

Cambridge International AS & A Level Computer Science

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For examination from 2017

Topic 4.4.3 Project management PERT and GANTT charts

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Introduction

How to use this guide

The aim of this guide is to facilitate your teaching of the objectives relating to Program Evaluation Review Technique (PERT) and GANTT charts in Cambridge International AS and A Level Computer Science, syllabus topic 4.4.3 Project management. This is part of topic 4.4 Software development. The guidance and activities in this resource are designed to help teachers devise programmes of study which provide teaching time devoted to theory work as well as activities that consolidate learning.

Section 1, and lists some key terms used in this topic and their definitions. Section 2 introduces PERT and GANTT charts, including some worked examples. Section 3 provides links to online resources. Section 4 gives ideas for class and homework activities.

Learning objectives

Using this document should help you guide learners in the following syllabus learning objectives:

- show understanding of project planning techniques including the use of GANTT and Program Evaluation Review Technique (PERT) charts
- describe the information that GANTT and PERT charts provide
- construct and edit GANTT and PERT charts

Prior knowledge

Before you begin teaching this topic you should:

- understand how tools available for project management (PERT and GANTT) can assist a project manager in the delivery of a project on-time and on-budget
- understand how a PERT chart displays project tasks, durations and dependencies and its advantages and disadvantages
- understand how a GANTT chart displays project tasks, durations and dependencies and its advantages and disadvantages
- understand the different task durations used as inputs to GANTT charts
- be able to calculate the estimated time
- know how to construct GANTT and PERT charts
- understand how to identify the critical path and calculate slack time for a project

1. Key terms

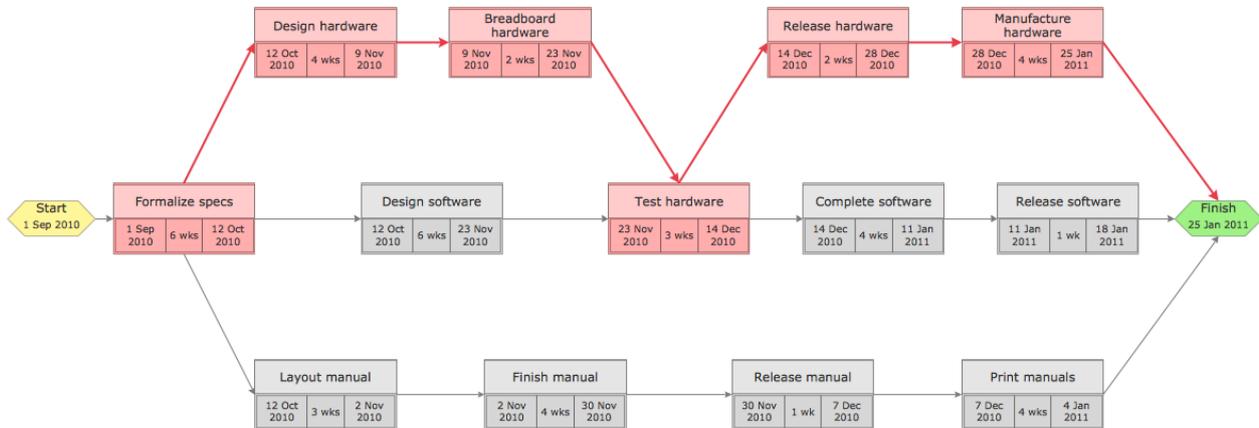
| Word/phrase | Meaning |
|---|---|
| backward pass | The process to determine the late start or late finish times for activities in the critical path method |
| critical path method | A mathematical modelling technique used to schedule a set of tasks. The model allows the longest path (the critical path) to be determined which gives the minimum time required for project completion |
| earliest finish time (EF) | The earliest start time for the activity plus the time required to complete the activity (the earliest an activity can be completed) |
| earliest start time (ES) | The earliest time an activity can start once the previous dependent activities are completed |
| expected time, T_E | Calculated using O, M and P, the expected time is: $T_E = \frac{O+4M+P}{6}$ |
| forward pass | The process to determine the early start or early finish times for activities in the critical path method |
| GANTT chart | A diagram that shows each task in a project as a block of calendar time. Each block is labelled with the task description and the amount of time the block represents. |
| latest finish time (LF) | The latest time an activity can be completed without delaying the entire project. |
| latest start time (LS) | The latest finish time minus the time required to complete the activity |
| most likely time (M) | The project manager should have a high degree of certainty that a task will be completed within this time |
| optimistic time (O) | The shortest time that an activity is likely to take – there will be a small probability (less than 5%) of this happening |
| pessimistic time (P) | The project manager should be almost certain (e.g. 99%) that the task will be completed within this time |
| Program Evaluation Review Technique (PERT) chart | An implementation of the Critical Path Method where the time for each task is estimated by using a weighted average based on a probabilistic estimation of the optimal, most likely and a pessimistic time to complete the task |
| slack | The number of spare / float weeks |

