FACTFILE:
GCE SOFTWARE SYSTEMS DEVELOPMENT

(iii) MANAGING PROJECTS

Managing Projects

Learning outcomes

Students should be able to:
- discuss the purpose of project management;

- examine and apply project management concepts;

- examine the roles and responsibilities of those working in project management;

- explain the resources involved in developing projects;

- apply project planning techniques including the use of Gantt, PERT, Milestones, Float and Critical Path;

Content

It is important to be able to distinguish between a project and the ordinary operations of a business. There are three main characteristics of a project:

- It is **temporary**: it may last days or months or years but eventually ends; there is a definite start and end; it does not continue forever. This is in contrast with operations which have no end in sight; they go on indefinitely.

- It produces a **unique**, new, novel output (product, service or result) that has not been created before. This is in contrast with operations in a business that do not produce anything new, are repetitive in nature, but sustain the business, hopefully making a profit.

- A project is an **endeavour**: Resources, such as people and equipment are required to complete it; they are constrained by limited resources; they are intentional, planned events. Successful projects do not happen spontaneously; some amount of preparation and planning happens first. Operations may be similar to projects in this aspect but are normally easier to manage as the activities are not new and the risks are well known.

Examples of Operations & Projects

Software projects are notoriously difficult to manage in comparison to other projects such as the construction of a building. Software cannot be touched or felt like a bridge; it is more difficult to estimate the work required, measure and see progress. There are many methodologies which can be used in their development and there are many ways to create a solution for the customer with lots of options for more features. Many software projects are 'one-off' projects and involve a degree of uncertainty.

Projects	Operations
Building the Titanic.	Running the SeaCat Service from Belfast Harbour to Cairnryan.
Building a School.	Bookkeeping and accounting.
Archaeological dig at Dunluce Castle.	Refinery producing petrol.
Designing a mobile phone.	Production of mobile phones.
Designing computer games.	Maintaining the BBC website.
Producing a film.	Putting on films in a cinema.
Building the pyramids.	Running tours of the pyramids

Table 3.1 – Examples of project and operations

The Project Lifecycle

The project life cycle consists of four main phases[1]:

- **Initiation:** the project is defined and the Terms of Reference are created;

- **Planning:** a detailed Software Development Plan is produced;

- **Execution:** monitoring and control of the development of the software product;

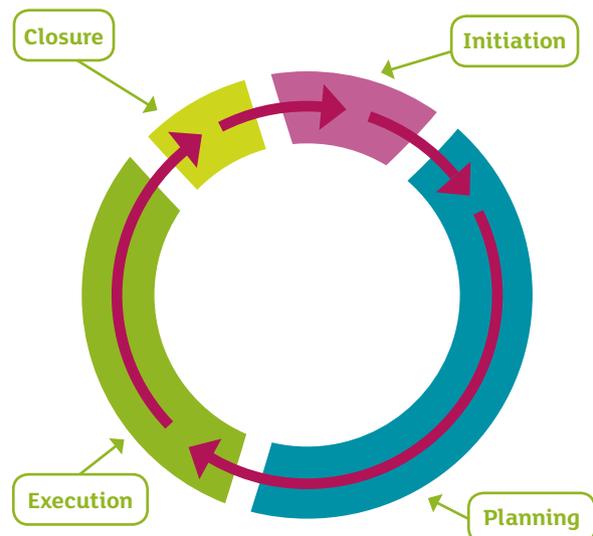- **Closure:** review and evaluation used as feedback for future projects.

Figure 3.1 – Project Life Cycle

[1] Specific software methodologies will provide more detailed phases, especially in execution, and may be iterative.

The project manager must perform a wide range of activities throughout each phase of the project to be successful. More details are provided in the following table. (Table 3.2)

Project Lifecycle	
Initiation	During initiation: • The **business problem or opportunity is identified and a solution is defined**. These are discussed with the person who initiated the project and is providing funding, (that is the customer/client/ business sponsor), and a high level person in the software development consultancy. • A **feasibility study** may be commissioned. The purpose of a feasibility study is to assess several alternative solutions looking at cost and benefits of each and making a recommendation. If a decision is taken to go ahead with the project: • A **Terms of Reference**[2] is established. This represents an agreement and possibly a legal contract between the customer/business sponsor and the software development consultancy. The Terms of Reference defines the vision, objectives, scope and deliverables for the new project. It also describes the organisation structure; activities, resources and funding required to undertake the project. It may reference other documents such as the feasibility study. Any risks, issues, assumptions and constraints are also identified. • Once a project has been approved the project manager is appointed and the project officially begins.
Planning	This is probably one of the most intensive, time consuming phases for project management and one of the most important. The project manager will study the Terms of Reference and create a detailed **Software Development Plan**[3], which includes: • Background to the project; • Goals and objectives; • Schedule/Timetable; • Estimated Budget; • Planned Resources; • How the following will be managed: Scope; Schedule; Budget; Resources; Risks; Quality; Change; and Communication.
Execution	During the Project Execution phase the: • Project Team produces the software products, while the Project Manager monitors and controls the project delivery. The project manager makes regular observations, so that potential problems and deviation from the project plan are identified at an early stage. Corrective action is taken before these problems become a bigger issue and harder to deal with.
Closure	Every project has a closing process during which: • the Project Manager should officially close the project and inform all stakeholders; • an evaluation (also known as a Post-Implementation Review) is carried out to determine the project's overall success (Were the agreed objectives accomplished?) • Lessons learnt are recorded to help future projects (i.e. 'what went right or wrong'; issues with scope, cost, budget, customer satisfaction, etc.); • Celebrations take place!

Table 3.2 – Activities for stages in a project.

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[2] This project initiation document may also be called the Project Charter or Project Mandate.
[3] Some of these areas may be separate plans and are simply referenced in the software development plan.
   For example the risk management plan may be either a section in this plan or a document in its own right.

The Purpose of Project Management

Projects need to be managed to ensure that they are delivered within a specified time period, within budget and with the right functionality. It is the project manager's duty to balance these three often competing goals. The constraints of time, cost and scope are sometimes referred to as the triple constraints of a project. They are often visualised in the so called Project Manager's Triangle or **'Iron Triangle'**:[4]

- **Time:** Often the most important constraint to manage; all projects have a deadline.
- **Cost:** This is the estimation of the amount of money that will be required to complete the project. Cost itself encompasses various things, such as: resources, salaries, software and hardware, hospitality, travel, etc.
- **Scope:** Project scope is about the work that needs to be completed in order to meet the customer's requirements within a specified boundary.

Figure 3.2 – Project Manager's Triangle

In this triangle each side represents a constraint. One side of the triangle cannot be changed without affecting the others:

- If scope/work to be completed increases because the customer has changed their mind about a requirement, then cost and time will probably increase.
- If the customer wants the software sooner rather than later (time constricted) then the only way to meet the deadline may be to increase the size of the development team, ask them to work overtime (both of these cost money) or cut out a bit of the scope or work that is to be completed.
- Sometimes one side of the triangle should not be changed: if the Dynamic Systems Development Method, DSDM, methodology is used then time and cost remain fixed and scope is managed so it fits within the boundaries of time and cost.

Roles and Responsibilities of the Project Manager

Successful project management means completion of projects on time, within budget and having satisfied customers. Project managers need to be alert, technically competent, highly resourceful, good communicators with strong human resources skills. They will be involved in a range of activities such as planning (deciding what is to be done), organising (making arrangements), staffing (selecting the right people for the job), directing (giving instructions), monitoring (check on progress), controlling (take action to remedy hold-ups), innovating (come up with right solutions) and representing (liaising with users). The main activities are:

- **Planning:** including estimating, scheduling and the creation of the project plan; and
- **Monitoring and Control:** project performance is observed and measured regularly to identify deviation/variances from the project management plan and corrective action is taken to address any issues.

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[4] There are many variations of this triangle: quality is sometimes put in the centre, other important criteria may be added making a diamond or star shape.

