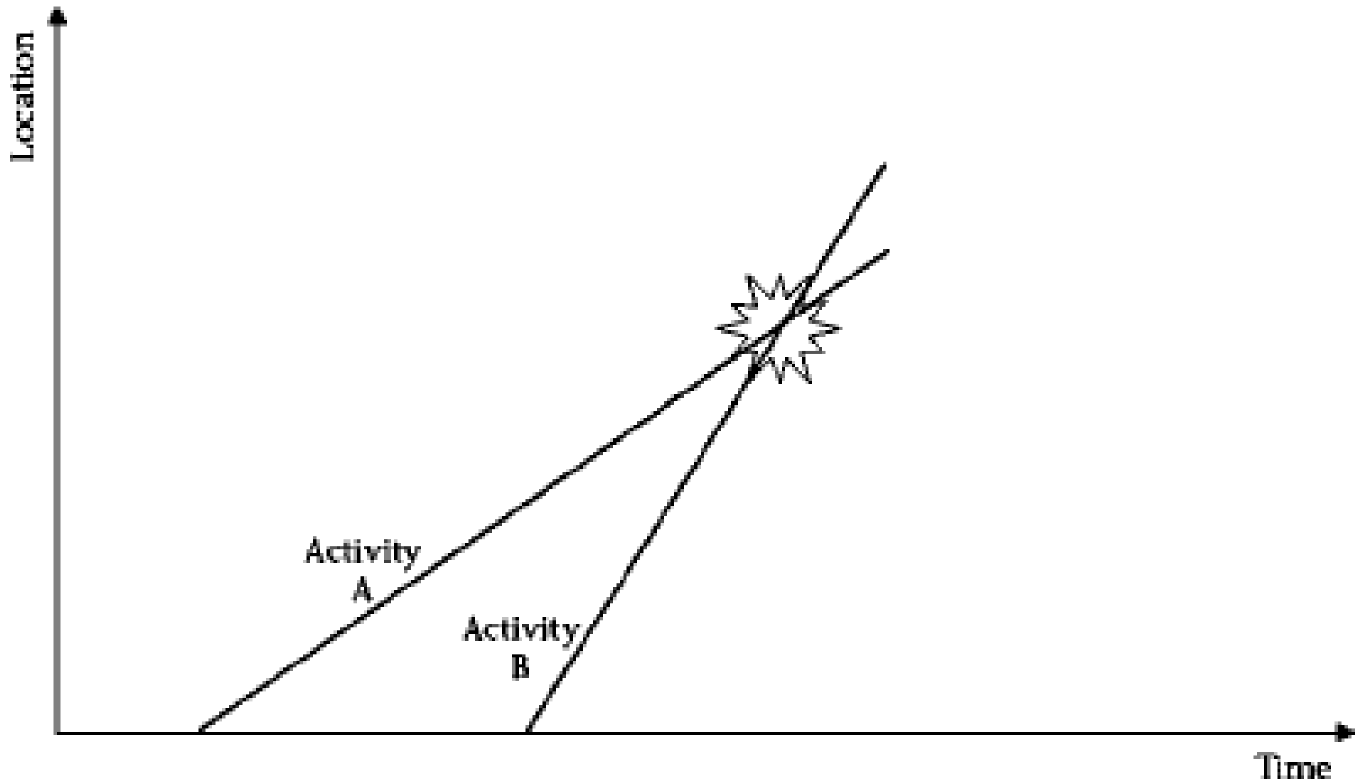
- When we have two or more activities, the production rate will differ from one to another.
- The horizontal distance between two lines represents the float of the earlier activity. In the LSM, we call it the time buffer. The vertical distance represents the distance separating the two operations. We call it the distance buffer. See Figure below




Buffer: When const. activities progress continuously in a chain, some spacing between activities is required. This spacing serves as a buffer and may be required distance or time interval between activities.

**11.14 Time and distance buffers in the LSM**

Lines are not allowed to intersect because an intersection literally means that the successor has gotten ahead of the predecessor, which is impossible (see Figure 11.15).