2. Theory and worked examples

2.1. What are PERT charts?

Program Evaluation Review Technique (PERT) charts show each task in a project as a node. Dependencies between tasks (e.g. where one task requires another one to be completed before it can start) are clearly shown by interconnections between the task nodes. PERT charts also show timing information for each task. PERT charts are similar to the critical path method (CPM) which identifies the longest path through the project, and therefore the minimum time for the project to be completed. In the example below, the critical path is shown by the red arrows.

PERT charts try to make a realistic estimate by considering three scenarios and then generating an Expected Time as a weighted average:



Project managers can use PERT charts to:

- set a realistic timetable for project completion
- make sure focus is maintained on the most critical tasks for the critical path – since the path leads to the minimum time the project requires, any delays to these tasks will result in a delay to the overall project
- identify tasks that need to be shortened if the overall project time needs to be reduced
- identify tasks that can be carried out simultaneously
- identify slack time where certain tasks are not as time-critical to the overall deadline.

Whereas CPM uses a single estimate for task duration, the PERT method requires the project manager to supply three estimates to make the estimates as accurate as possible. The three estimates are:

- Optimistic Time (O) – the shortest time that the activity is likely to take. There will be a small probability (less than 5%) of this happening
- Most Likely Time (M) – the project manager should have a high degree of certainty that the task will be completed within this time
- Pessimistic Time (P) – the project manager should be almost certain (e.g. 99%) that the task will be completed within this time

The 'expected time' T_E is then calculated as $T_E = \frac{O+4M+P}{6}$.

2.2. PERT chart – worked example

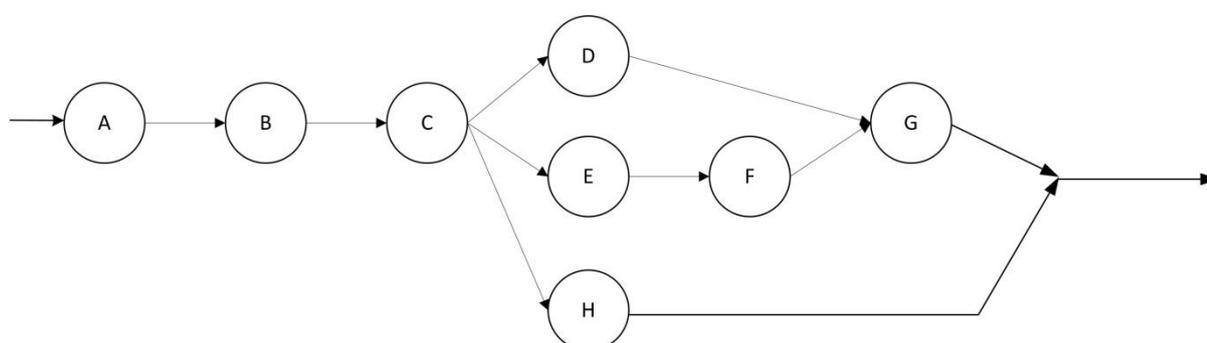
2.2.1 Inputs

The following table shows the tasks, dependencies, and estimated times a project manager might input to a PERT chart for a software development project (estimates are used for illustrative purposes only), and the calculated Expected Times:

| Task Identifier | Task Description | Predecessor Task(s) | Optimistic Time (O) | Most Likely Time (M) | Pessimistic Time (P) | Expected Time (T_E) |
|-----------------|--|---------------------|---------------------|----------------------|----------------------|-------------------------|
| A | Establish project | | 4 | 5 | 12 | 6 |
| B | Establish customer requirements | A | 2 | 3 | 4 | 3 |
| C | Produce software specification documents | B | 6 | 8 | 22 | 10 |
| D | Write test plans | C | 4 | 6 | 8 | 6 |
| E | Write code | C | 3 | 4 | 5 | 4 |
| F | Developer testing | E | 2 | 4 | 6 | 4 |
| G | System testing | D, F | 2 | 3 | 4 | 3 |
| H | Write manuals | C | 5 | 7 | 15 | 8 |