Project Management Concepts

The project manager's roles and responsibilities in several key management areas such as **scope, time, cost/ resources, quality, risk, change and communication** are described in the following section with examples of both planning activities and monitoring and control activities.

1. Manage Scope (What?)	
Intro	From the project manager's viewpoint scope refers to the work that needs to be done in order to deliver a successful project that meets the customer's expectations. The project manager will receive an initial outline of the product scope in the Terms of Reference document developed in the project initiation stage.
Planning	The project manager will need to **plan** the work that is to be done. • The work may be broken down or subdivided into several large sections. In the waterfall model these could relate to the phases in the lifecycle: Initiation, Analysis, Design and Build/ Implementation, Testing, Implementation/Install and Evaluation.[5] In agile projects the work may be broken down into various releases to the customer. • For each phase or following iteration the project manager could identify required activities and tasks. Examples of these tasks could be: conduct interview, select software, create E-R diagram, produce storyboards, train users, etc. • The project manager would also identify points when he will determine how much work has been completed by examining the outputs/deliverables of each phase; the design specification is an example. These points in the schedule are also called **milestones**; when progress can be observed and measured.

Monitor & Control	During **execution** of the project the project manager would:
	• **Monitor and Record Work:** The work done will be recorded and progress communicated to stakeholders periodically.
	  – The project manager examines the work that has been completed throughout the project. E.g. the work produced at the end of a phase in the waterfall model will be examined.
	  – Progress may be recorded on a **Gantt** chart and actual work compared to planned work. If work has not been completed (maybe plans were very optimistic) then the project manager must take corrective action; more time or more people may be allocated to the team (resulting in higher costs) so that the agreed functionality in the product scope is delivered.
	
	• **Control 'Scope/Feature Creep'** (that is changing customer requirements) as it is a big risk to the schedule. If project managers do not control change to scope then it is highly likely that the project will run over time and budget. Changes to scope often come from customers who find it difficult to know or communicate what they want/expect at the beginning of the project and request changes to the requirements.
	  – Project managers often use **change request forms** and carefully evaluate the impact of each change on the schedule and budget before any request for change is approved.

Table 3.3 – Manage Scope

[5] Note that there are many variations of the phase names in different textbooks.

2. Manage Time (When?)

Intro	Project managers need to provide a detailed schedule or timetable showing an estimate of when each activity in the work plan will start and end.
Planning	To create the plan the project manager will perform the following tasks: • **Estimate:** Estimating a realistic time for each task/activity is difficult and can be quite subjective, but project managers should aim to make them as realistic as possible. They should consider characteristics of the project (size, complexity, experience of the team, type of product being created), compare time taken for tasks in similar projects that have already been completed, and possibly obtain an expert opinion. • **Create a Schedule:** Project managers may use software tools such as Microsoft Project to create a schedule in the form of a Gantt and/or PERT (Program Evaluation Review Technique) chart. These show the order of the tasks/phases, important dates, dependencies between tasks, frequent milestones and the critical path.[6] • **Consider Risks:** Sometimes unexpected events occur and they have a negative impact on the schedule. Project managers may want to build some buffer into the schedule to account for these unexpected events/risks.
Monitor & Control	During execution, project managers will: • **Track and record** the amount of time team members spend on each task/activity; timesheets may be requested. • **Compare** actual time to complete tasks with the estimated time. • **Take Corrective Action if there is Variance:** If the project schedule is beginning to slip the project manager may want to get it back in line. For example, more staff could be added to the team. Project managers should be careful; above a certain team size, adding more staff may actually be detrimental to the project. In larger teams, communication and coordination is more complex and difficult; increasing the number of people on the team may hinder rather than enhance team productivity.

Table 3.4 – Manage Time

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[6] See the section in this fact file on scheduling projects for more detailed information and definitions of dependency and milestone.

3. Manage Cost/Resources (How?)

Intro	Usually customers have a limited budget for the project. Project managers will be judged on their ability to keep within the allocated budget; if the project goes wildly over budget (which they often do) it will not be considered a success, even if it is delivered on time and meets end users' needs.

Planning	The project manager needs to create a budget plan to determine if the funding is adequate. The project manager will:
	• **Identify the Resources:** The project manager will need to identify resources that already exist and determine if they are available for use in the project. The project manager may need to procure/buy in resources or recruit team members. These resources will be allocated to each task/activity in the schedule and optimise their use so they are utilised well. Examples of resources include, amongst other things:
	  – **Staff:** Different skills are required for each role in the team. For example, an analyst will play a crucial role in determining the customer requirements and designing the system while the programmer will write the code and unit test that code. Some team members may require training to be effective.
	  – **Office furniture and fixtures:** The project manager should set up the correct working environment and atmosphere (consider lighting, desk space, privacy from interruptions, etc.).
	  – **Hardware:** Such as servers, memory, printer, scanners, networking equipment. The project manager may decide whether to buy or lease these. Companies may have to invest in cutting edge technology to remain competitive.
	  – **Software:** The project manager will have to consider Operating Systems, Integrated Development Environments such as Visual Studio and Eclipse, Database Management Systems such as SQL Server and MySQL, and Project Management Tools such as Microsoft Project. The number of licences required should be determined.
	
	• **Estimating Costs:** Once the resources have been identified a cost for each can be estimated. Costs can be regarded as either direct or indirect. The project manager will have more control over the direct costs. Consider some examples:
	  – **Direct Costs:** These are specific to the project and may include hourly labour rates for each team member on the project (a significant cost in software development), travel (such as visiting the client), hospitality (catering for meetings or training events); consumables (stationery, printer cartridges, etc.).
	  – **Indirect Costs:** Indirect costs refer to the costs of keeping the business/consultancy functioning. Every project may utilise these resources and it is hard to determine how much each individual project uses. The finance department usually advises project managers on a figure for indirect costs. Costs that might come into this category are: office space rent, general supplies, administration, salaries of staff employed to keep the consultancy operational but not directly linked to the project such as accountants, executives and secretaries.
	
	• **Allocate a Contingency fund:** Funds for the unexpected events may be set aside, the amount depending on the amount of risk and uncertainty in the project.

Monitor & Control	During execution of the project the project manager will have to manage and control cost/resources. This might involve for example: • **Budgetary Control Systems:** These will enable the project manager to monitor and record costs. Approval may be required before funds are spent. The project manager will create reports for stakeholders and information will feed into the end of year accounts. • **Reporting Variance:** when there is significant variance between the actual cost of the work and the estimated cost, the project manager needs to take corrective action to manage the budget more tightly. • **Team Managing:** staff is one of the most critical resources, with high direct labour costs and large amounts of risk. There are many risks associated with people leaving the team, becoming ill, conflicts, poor morale and motivation. The project manager must manage the team effectively to ensure productivity.

Table 3.5 – Manage Cost/Resources

Managing the triple constraints of scope, time and cost is very important but there are other supporting areas that must be managed such as Quality, Change, Risk and Communication. A brief outline of each is provided in table 3.6 below.

Manage Quality

A high quality software product will satisfy the needs of the business (meeting all high priority requirements, user-friendly, reliable, excellent performance, efficient, easy to maintain); a poor quality software product will cause great customer dissatisfaction until it has been replaced or fixed (it may fail to meet the needs of the business, contains the wrong functionality, has too many errors, is very complex and difficult to use).

The project manager is responsible for **Quality Assurance**[7] which is meant to assure customers/clients (give them confidence) that the management of the software development process is of such a high standard that the software product is likely to meet their quality expectations. It focuses on checking and improving how the software is created by the project team so that errors/defects can be prevented (never happen in the first place) or minimized and at least detected at an earlier stage when correcting them is less expensive.

As part of quality assurance the project manager will check that the **quality control** activities (unit, integration and acceptance testing, structured walkthroughs[8] and code inspections) are carried out according to the software development plan. They will use the results of these quality control activities, such as number and severity of defects found, to determine the appropriate action to be taken.

Many software development companies develop standards and procedures[9] as part of a quality certification program such as ISO (International Organisation for Standardisation) 9000, CMM (Capability Maturity Model) and PRINCE2 (Projects IN Controlled Environments). These specify the quality activities that should be performed by the team. Customers tend to trust software development companies who have these certifications.