**11.15 A successor's getting ahead of its predecessor: an illegal relationship**

# example

- a carpentry crew installing and taping drywall for a total of 10,000 square feet (SF).
- The production rate for the crew is 500 SF per day for installation and taping.
- The painting crew is directly behind at a production rate of 800 SF per day.
- Assume that the painting crew starts on day 2 (1 day after the carpentry crew started).
  - Then, at the end of day 3, the carpentry crew would have finished 500 x3 = 1,500 SF,
  - but the painting crew would have finished 800 x2 = 1,600 SF

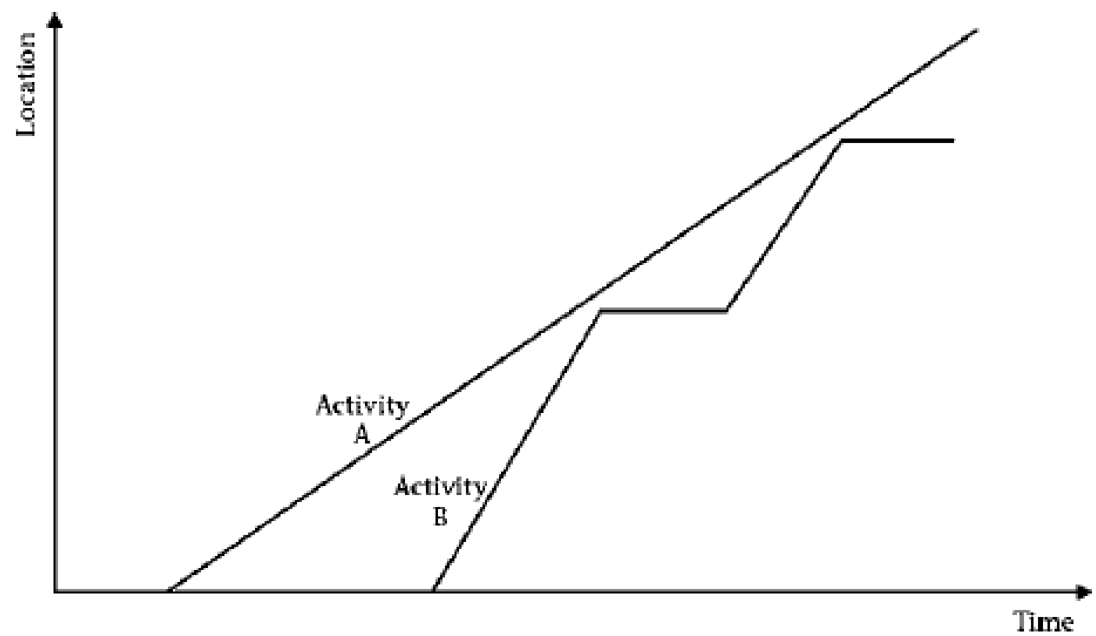
**WHICH IS IMPOSSIBLE**.

There are four solutions for this problem:

1. Speed up the rate of the carpentry crew
2. Slow the rate of the painting crew
3. Make the painting crew start later (calculate the time buffer)
4. Make the painting crew work in intervals: once they catch up with the carpentry team, they stop for a period, resume, and so on

