PERT CPM EXAMPLE PROBLEMS WITH SOLUTION

Pert CPM Example Problems with Solution: Mastering Project Scheduling Techniques

PERT CPM EXAMPLE PROBLEMS WITH SOLUTION are essential learning tools for anyone involved in project management or studying project scheduling techniques. Understanding how to apply Program Evaluation Review Technique (PERT) and Critical Path Method (CPM) through practical problems can significantly enhance your ability to plan, analyze, and control complex projects. These methods help identify the most efficient path to complete a project, estimate durations accurately, and manage resources effectively.

In this article, we'll explore several example problems involving PERT and CPM, walk through their solutions step-by-step, and shed light on key concepts that will deepen your understanding. Whether you're a student, a project manager, or simply curious about project scheduling, these real-world examples will clarify how PERT and CPM work in harmony to optimize project outcomes.

Understanding the Basics: PERT and CPM Explained

Before diving into example problems, it's important to grasp what PERT and CPM are and how they differ yet complement each other.

PERT (Program Evaluation Review Technique) is a statistical tool used to analyze and represent the tasks involved in completing a given project. It focuses on estimating the time required to complete each task when there is uncertainty. PERT uses three time estimates for each activity: optimistic, most likely, and pessimistic.

CPM (Critical Path Method), on the other hand, is a deterministic technique that assumes known activity durations. It identifies the longest sequence of activities (the critical path) that determines the minimum completion time for the project. CPM helps in resource allocation and scheduling.

By combining PERT's probabilistic approach with CPM's scheduling prowess, project managers can better anticipate delays and optimize timelines.

Example Problem 1: Simple PERT Analysis with Solution

Let's start with a straightforward PERT example to understand how to calculate expected time and variance for an activity.

Problem Statement

A project consists of an activity with the following time estimates:

- Optimistic time (O) = 3 days
- Most likely time (M) = 5 days
- Pessimistic time (P) = 9 days

Calculate the expected time (TE) and variance (σ^2) of the activity.

Solution

PERT uses the formula to calculate expected time:

$$
TE = \frac{O + 4M + P}{6}
$$

Plugging in the values:

$$
TE = \frac{3 + 4(5) + 9}{6} = \frac{3 + 20 + 9}{6} = \frac{32}{6} = 5.33 \text{ days}
$$

Next, calculate the variance, which measures the uncertainty:

$$
\sigma^2 = \left(\frac{P - O}{6}\right)^2 = \left(\frac{9 - 3}{6}\right)^2 = \left(\frac{6}{6}\right)^2 = 1^2 = 1
$$

So, the expected duration is approximately 5.33 days, with a variance of 1 day². This means the actual duration might vary, but on average, it should be about 5.33 days.

Example Problem 2: CPM Network Diagram and Critical Path

Now, let's look at a CPM problem where we identify the critical path.

Problem Statement

Consider a project with the following activities and durations (in days):

Activity	Predecessor	Duration (days)
A	-	3
B	A	4
C	A	2
D	B	5
E	C	6
F	D, E	2

Draw the network diagram, calculate the earliest start (ES), earliest finish (EF), latest start (LS), latest finish (LF) for each activity, and determine the critical path.

Solution

Step 1: Draw the Network Diagram

- Activity A starts first.
- B and C depend on A.
- D depends on B.
- E depends on C.
- F depends on both D and E.

Step 2: Forward Pass (Calculate ES and EF)

- A: ES=0, EF=ES + duration = 0 + 3 = 3

- B: ES = EF of A = 3, EF = 3 + 4 = 7
- C: ES = EF of A = 3, EF = 3 + 2 = 5
- D: ES = EF of B = 7, EF = 7 + 5 = 12
- E: ES = EF of C = 5, EF = 5 + 6 = 11
- F: ES = max(EF of D, EF of E) = max(12, 11) = 12, EF = 12 + 2 = 14

Step 3: Backward Pass (Calculate LF and LS)

Start with the last activity:

- F: LF = EF = 14, LS = LF - duration = 14 - 2 = 12
- D: LF = LS of F = 12, LS = 12 - 5 = 7
- E: LF = LS of F = 12, LS = 12 - 6 = 6
- B: LF = LS of D = 7, LS = 7 - 4 = 3
- C: LF = LS of E = 6, LS = 6 - 2 = 4
- A: LF = min(LS of B, LS of C) = min(3, 4) = 3, LS = 3 - 3 = 0

Step 4: Calculate Slack and Identify Critical Path

- Slack = LS - ES (or LF - EF)

Activity	ES	EF	LS	LF	Slack
A	0	3	0	3	0
B	3	7	3	7	0
C	3	5	4	6	1
D	7	12	7	12	0
E	5	11	6	12	1
F	12	14	12	14	0

Activities with zero slack form the critical path: A → B → D → F.