Manage Change (Configuration Management)

Managing change in software development is difficult as:
- there is a **lot of change** as the product evolves (changes to the specification for example may occur in response to feedback from a customer evaluating a prototype; changes to the software may be needed to correct errors after testing);

- there are numerous people in the project team who are making changes to **lots of items**, for example: specifications, user documentation, source and executable programs, configuration files, installation programs, management plans, test plans, and test data;

- There may be even different items for different versions of the software running on different operating systems.

There is huge potential for lots of confusion! Which items are the most recent and to be used in the product released to the customer? How can programmers be prevented from making changes to the wrong version of the code? How can it be ensured that testing is performed on the correct version of the software?

The project manager must plan how changes to these items are managed and controlled (Is there a numbering system for version control?[10] Is approval required for change? Is there a form to record changes? Can software[11] help?). They will also monitor that the configuration management system is being used properly by the members of the team according to the project plan.

Manage Risk

Project managers must manage risks. Risks are things that threaten the project and the achievement of the objectives. Risk management needs to be performed throughout the software development process. Risks are identified at an early stage of the project and throughout the life of the project. They can range from severe threats that would result in the whole project being cancelled or minor threats that might cause a small delay. Some examples of risk are:

- Unrealistic and overly optimistic estimates of time which result in the project being later than expected;
- Insufficient funds to pay for adequate resources and talented staff;
- Scope Creep: changing customer requirements that increase the work to be done and thus affect the budget and schedule;
- Personnel problems such as key team members getting a job elsewhere or becoming ill;

Once risks are identified they should be assessed (what is the probability that they will occur and if so what would be their impact on the project?) and the project manager should determine the most appropriate action (prevent/eliminate, reduce, accept or transfer?) bearing in mind cost and time. A plan for how the team records and reports risks should be made. A risk log may be implemented and reviewed by the project manager.

Manage Communication

Good communication between all stakeholders is critical for project success. **Stakeholders** are people who have a vested interest in the outcome of the project and will want to know about the progress and status of the project (are there any issues/problems?).

Project managers should identify all stakeholders (customers, managers and the development team, etc.), what information needs to be communicated, how often and by what means (meetings, email, reports). They should monitor communication and take action to solve any breakdown in communication especially due to conflict.

Table 3.6 – Manage Quality/Change/Risk/Communication

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[7] Quality Assurance focus: prevention of faults by inspecting and testing the software development process and improving it.
Quality Control focus: detection of faults in the product and outputs of the software development process and their correction.

[8] At a milestone there may be a meeting where the developer presents his/her work to panel of peer reviewers who judge the technical merit of the work.

[9] Examples of standards and procedures are : 'Configuration Management Standard', 'Risk Management Standard', 'Test Plan and Defect Reporting Procedure'. These standards and procedures lay out everything in detail that the team should do.

[10] Software versions may be identified with a number like 1.5.3. Each number increments when there is a change to the software: the first number at each major release, the second number at each minor release when some extra functionality is added, and the third, called the patch, when the release has corrected some errors. Documents may also be allocated a useful name: for example 20140523-SENFIT-Specification-v1-DRAFT.doc may indicate the date of creation (23/05/2014; it is in reverse order in the name so that files are automatically sorted by date in a directory), the project ID (SENFIT), the document name (Specification), the version number (1) and status (DRAFT).

[11] Configuration management software, such as CVS and ClearCase, can be used to keep track of the versions and changes made. Each time an item is to be changed it is checked out of a repository/store. When it has been changed it is checked in again as a new version. The software can also keep track of the versions of all items used in a build or release.

Management of Agile Projects

In Agile methodologies the project management approach may be slightly different, for example:

- **Incremental Releases:** Scope/work to do may be divided up into products/planned releases rather than within phases like in the waterfall model; these working products are delivered incrementally to the customer/client throughout the software development lifecycle.[12]

- **Difficult to plan far ahead in detail:** The overall high level plan can give some indication of when each incremental product is released to the customer but the detailed planning only occurs at the start of each iteration when the team decides how much they can do and tasks are assigned to team members.

- **The team undertakes detailed planning:** Day to day responsibility for planning is delegated to the software development team who decide how much work/scope they can achieve on that day and who will do it.

- **Automatic control of 'Scope/Feature Creep':** Time and cost in agile projects are fixed and the project manager concentrates on managing scope; the technique of timeboxing is used.

- **Gantt Charts are less useful for monitoring progress in an iteration:** Gantt charts may be used for showing a high level schedule but burndown charts are typically used to measure the amount of work done/features implemented each day of the timebox.

- **Team Management:** In traditional methodologies the project manager tightly controls the team in an authoritative manner, giving specific orders about what was to be achieved. The agile approach to team management is very different. Agile teams are expected to be self-directing, taking the initiative and being proactive. The project manager's role is more as a facilitator who is supportive of their team, encouraging collaboration and cooperation. The project manager is responsible for the motivation and morale of the team; they should recognise achievement, develop staff, and resolve conflicts effectively.

- **Verbal communication important:** In agile projects there are specific communication techniques such as the daily stand up/scrum and facilitated workshops. These encourage face-to-face verbal communication between stakeholders; this is in contrast to the traditional approach which emphasises detailed documentation passing between each phase.

Scheduling

Project managers create charts for project planning and to help with monitoring and control. Their use here demonstrates the creation of a project timetable/plan or schedule for a software development project. Planning involves the identification of tasks in a project, their duration and any dependencies. Dependencies specify which tasks control the scheduling of another. The predecessor task determines the scheduling of the dependent (the successor) task. An example of some typical data is given in table 3.7 below. Gantt or PERT charts may be prepared from such tables.

ID	Task	Duration	Predecessors
A	Write Job Specification	3 days	-----
B	Appoint Interviewers	2 days	A
C	Advertise Job	1 day	A
D	Select Applicants	2 days	C
E	Book Interview Room	1 day	B,D
F	Send Invitation Letters	3 days	D
G	Run Interviews	3 days	E;F
H	Make Decision	1 day	G
I	Appoint New Programmer	1 day	H

Table 3.7 – Scheduling Tasks.

[12]Each of these releases is created/developed in a timebox (also called an iteration/sprint) which has a fixed period of time; features are implemented in order of priority until time runs out.

Gantt Charts

In 1917, Henry Gantt developed the Gantt chart as a tool for scheduling work in factories. It is really a horizontal bar chart with time on the horizontal (x) axis and the tasks/activities on the vertical (y) axis. Tasks are represented by horizontal bars, whose length represent the duration of that activity/task. Dependencies between tasks are sometimes shown with an arrow, although not as explicitly as in a PERT chart and they are optional. Milestones, scheduled events that indicate the completion of a deliverable, may be shown as a task with zero duration, possibly represented as a diamond.