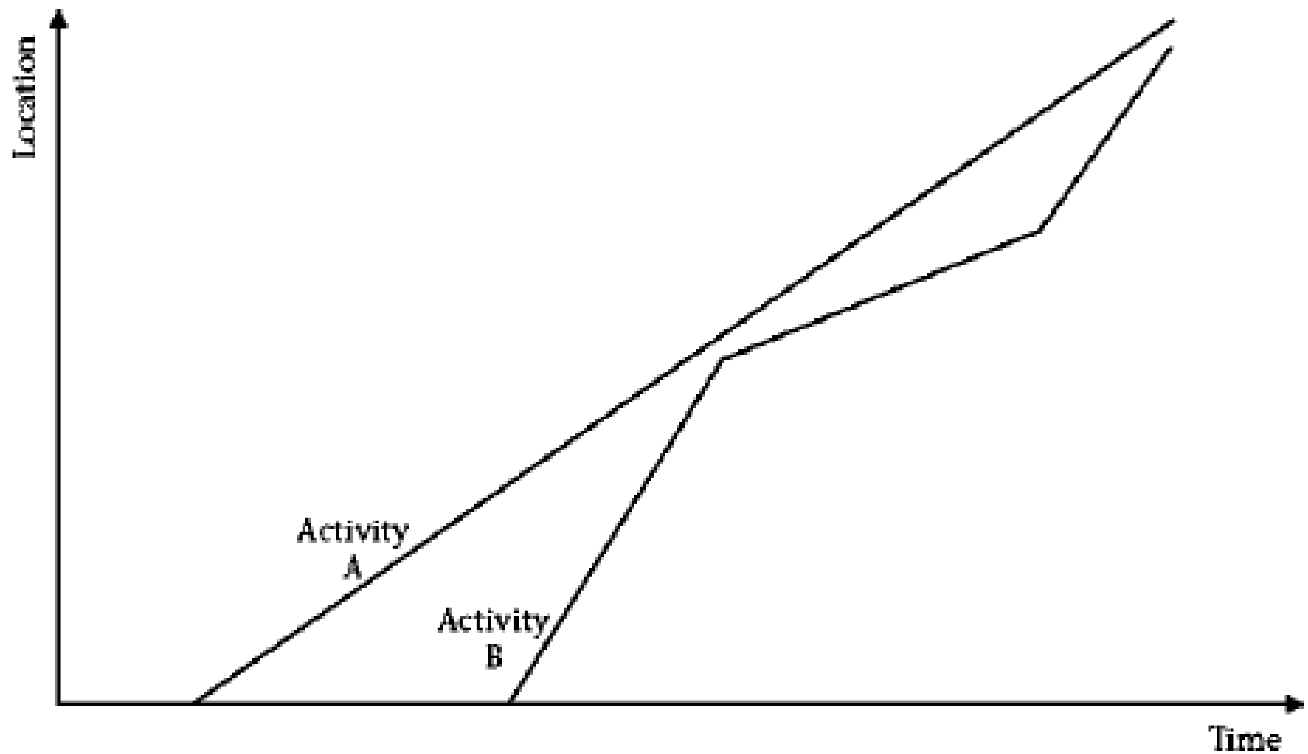
- Solution 1 would increase the slope of activity A. (Speed up the rate of the carpentry crew)
- Solution 2 would decrease the slope of activity B. (Slow the rate of the painting crew)
- Solution 3 would increase the time buffer. All three solutions aim at preventing the intersection of the two lines.
- Solution 4 would be represented in an LSM diagram as shown in Figure 11.16. (Make the painting crew work in intervals: once they catch up with the carpentry team, they stop for a period, resume, and so on)

The horizontal lines (slope =0) represent an interruption or stoppage time (no production). If the productivity of the crew changes, the slope changes too.