2.2.2 Network diagram

The network diagram is based on the tasks and their dependencies (predecessor tasks). Task A has no predecessor, and therefore starts the project on the left. Task B has only task A as a predecessor, and is therefore the next task. The diagram shows that tasks D, E and H (writing test plans, code and manuals) all have task C (specification) as a predecessor, and can therefore be carried out simultaneously.

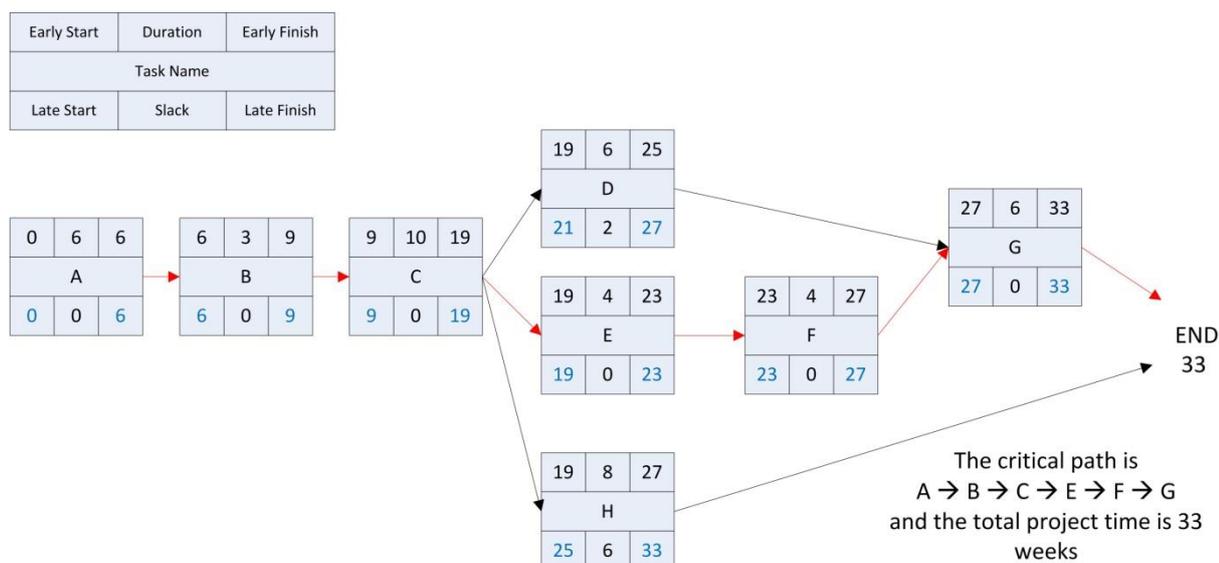


2.2.3 Identify the critical path

The critical path is determined by using the estimated times to work out the earliest start (ES) and finish (EF) times (forward pass), and latest start (LS) and finish (LF) times (backward pass), and identifying the tasks where ES and LS are equal.

Step1: Forward pass

This is done by working from left to right across the chart. The ES of task A is week 0, and the EF is 6 since this is the ES plus the duration (estimated time). The earliest that task B can begin is week 6 (since task A must be complete) so its ES is 6, and EF is $6 + 3 = 9$. Note that task G has an ES of 27 because it is dependent on both task D and task F being complete first, and the earliest that both tasks will be completed is week 27.



Step 2: Backward pass

Working from right to left, the Latest Finish Time (LF) and Latest Start Time (LS) can be filled in. The final time is 33 weeks, so the LF of task H must be 33. Because this task has a duration of eight weeks it means it has an LS of $33 - 8 =$ week 25.