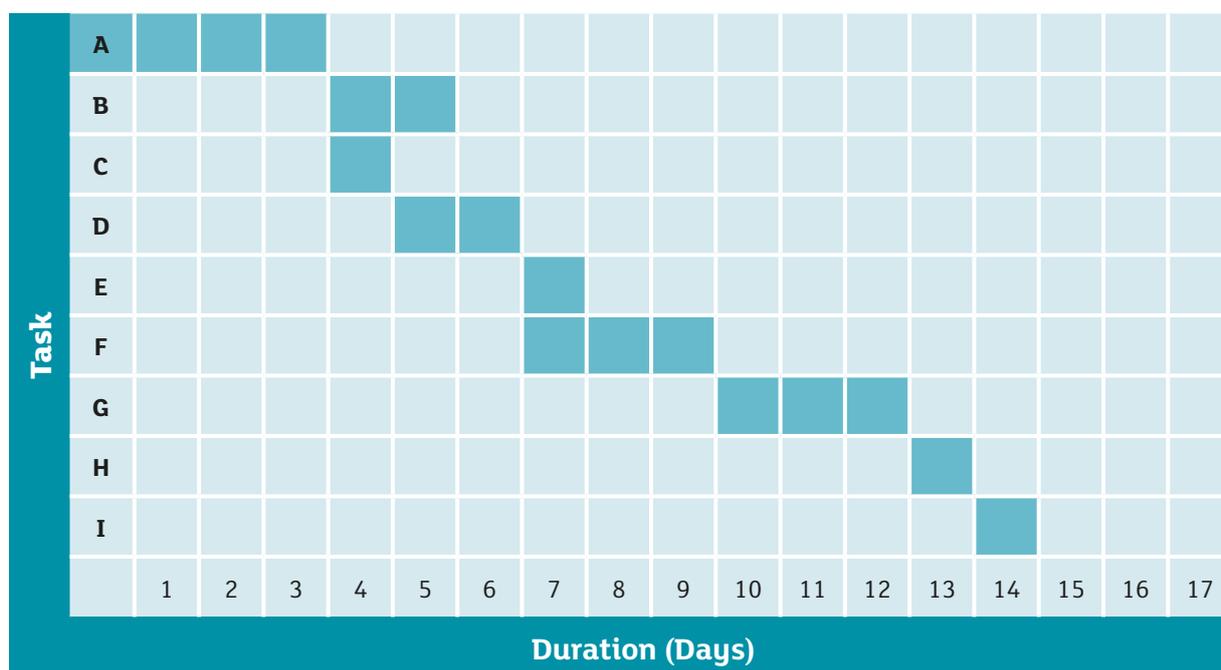The table of tasks, durations and dependencies can be transformed into the chart below:

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
A	■	■	■														
B				■	■												
C				■													
D					■	■											
E							■										
F							■	■	■								
G										■	■	■					
H													■				
I														■			

Duration (Days)

Table 3.8 – Simple Gantt Chart

ID	Task	Predecessors	Start-Finish (Days)	Comment
A	Write Job Specification	-----	0-3	No predecessor therefore this task starts at the beginning of the project.
B	Appoint Interviewers	A	3-5	Must start after task A.
C	Advertise Job	A	3-4	Must start after task A.
D	Select Applicants	C	4-6	Must start after task C.
E	Book Interview Room	B,D	6-7	Must start after either task B or D whichever has the latest end date which is in our case D.
F	Send Invitation Letters	D	6-9	Must start after task D.
G	Run Interviews	E;F	9-12	Must start after either task E or F whichever has the latest end date which is in our case F.
H	Make Decision	G	12-13	Must start after task G.
I	Appoint New Programmer	H	13-14	Must start after task H.
Total Project Duration			**14 days**	

Table 3.9 – Tasks, Durations and Dependencies

Monitoring the Project using the Gantt Chart

The problem with a Gantt chart is that it is hard to see the critical path, although software may help by highlighting it. The critical path is the longest sequence of activities in a project, each of which must be completed on time for the project to finish on the due date.

For example what happens to the project schedule if:
- **Task G:** Run Interviews actually lasted 4 days, rather than the estimated 3 days?
- **Task B:** Appoint Interviewers actually lasted 3 days, rather than the estimated 2 days?
- **Task B:** Appoint Interviewers could not start until day 7, 4 days later than expected?

Redraw the Gantt chart for each new scenario. Which tasks are on the critical path? PERT charts are better at this type of analysis.

PERT Charts

Members of the US Navy Polaris missile/submarine project first used network diagrams in 1958. These diagrams model the relationships among project tasks and enable the critical path to be found more easily.

Before a PERT chart is drawn, some terms must be defined and notation for tasks decided, see Table 3.10. Project tasks are shown as rectangular boxes filled with information about the project. They are arranged in a sequence.
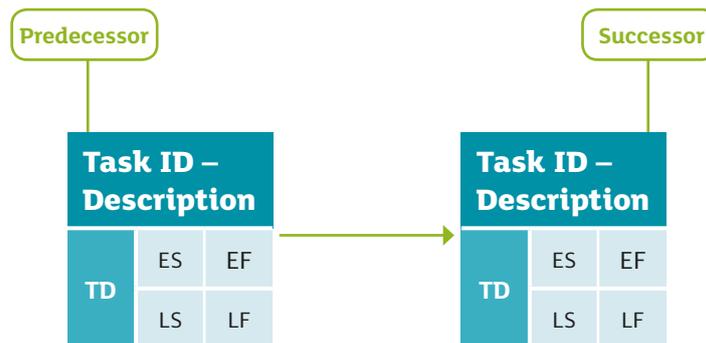

Figure 3.3 – Simple PERT Chart

TD	Task Duration (the time the task will take in hours, weeks, months, etc.).
ES	Earliest Start (the earliest time this task can begin).
EF	Earliest Finish (the earliest time this task can finish).
LS	Latest Start (the latest time this task can begin without delaying the overall project).
LF	Latest Finish (the latest time that this task can finish without delaying the overall project).
Arrow	Indicates that there is a dependency: that is the task at the end of the arrow (the successor) is dependent on the task at the start of the arrow (predecessor). The successor task cannot start until the predecessor task has been completed.

Table 3.10 – Terms and Notation used in PERT chart

Step by Step Production of PERT chart

1. Start by drawing boxes for each task.
2. Place them in order sequence.
3. Use arrows to show which tasks are dependent on other tasks.
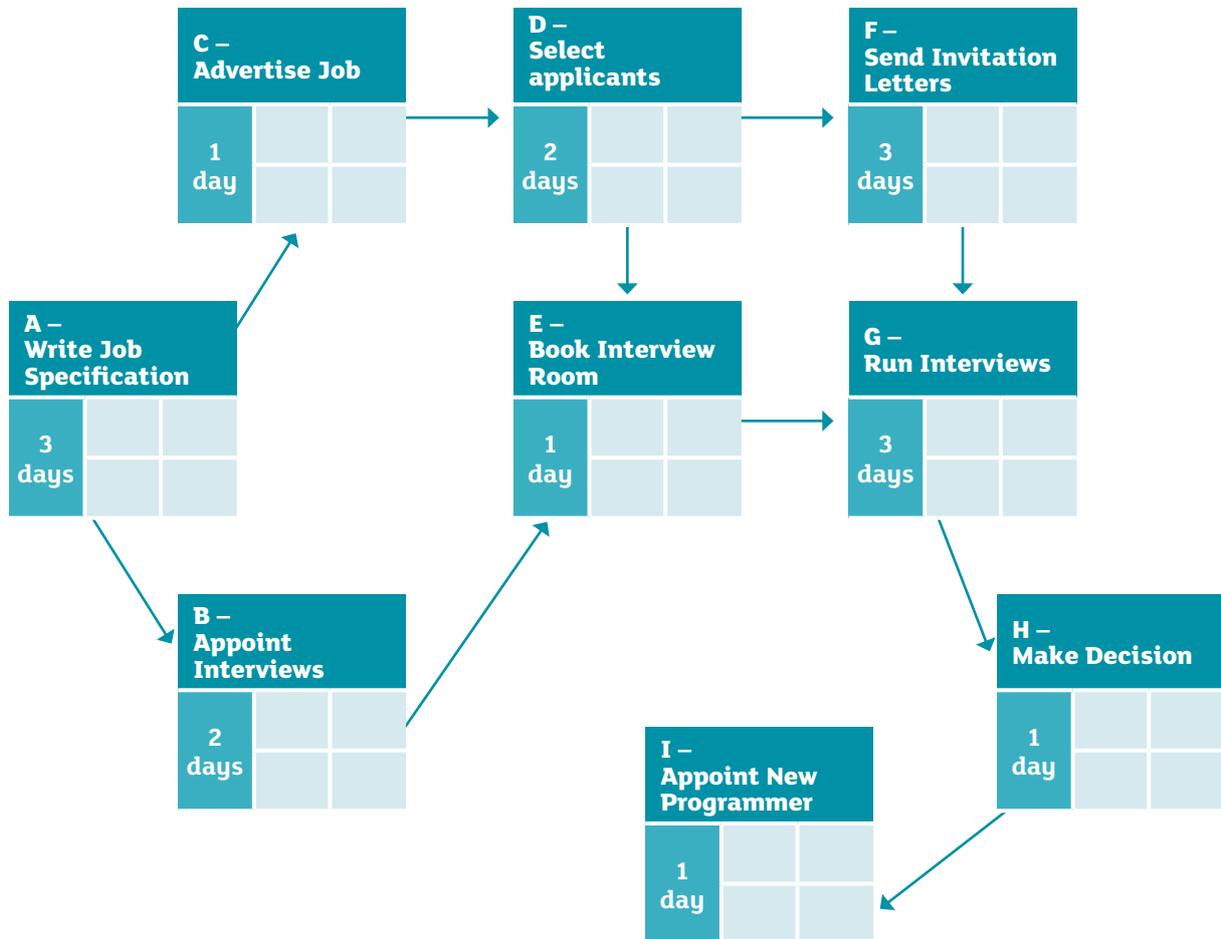**4.** The duration of each task is entered.