Project Duration: 14 days.

This example highlights how CPM helps identify the critical sequence of activities that determine the project duration.

Combining PERT and CPM: A Realistic Project Example

In many projects, durations are uncertain. Here, PERT helps estimate times, and CPM helps identify the critical path based on those estimates.

Problem Statement

A project has the following activities with three-time estimates (in days):

Activity	Predecessor	Optimistic (O)	Most Likely (M)	Pessimistic (P)
A	-	2	4	6
B	A	3	5	9
C	A	1	2	3
D	B	4	6	8
E	C	3	4	5
F	D, E	2	3	4

Calculate expected times, build the network, determine the critical path, and find the expected project duration.

Solution

Step 1: Calculate Expected Times (TE) Using PERT Formula

$$
TE = \frac{O + 4M + P}{6}
$$

Activity	Calculation	TE (days)
A	(2 + 4×4 + 6)/6 = (2+16+6)/6	4
B	(3 + 4×5 + 9)/6 = (3+20+9)/6	5.33
C	(1 + 4×2 + 3)/6 = (1+8+3)/6	2
D	(4 + 4×6 + 8)/6 = (4+24+8)/6	6
E	(3 + 4×4 + 5)/6 = (3+16+5)/6	4
F	(2 + 4×3 + 4)/6 = (2+12+4)/6	3

Step 2: Build Network and Calculate ES and EF (Forward Pass)

- A: ES=0, EF=0+4=4
- B: ES=EF of A=4, EF=4+5.33=9.33
- C: ES=EF of A=4, EF=4+2=6
- D: ES=EF of B=9.33, EF=9.33+6=15.33
- E: ES=EF of C=6, EF=6+4=10
- F: ES=max(EF of D, EF of E)=max(15.33, 10)=15.33, EF=15.33+3=18.33

Step 3: Backward Pass (Calculate LF and LS)

Start with last activity F:

- F: LF=EF=18.33, LS=18.33 - 3=15.33
- D: LF=LS of F=15.33, LS=15.33 - 6=9.33
- E: LF=LS of F=15.33, LS=15.33 - 4=11.33
- B: LF=LS of D=9.33, LS=9.33 - 5.33=4
- C: LF=LS of E=11.33, LS=11.33 - 2=9.33
- A: LF=min(LS of B, LS of C)=min(4, 9.33)=4, LS=4 - 4=0

Step 4: Calculate Slack

Activity	ES	EF	LS	LF	Slack
A	0	4	0	4	0
B	4	9.33	4	9.33	0
C	4	6	9.33	11.33	5.33
D	9.33	15.33	9.33	15.33	0
E	6	10	11.33	15.33	5.33
F	15.33	18.33	15.33	18.33	0

Critical Path: A → B → D → F

Expected Project Duration: 18.33 days

This integrated example demonstrates how PERT's probabilistic time estimates feed into CPM scheduling to identify the critical path and project timeline when uncertainty exists.

Tips for Solving PERT CPM Example Problems Efficiently

Successfully tackling PERT CPM problems requires a systematic approach and attention to detail. Here are some tips:

- **Draw the Network Diagram First:** Visualizing dependencies helps avoid confusion when calculating times.
- **Calculate Expected Times Carefully:** For PERT, use the three-time estimates correctly to find expected durations.
- **Perform Forward and Backward Passes:** These passes are key for determining early and late start/finish times.
- **Identify Slack to Find Critical Path:** Activities with zero slack are critical and can't be delayed without affecting the project.
- **Double-Check Calculations:** Small miscalculations can lead to incorrect critical path determination.
- **Use Software Tools:** For complex projects, tools like Microsoft Project or specialized PERT/CPM software can speed up analysis.

Why Practicing PERT CPM Example Problems with Solution Matters

Working through example problems enriches your conceptual understanding and builds confidence in applying these techniques to real projects. It also sharpens your analytical skills, enabling you to anticipate bottlenecks, allocate resources wisely, and develop realistic schedules.

Moreover, as project environments become more dynamic and uncertain, mastering PERT CPM methods equips you to handle variability and risk effectively. Learning through problems with detailed solutions ensures you grasp both the theory and practical nuances of project scheduling.

As you continue to practice various problems, try to vary project sizes and complexity. Incorporate resource constraints, parallel activities, and different types of dependencies to simulate real-world scenarios. This hands-on experience is invaluable for both academic success and professional excellence in project management.

Exploring pert cpm example problems with solution not only clarifies the mechanics of project scheduling but also empowers you to manage time, cost, and risk in your projects more effectively. With consistent practice, these tools become second nature, making complex projects more manageable and successful.

Frequently Asked Questions

What is a simple example of a PERT problem with solution?