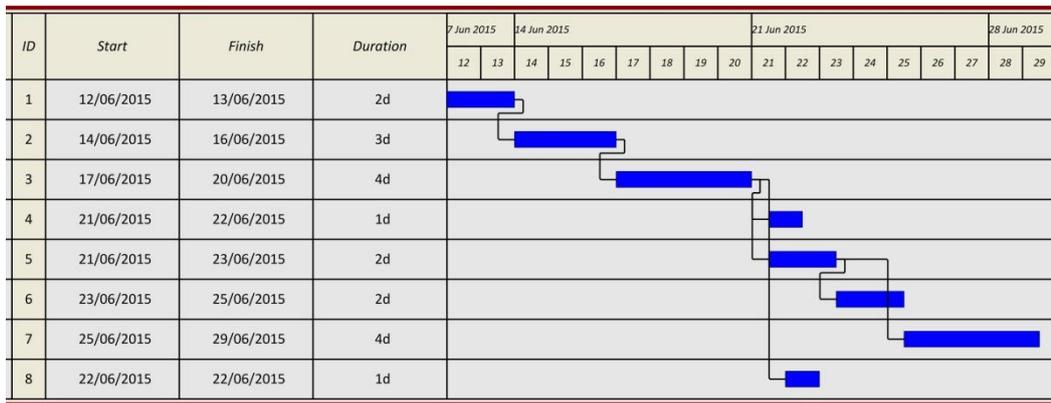
Note that for some tasks, such as Task C, there are different possibilities. To calculate the LF of Task C we need to look at the latest start times for Tasks D, E and H which are dependent on it. The latest time task C can finish (LF) must be 19 weeks because Task E has to start at this point.

Step 3: Critical path and slack

The critical path is identified by finding the nodes where $ES = LS$. These are nodes for which there is no 'slack' or spare time for a task in the project.

The slack is calculated as $LS - ES$, e.g. Task H has 6 weeks' slack, and could be scheduled to start sometime between week 19 and week 25 depending on factors such as the resources available to a task on the critical path.

Theory and worked examples



3. Online resources

There are numerous resources available that introduce and contain examples of GANTT and PERT charts. The following resources are ones that you and your users should consider using.

The content of websites is dynamic and constantly changing. Schools are strongly advised to check each site for content and accessibility prior to using it with learners. Cambridge International Examinations is not responsible for the accuracy or content of information contained in these sites. The inclusion of a link to an external website should not be understood to be an endorsement of that website or the site's owners (or their products/services).

3.1. Websites

3.1.1 General

Overview of PERT, GANTT and CPM: why they are needed, advantages and disadvantages of each.

<http://www.southampton.ac.uk/~jps7/Aircraft%20Design%20Resources/project%20management/gantt1.pdf>

Covers most of the topic – Gantt charts, PERT charts, and includes a worked example of forward and backward pass to find the critical path, although not in the context of software development projects.

http://www.teach-ict.com/as_a2_ict_new/ocr/A2_G063/331_systems_cycle/planning_tools/miniweb/pg9.htm

Explanation of GANTT and PERT charts, including step-by-step instructions on how to construct them and the benefits of each.

http://www.umsl.edu/~sauterv/analysis/488_f02_papers/ProjMgmt.html

3.1.2 GANTT

What a Gantt chart is, and how to create them.

<http://www.gantt.com/index.htm>

3.1.3 PERT

Comprehensive look at critical path and PERT.

<https://www.smartsheet.com/critical-path-method>

3.2. Videos

3.2.1 General

Project management (eight minutes) – how a project manager can use PERT and GANTT charts for project management. This is a generic video, but gives a good overview of the responsibilities of a project manager.

https://www.youtube.com/watch?v=qkuUBcmmBpk&feature=youtu.be&feature=iv&src_vid=Es4IKP_pQh0&annotation_id=annotation_2969299389

3.2.2 GANTT

Brief summary of GANTT chart purpose (three minutes)

<https://www.youtube.com/watch?v=VIm8yWpBxFA>

3.2.3 PERT

The following videos are from an hour-long lecture showing how to construct a PERT chart. It goes through the principles of CPM and PERT. Part 4 is beyond A Level and starts to look at the statistical variables / expectations that can be applied to the models created.