Figure 3.4 – PERT Chart showing the various stages, durations and sequencing

Forward Pass

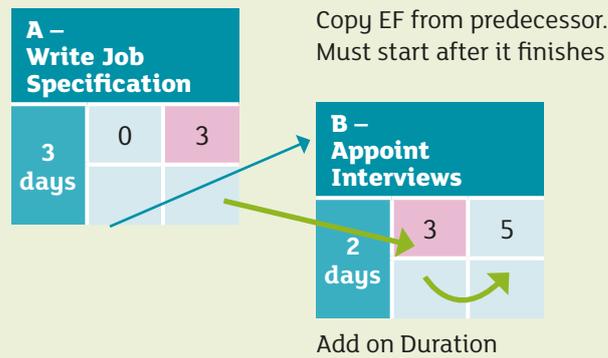Add on Duration and enter as Earliest Finish Date

In the 'forward pass' the Earliest Start (ES) and Earliest Finish (EF) values are entered.

Task A

TASK A has no predecessors and therefore the earliest it can start is day 0, at the beginning of the project. Place 0 in the ES box. To determine the earliest finish date add the task duration of 3 days to the earliest start date and place 3 in the EF box.
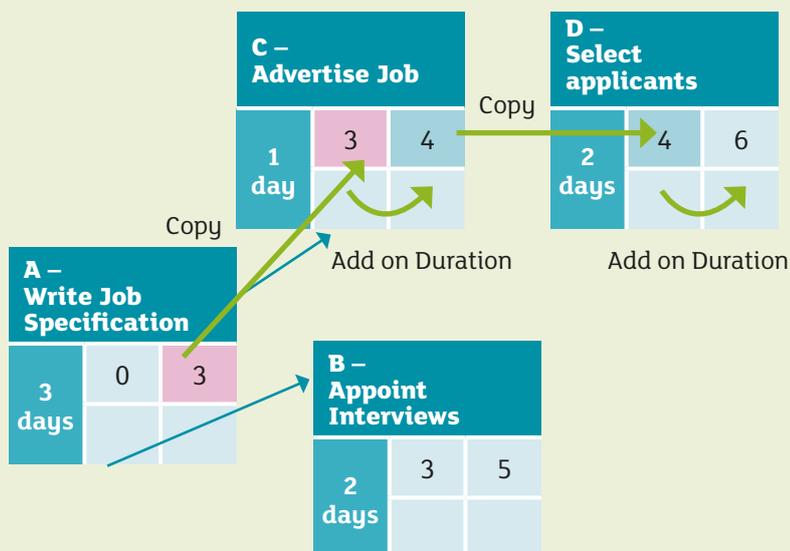
Task B

Task B is dependent on A, so it must start after task A. Enter 3 for the Earliest Start (ES) of Task B and add on the duration to get 5 for Earliest Finish (EF).

Copy EF from predecessor.
Must start after it finishes

A – Write Job Specification		
3 days	0	3

B – Appoint Interviews		
2 days	3	5

Add on Duration

Task C and D

These are determined in similar fashion.

C – Advertise Job		
1 day	3	4

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D – Select applicants		
2 days	4	6

Add on Duration

Add on Duration

Copy

A – Write Job Specification		
3 days	0	3

B – Appoint Interviews		
2 days	3	5

Task E

This is a special case as it has two predecessors. Task E must wait for 2 tasks to finish before it can start. The ES for task E must be the highest EF in the preceding tasks. Task D is the last to finish (task D finished in 6 days compared to 5 days for task B) so it must come after this. The value for ES, task E, is 6. Add on the duration of Task E, 1 day, to obtain 7 for EF.