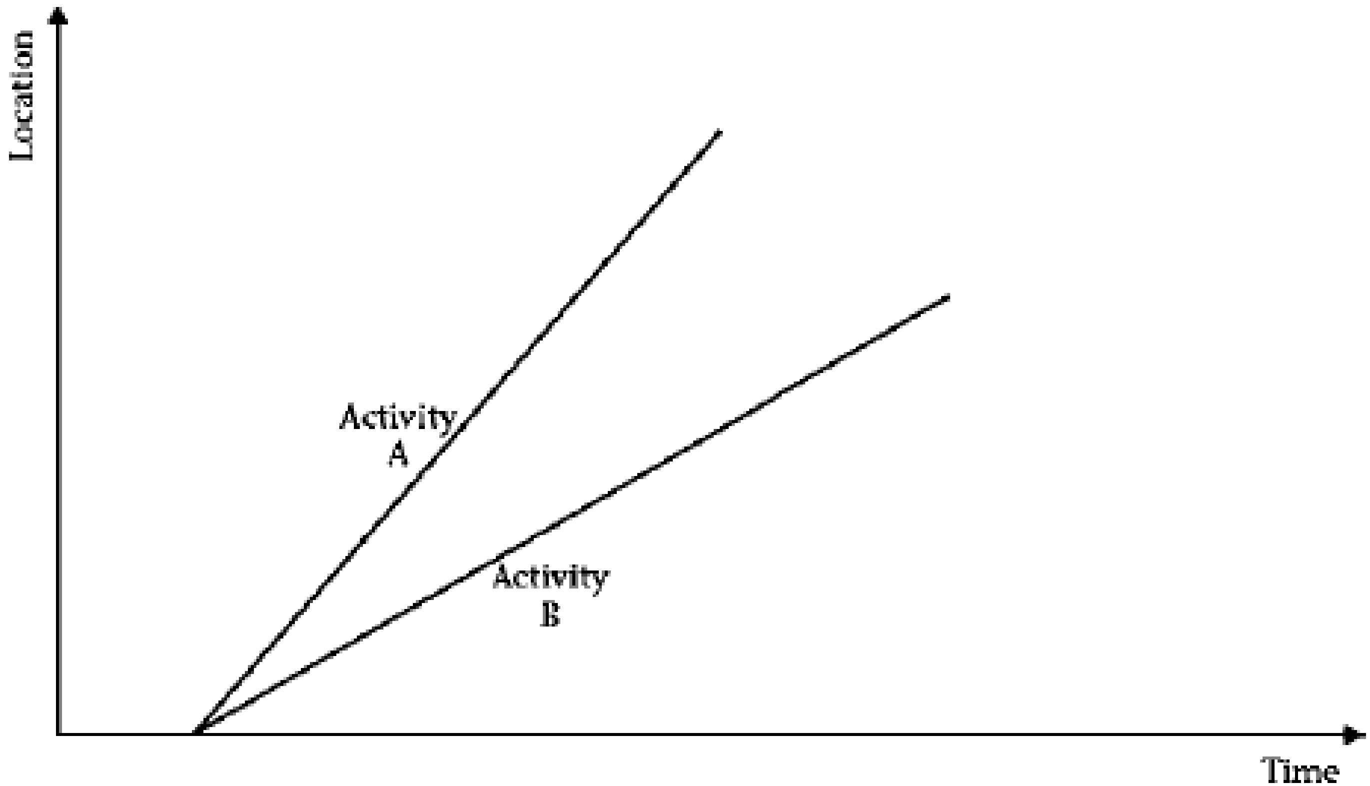

**11.16 Solution 4 for avoiding an intersection in the LSM**

Therefore, alternatively, instead of completely halting activity B during intervals, we can reduce the crew size to slow the rate until there is a safe time buffer (a combination of solutions 2 and 4; see Figure 11.17).