- Part 1 <https://www.youtube.com/watch?v=LdRZN5o08eM>
- Part 2 <https://www.youtube.com/watch?v=d6-bb9oDsSA>
- Part 3 <https://www.youtube.com/watch?v=Os1XRKt8ABA>
- Part 4 https://www.youtube.com/watch?v=wW1uU_UsARY

3.3. Software

Microsoft Visio has a number of templates including PERT and GANTT tools

GanttProject is a free package that allows professional quality GANTT charts to be developed

<http://www.ganttproject.biz/>

4. Class and homework activities

To cover the learning objectives in this topic, learners will need to practise the following:

- how to construct a PERT / GANTT chart for a set of tasks given the tasks, their relationship (e.g. successor / predecessor) and the time taken for each task
- how to interpret PERT / GANTT charts to determine the total time for completion, potential blockages and slack periods

4.1. Homework questions

The following activities are suggested to consolidate your students' learning after they have studied this topic:

1. The probable times (in days) for a number of tasks in a software development project have been estimated. Calculate the weighted expected time, T_E , that would be used for estimating the overall task time in a PERT chart.

| Task | Description | Optimistic O | Most Likely M | Pessimistic P | Time Expected T_E |
|------|--------------------------------|-----------------|------------------|------------------|------------------------|
| A | Produce software specification | 4 | 7 | 10 | |
| B | Write test plans | 7 | 23 | 27 | |
| C | Software design | 11 | 14 | 17 | |
| D | Software code | 10 | 22 | 28 | |
| E | Developer test | 7 | 23 | 27 | |
| F | Software test | 22 | 29 | 30 | |

2. The expected duration of each task has been calculated. The task dependencies are shown in the table below.

| Task | Description | Order | Duration |
|------|--------------------------------|-----------------------|----------|
| A | Produce software specification | To be completed first | 1 week |

Class and homework activities

| | | | |
|---|------------------|---------------------------------|---------|
| B | Write test plans | Start when A is complete | 3 weeks |
| C | Software design | Start when A is complete | 2 weeks |
| D | Software code | Start when B is complete | 3 weeks |
| E | Developer test | Start when C is complete | 3 weeks |
| F | Software test | Start when D and E are complete | 4 weeks |

- a. Construct a PERT chart for the project.
 - b. Identify the critical path and hence the minimum time to completion.
 - c. Describe where there is slack time in the system.
-
3. Construct a GANTT chart for the software development project. Assume that the first task starts on 17th October 2015.

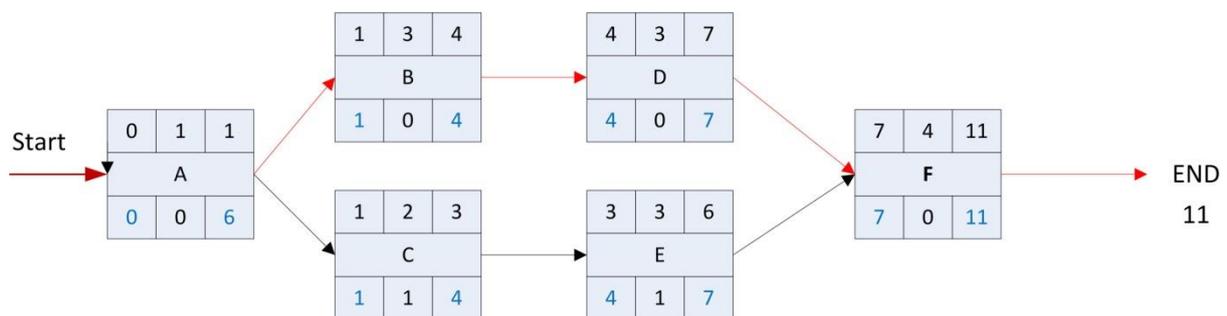
4.2. Homework solutions

1. The time expected is calculated as $T_E = \frac{O+4M+P}{6}$

| Task | Description | Optimistic O | Most Likely M | Pessimistic P | Time Expected T_E |
|------|--------------------------------|-----------------|------------------|------------------|------------------------|
| A | Produce software specification | 4 | 7 | 10 | 7 |
| B | Write test plans | 7 | 23 | 27 | 21 |
| C | Software design | 11 | 14 | 17 | 14 |
| D | Software code | 10 | 22 | 28 | 21 |
| E | Developer test | 7 | 23 | 27 | 21 |
| F | Software test | 22 | 29 | 30 | 28 |

2. PERT Chart

a.



- b. The Critical Path is $A \rightarrow B \rightarrow D \rightarrow F$ and it will take a time of 11 weeks to complete the project at best.
- c. Tasks C and E both have 1 week of slack time since the Latest Start Times are both one week more than the Earliest Start Times.

3. (Note – the task description should also be displayed, as well as the task ID.)