Copy highest EF from predecessor

Add on Duration
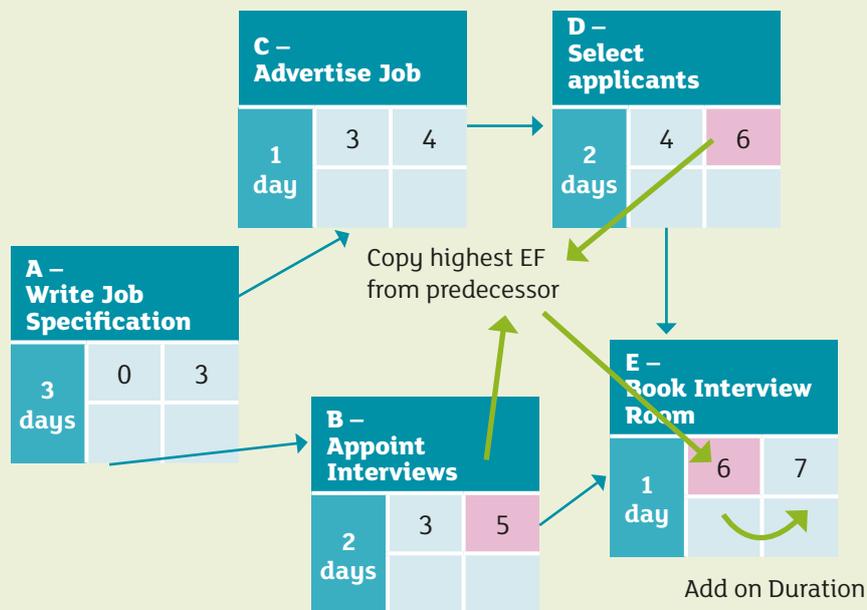
Task F, G, H and I

Task F has only one predecessor so it is straightforward to complete. TASK G has two predecessors and cannot start until after the task with the latest EF, which is Task F. TASK H and I are relatively straightforward.
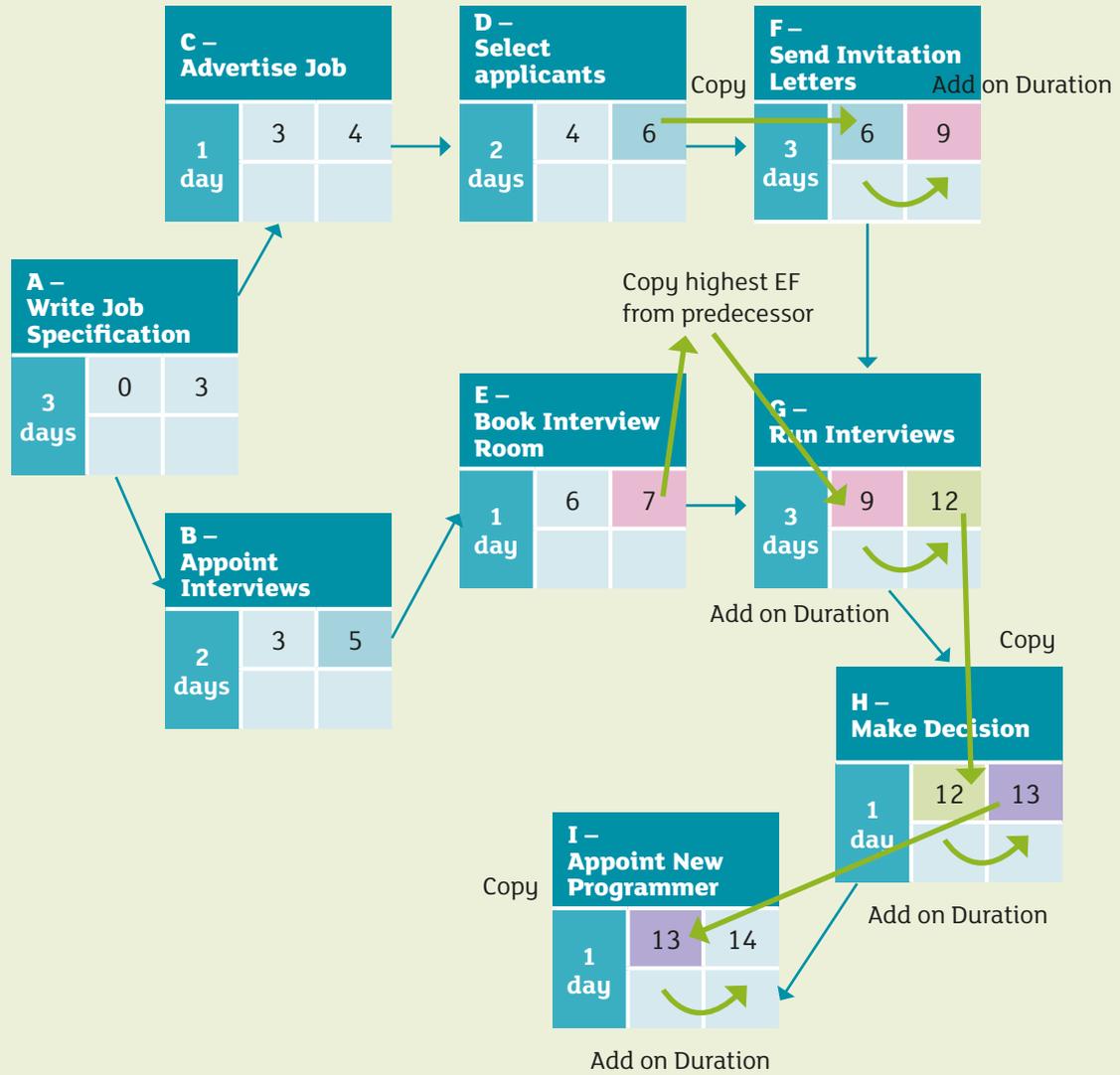

*Figure 3.4a – PERT Chart detailing the Forward Pass*

The forward pass is now complete. The expected final duration of the project is 14 days.
This is the Earliest Finish of the final task in the project.

Backward Pass

In the 'Backward Pass' the Latest Finish (LF) is determined and then the Latest Start (LS) dates by working from right to left and from **TASK I** to start **TASK A**.

Task I

Start with the last TASK I, with no successors, and fill in the latest possible finish date (LF), which the last date of the project as determined in the first pass. 14 is placed in the LF box. The latest start date (LS) is determined by taking away the duration from LF.
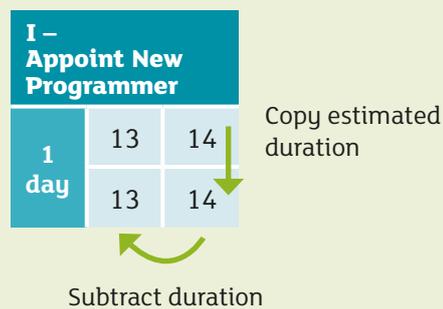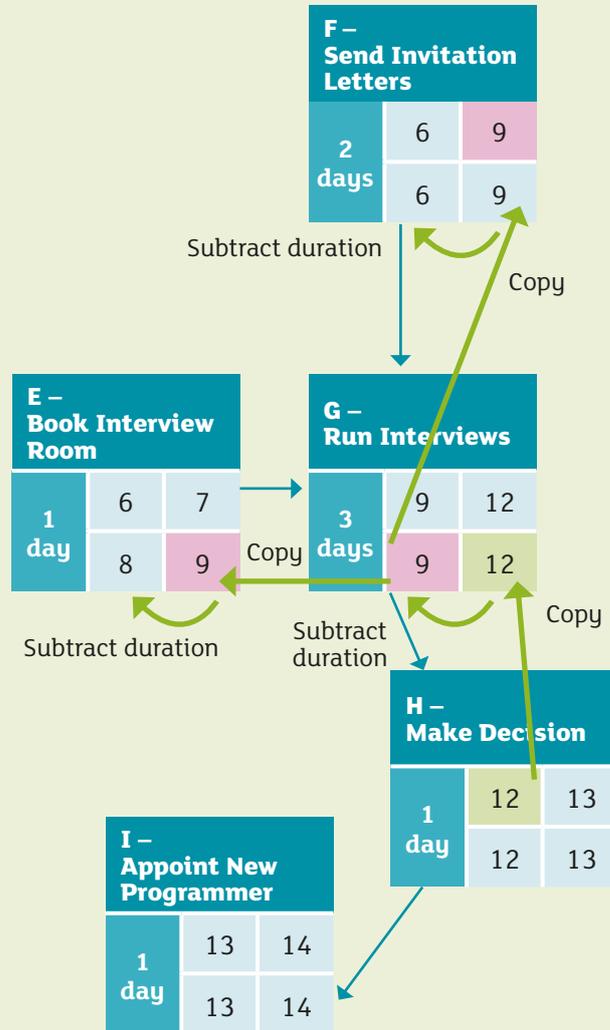

Task H

This cannot finish any later than 13 as it would mean that Task I could not start as expected, and it would extend the project deadline. LF for task H is 13. LS, 12, is calculated by subtracting the duration, 1 day, from the LF of 13.
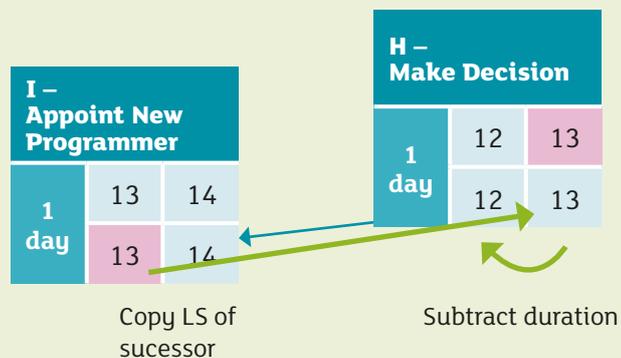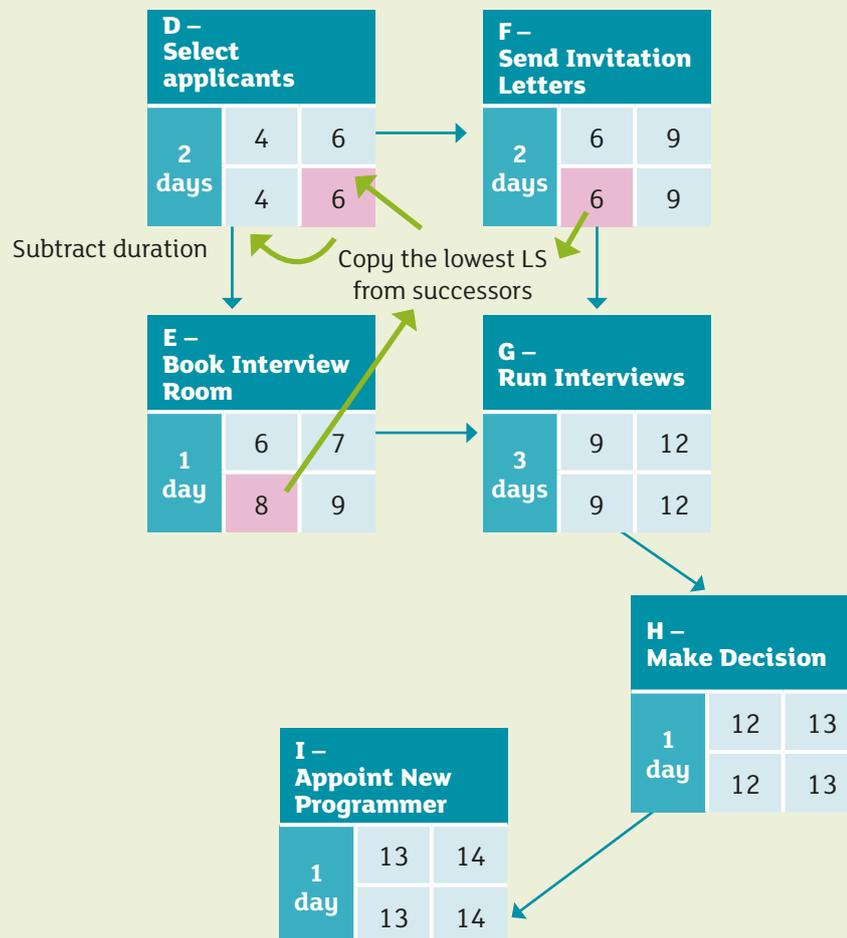
Task G, F, and E