A project has three activities with optimistic, most likely, and pessimistic times as follows: Activity A (2, 4, 6 days), Activity B (3, 5, 9 days), Activity C (1, 2, 3 days). Calculate the expected time for each activity using the PERT formula: Te = (O + 4M + P) / 6. For Activity A: (2 + 4*4 + 6)/6 = 4 days. Activity B: (3 + 4*5 + 9)/6 = 5.33 days. Activity C: (1 + 4*2 + 3)/6 = 2 days. Then use these expected times in the CPM network to find the critical path and project duration.

How do you solve combined PERT and CPM example problems?

In combined PERT and CPM problems, first calculate the expected durations for activities using PERT formula. Then, create a network diagram and identify all paths. Use CPM techniques to calculate earliest start (ES), latest start (LS), earliest finish (EF), and latest finish (LF) times for each activity. The path with zero slack is the critical path, and its total expected duration is the project completion time.

Can you provide a solved example of a PERT CPM problem with multiple paths?

Consider a project with activities and durations: A (expected 3 days), B (4 days), C (5 days), D (2 days), and E (3 days). The network paths are: A-B-D, and A-C-E. Calculate total time for path A-B-D: 3 + 4 + 2 = 9 days; for A-C-E: 3 + 5 + 3 = 11 days. The critical path is A-C-E with duration 11 days. This means the project completion time is 11 days.

What is the step-by-step solution for a PERT CPM example problem?

Step 1: List all activities with optimistic, most likely, and pessimistic times. Step 2: Calculate expected times using PERT formula: Te = (O + 4M + P)/6. Step 3: Draw the project network diagram. Step 4: Perform forward pass to calculate earliest start and finish times. Step 5: Perform backward pass to calculate latest start and finish times. Step 6: Determine slack for each activity. Step 7: Identify the critical path (activities with zero slack). Step 8: Calculate project duration as sum of activities on critical path.

How do you interpret the solution of a PERT CPM example problem?

The solution provides the expected duration of the project and identifies the critical path, which is the sequence of activities that determines the minimum project completion time. Activities on the critical path have zero slack, meaning any delay in these activities will delay the entire project. The solution also helps in resource allocation and risk management by highlighting which activities have slack and which do not.

Additional Resources

Pert CPM Example Problems with Solution: A Detailed Examination

pert cpm example problems with solution are essential learning tools for project managers, students, and professionals seeking to master project scheduling and time management techniques. The Program Evaluation Review Technique (PERT) and Critical Path Method (CPM) are fundamental methodologies used to plan, schedule, and control complex projects. Understanding how to solve example problems that incorporate both PERT and CPM principles not only enhances theoretical knowledge but also equips practitioners with practical skills for real-world application.

In this article, we will delve into the intricacies of PERT and CPM through example problems, highlighting step-by-step solutions that unravel the complexities of project timelines, task dependencies, and critical path identification. We will explore how these methods complement each other, their unique features, and the significance of integrating probabilistic time estimates from PERT with the deterministic scheduling of CPM.

Understanding PERT and CPM: Fundamentals Before Examples

Before tackling example problems with solutions, it is crucial to revisit the core concepts of PERT and CPM to appreciate their applications fully.

PERT is primarily used for projects where activity durations are uncertain. It employs three time estimates for each task—optimistic (O), most likely (M), and pessimistic (P)—to calculate expected durations and variances, using probabilistic models. This approach facilitates risk assessment and helps in managing uncertainty.

CPM, in contrast, deals with projects where activity durations are known and fixed. It focuses on identifying the critical path—the longest sequence of tasks that determines the minimum project completion time—and calculating slack times for non-critical activities.

Both methods utilize network diagrams to represent activities and their dependencies, but their treatment of time estimates and focus differ.

Key Differences Between PERT and CPM

- **Time Estimates:** PERT uses probabilistic time estimates; CPM assumes deterministic durations.
- **Focus:** PERT emphasizes time uncertainty and risk management; CPM prioritizes cost optimization and resource allocation.
- **Application:** PERT is suited for research and development projects with unknown durations; CPM fits construction or manufacturing projects with predictable timelines.

Understanding these distinctions helps in selecting the appropriate method for a given project scenario and interpreting example problems effectively.

Pert CPM Example Problems with Solution: Step-by-Step Guide

To illustrate how PERT and CPM work in tandem, let's analyze a comprehensive example problem incorporating both techniques.

Example Problem

A project consists of six activities (A to F) with the following dependencies and time estimates. For each activity, the optimistic (O), most likely (M), and pessimistic (P) durations are provided:

Activity	Predecessor(s)	Optimistic (O)	Most Likely (M)	Pessimistic (P)
A	-	2	4	6
B	A	3	5	9
C	A	1	2	3
D	B	2	4	6
E	C	4	6	8
F	D, E	3	5	7

The task is to find:

1. The expected time for each activity using PERT.
2. The project's critical path using CPM.
3. The probability that the project will be completed within 20 days.