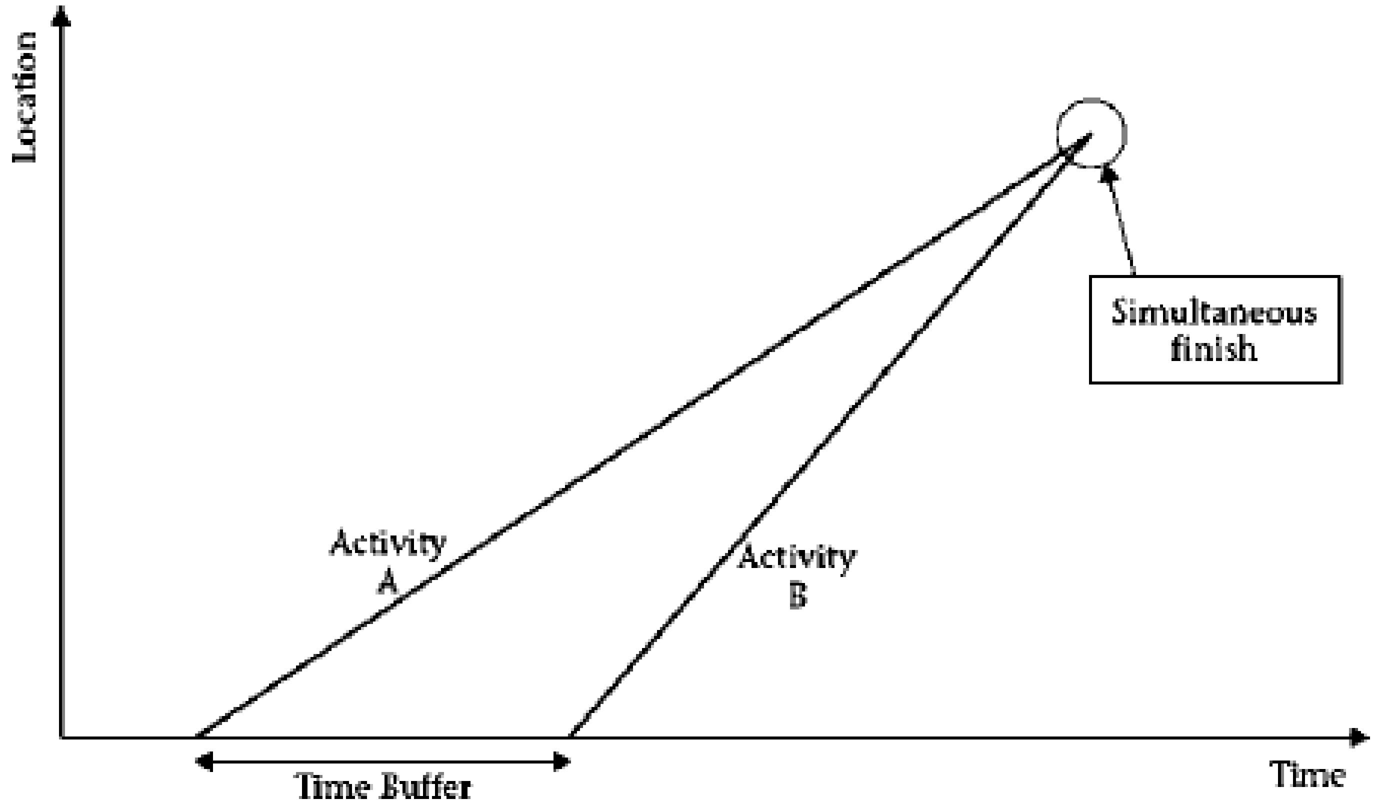

**11.17 Combination of solutions 2 and 4 for avoiding an intersection in the LSM**

Naturally, the successor (activity B) will finish after the predecessor (activity A). See Figure 11.18.




**11.18 Rate of successor slower than rate of predecessor in the LSM**

- To calculate the time buffer (Figure 11.19), we **START FROM THE END**: Allow activities A and B to finish simultaneously.
- Then, Duration A = Duration B + Time buffer
- Or Time buffer = Duration A  - Duration B




**11.19 Time buffer calculation in the LSM**

## Example 11.4

A project consists of five activities:

A. Excavating a trench

B. Laying a sub-base of gravel

C. Laying a concrete pipe

D. Backfilling

E. Compacting

Assume that the length of the pipe is 1,000 LF and that the productivity rates for the five activities are 100, 125, 75, 200, and 150 LF per day, respectively. Draw the project diagram, using the LSM. Leave a minimum 1-day time buffer.

Solution

- First, determine the durations by dividing the total quantity, 1,000 LF, by the production rate for each activity. The following durations result: 10, 8, 14, 5, and 7 days for activities A through E.
- If we start activity A on (end of) day 0, it will finish on day 10.
- Activity B lasts only 8 days and we must leave at least a 1-day time buffer so that we can finish this activity on day 11. Subtracting its duration of 8 days, we find the starting point: day 3.
- Activity C lasts 14 days, so we lag it by 1 day and start it on day 4. It will finish on day 18.
- Activity D can finish no earlier than day 19. It will start on day 14.
- Finally, activity E can start on day 15 and finish on day 22.