TASK G, F, and E have one successor and are relatively straightforward.
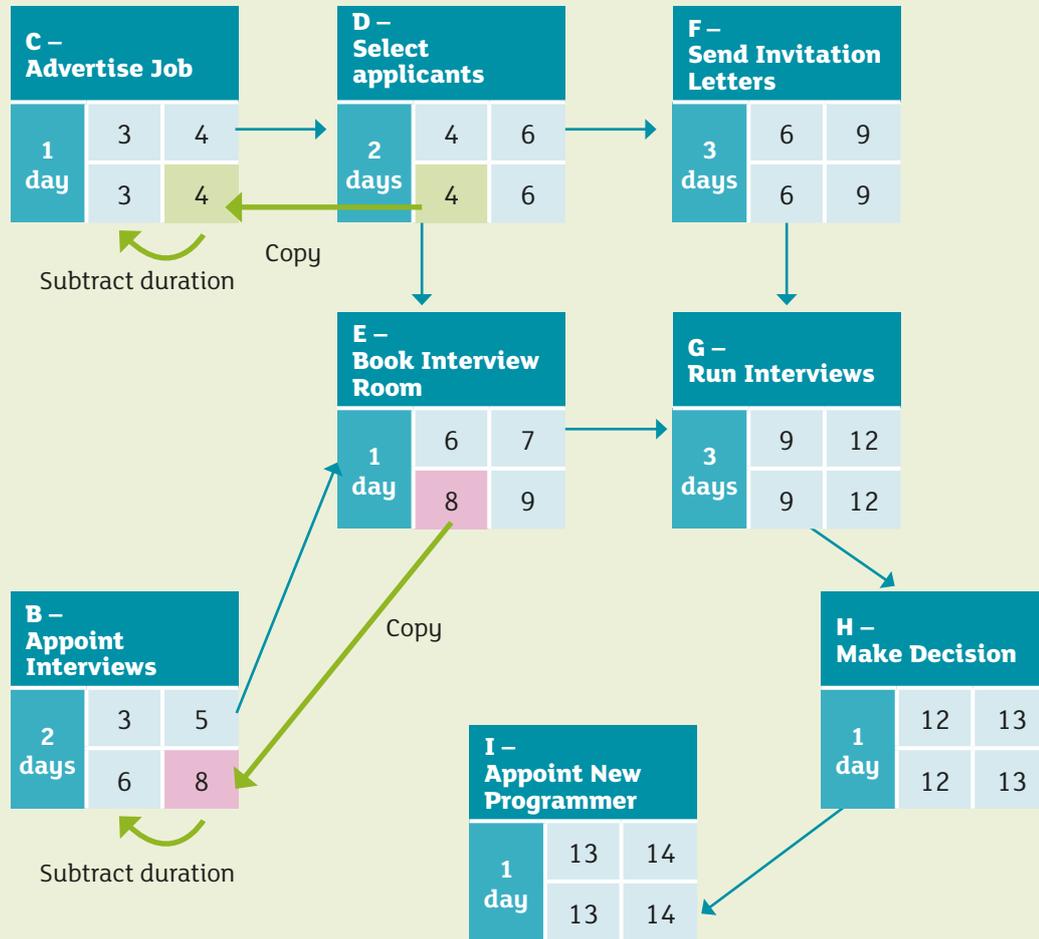
Task D

This is more unusual as this has 2 successors. In this case the Latest Finish date (LF) must be the lowest Latest Start date of the two successors. LF for task D should be 6.

Task C and B

Tasks C, B are completed as before as each only has one successor.

C – Advertise Job		
1 day	3	4
	3	4

Subtract duration / Copy

D – Select applicants		
2 days	4	6
	4	6

F – Send Invitation Letters		
3 days	6	9
	6	9

E – Book Interview Room		
1 day	6	7
	8	9

G – Run Interviews		
3 days	9	12
	9	12

B – Appoint Interviews		
2 days	3	5
	6	8

Subtract duration / Copy

H – Make Decision		
1 day	12	13
	12	13

I – Appoint New Programmer		
1 day	13	14
	13	14

Task A

This task has two successors and the LF is the value of the lowest LS dates of the successor tasks C and B.
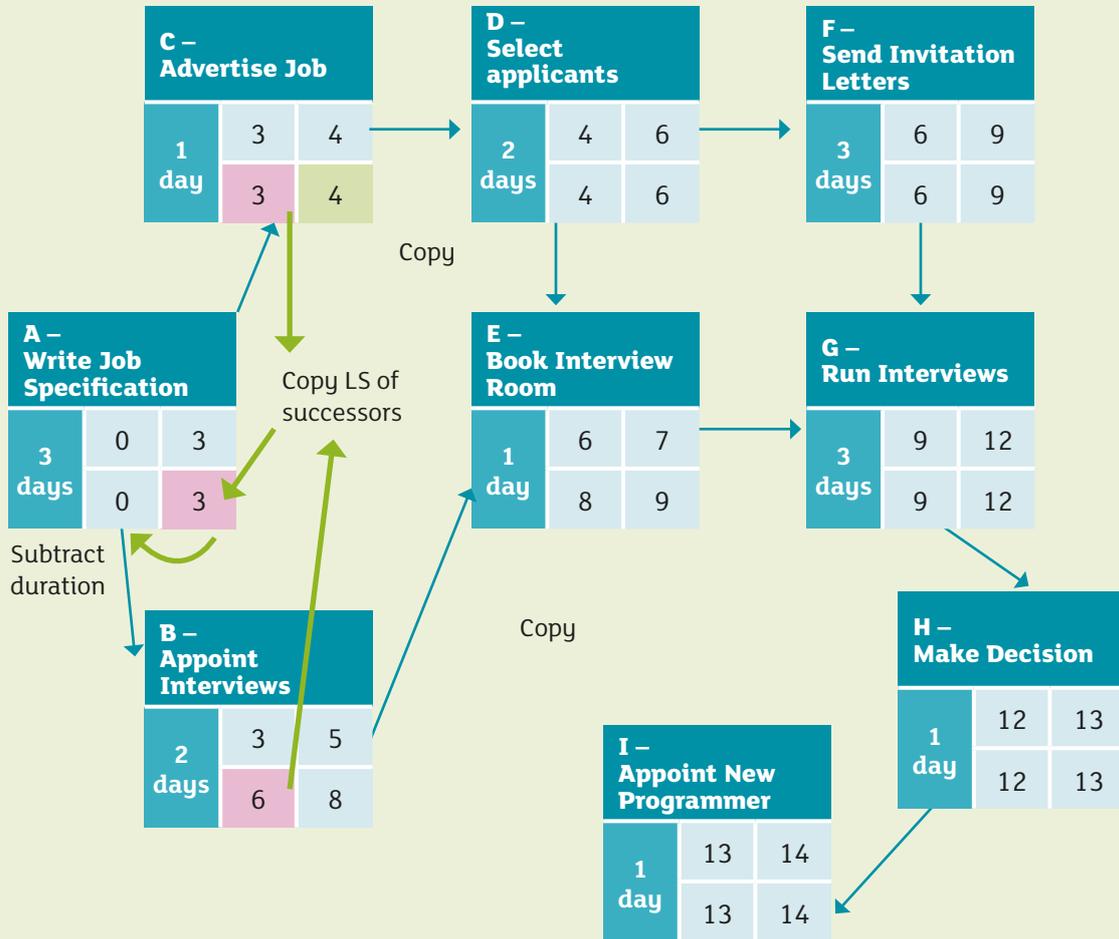