Step 1: Calculating Expected Time and Variance for Each Activity

PERT calculates the expected time (TE) for each activity with the formula:

$$
TE = \frac{O + 4M + P}{6}
$$

The variance (σ^2) is:

$$
\sigma^2 = \left(\frac{P - O}{6}\right)^2
$$

Calculations:

Activity	TE = (O+4M+P)/6	Variance = ((P-O)/6)^2
A	(2+4*4+6)/6 = 4	((6-2)/6)^2 = (4/6)^2 = 0.44
B	(3+4*5+9)/6 = 5.33	((9-3)/6)^2 = (6/6)^2 = 1.0
C	(1+4*2+3)/6 = 2	((3-1)/6)^2 = (2/6)^2 = 0.11
D	(2+4*4+6)/6 = 4	((6-2)/6)^2 = 0.44
E	(4+4*6+8)/6 = 6	((8-4)/6)^2 = (4/6)^2 = 0.44
F	(3+4*5+7)/6 = 5	((7-3)/6)^2 = (4/6)^2 = 0.44

Step 2: Constructing the Network Diagram and Determining Paths

The project network can be constructed based on dependencies:

- Activity A starts the project.
- B and C depend on A.
- D depends on B.
- E depends on C.
- F depends on D and E.

Possible paths:

1. A → B → D → F
2. A → C → E → F

Step 3: Calculating Expected Duration for Each Path

Sum the expected times along each path:

- Path 1: A(4) + B(5.33) + D(4) + F(5) = 18.33 days
- Path 2: A(4) + C(2) + E(6) + F(5) = 17 days

Step 4: Identifying the Critical Path

The critical path is the longest path in terms of expected duration. Here, Path 1 (A-B-D-F) is the critical path with 18.33 days.

Step 5: Calculating the Variance of the Critical Path

Add variances of activities on the critical path:

$$
\sigma^2_{critical} = 0.44 + 1.0 + 0.44 + 0.44 = 2.32
$$

Standard deviation:

$$
\sigma = \sqrt{2.32} \approx 1.52
$$

Step 6: Calculating the Probability of Completion Within 20 Days

Assuming the total time follows a normal distribution, the Z-score is:

$$
Z = \frac{D - TE}{\sigma} = \frac{20 - 18.33}{1.52} = \frac{1.67}{1.52} \approx 1.10
$$

From standard normal distribution tables, a Z-score of 1.10 corresponds to a probability of approximately 0.8643, or 86.43%.

This means there is an 86.43% chance the project will be completed within 20 days.

Analyzing the Solution: Practical Implications and Insights

This example encapsulates the synergy between PERT and CPM:

- PERT's probabilistic time estimates provide a realistic expected duration and variance, crucial for projects with uncertain activity times.
- CPM's deterministic approach helps in identifying the critical path and evaluating time constraints efficiently.
- The integration allows calculation of the likelihood of meeting project deadlines, enhancing risk assessment.

Using PERT CPM example problems with solution like this one empowers project managers to make informed decisions, allocate resources prudently, and communicate timelines effectively.

Pros and Cons of Using PERT and CPM Together

- **Pros:** Offers comprehensive scheduling by addressing uncertainty and fixed dependencies; improves planning accuracy; facilitates risk management.

- **Cons:** Requires detailed data collection; probabilistic estimates may be subjective; complex for very large projects with numerous activities.

Additional Example: Simplified CPM Calculation

For comparison, consider a project with fixed durations, eliminating the probabilistic element.

Activity	Predecessor	Duration (days)
A	-	4
B	A	6
C	A	3
D	B	5
E	C	7
F	D, E	4

Paths and durations:

- A → B → D → F = 4 + 6 + 5 + 4 = 19 days
- A → C → E → F = 4 + 3 + 7 + 4 = 18 days

Critical path is A-B-D-F with 19 days.

This deterministic approach is straightforward but lacks the probabilistic nuance of PERT, which is vital for projects with uncertain durations.

Conclusion: Mastery through Practice of PERT CPM Example Problems with Solution

Engaging with pert cpm example problems with solution is indispensable for grasping the practicalities of project time management. The ability to calculate expected times, identify critical paths, and quantify probabilities of project completion equips professionals with a robust toolkit for handling complex projects under uncertainty.

The illustrative example above demonstrates how precise calculations, combined with network analysis, lead to actionable insights. Whether managing a research initiative with variable task durations or a construction project with fixed timelines, understanding the interplay between PERT and CPM methodologies enhances project control and success rates.

As project environments grow increasingly dynamic, continued exploration and application of pert cpm example problems with solution remain a vital component of effective project management education and practice.

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