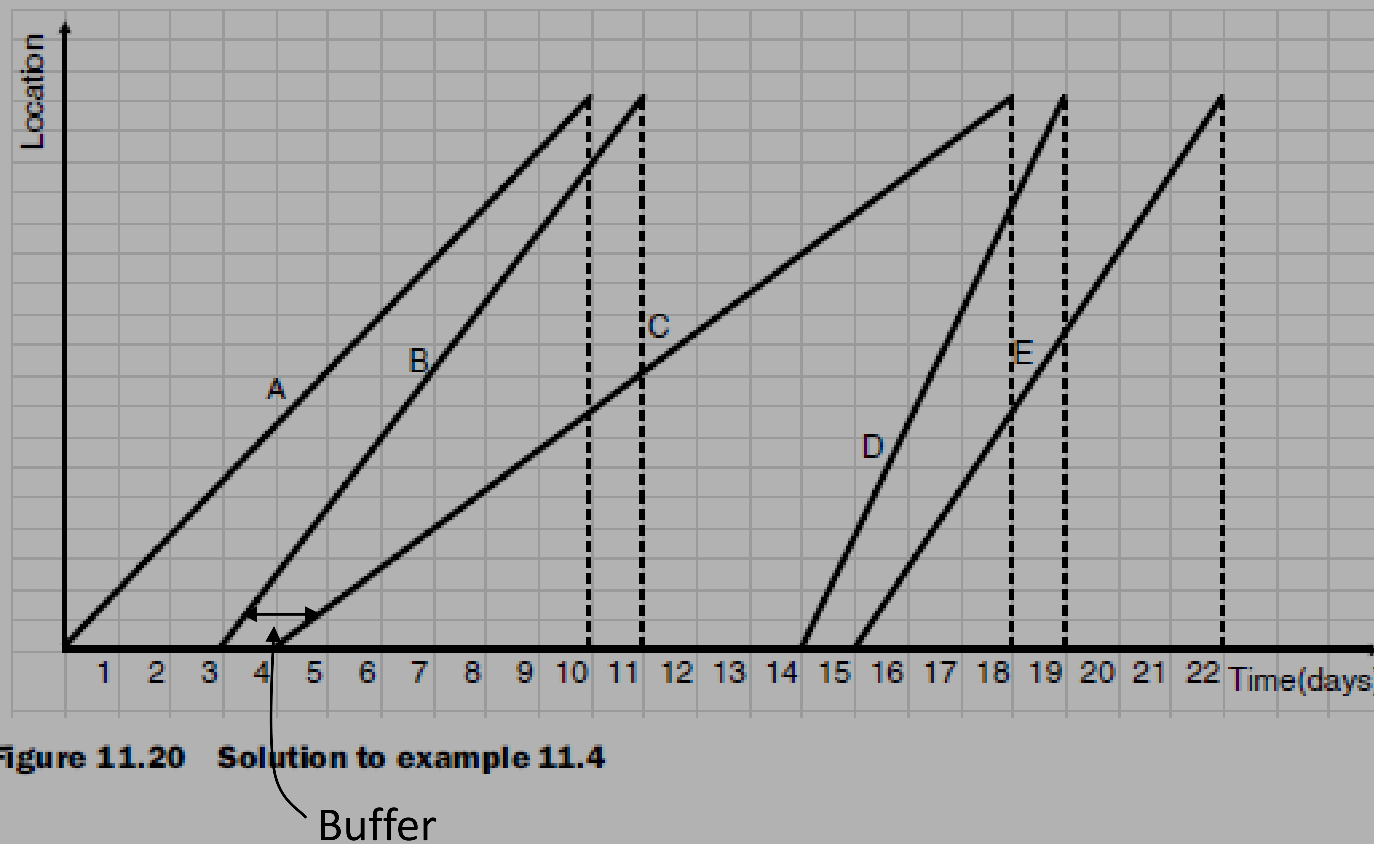



**Figure 11.20 Solution to example 11.4**

# Exercise

Draw an LSM schedule for a 5-mile stretch of a road project. Consider the following activities:

| Activity | Daily production (LF) |
|---|---|
| A. Excavation | 500 |
| B. Subbase | 300 |
| C. Base | 240 |
| D. Paving | 1,000 |
| E. Striping and Signage | 1,500 |