Figure 3.4b – PERT Chart detailing the Backward Pass

The final PERT chart has now been produced and the critical path is highlighted – it can be seen that the ES and LS match as do the EF and LF. The critical path contains the tasks A, C, D, F, G, H and I. The project manager knows that if there is a delay in any of these tasks the overall project schedule would be delayed too.
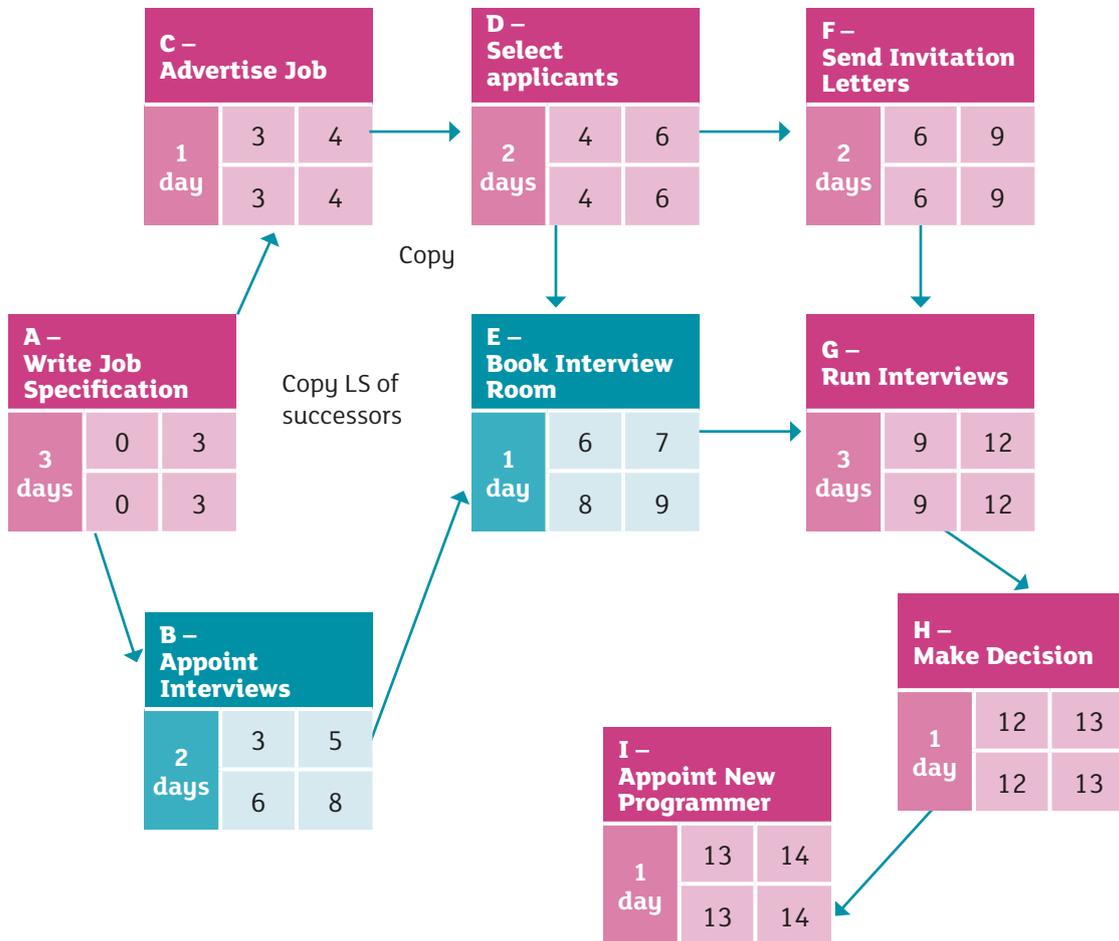
C – Advertise Job		
1 day	3	4
	3	4

D – Select applicants		
2 days	4	6
	4	6

F – Send Invitation Letters		
2 days	6	9
	6	9

Copy

A – Write Job Specification		
3 days	0	3
	0	3

Copy LS of
successors

E – Book Interview Room		
1 day	6	7
	8	9

G – Run Interviews		
3 days	9	12
	9	12

B – Appoint Interviews		
2 days	3	5
	6	8

H – Make Decision		
1 day	12	13
	12	13

I – Appoint New Programmer		
1 day	13	14
	13	14

Figure 3.5 – The completed PERT Chart with the Critical Path highlighted.

Calculation of Float

Float or slack refers to the amount of time that activities can be delayed before there is an impact on the schedule. For example, the Earliest Start date for Task B is 3 and the Latest Start Date is 6. This means that starting task B can be delayed by 3 days without an impact on the overall schedule. The float is said to be 3 days.
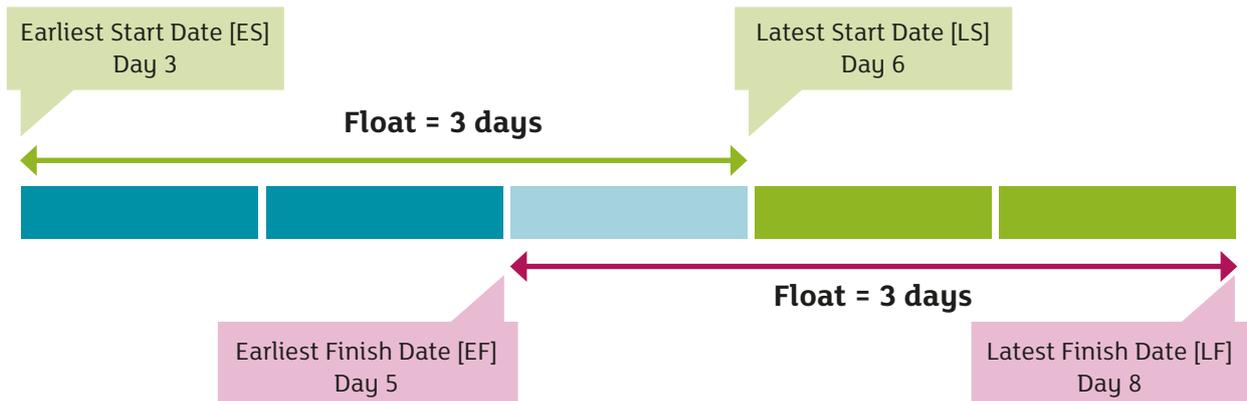

Figure 3.6 – Calculation of Float.

The calculation of the float on a PERT chart can be achieved by subtracting the ES from LS or the EF from the LF. This is shown in the table below. Note that tasks on the critical path have no float. They cannot be delayed without the schedule being affected.

ID	Task	Float (Days)
A	Write Job Specification	0
B	Appoint Interviewers	3
C	Advertise Job	0
D	Select Applicants	0
E	Book Interview Room	2
F	Send Invitation Letters	0
G	Run Interviews	0
H	Make Decision	0
I	Appoint New Programmer	0

Table 3.11 – Calculation of Float using PERT Chart.

Monitoring the Project using the PERT chart

The PERT chart can be used to see what happens if there is a delay in one of the tasks. Consider what would happen to the schedule if:

- **A task on the critical path is delayed.** This will always affect the estimated date for completion. For example:

  – **Task G Run Interviews actually lasted 4 days, rather than the estimated 3 days?** As there is no float the delay will impact the schedule making it 1 day late.

- A task not on the critical path is delayed. It is necessary to know how much it is delayed as there is a float for these tasks. There are two situations, one when the delay is less than or equal to the float and it will not affect the overall schedule and another when the delay is greater than the float and it will impact the schedule making the overall completion date later.

– **Task B: Appoint Interviewers actually lasted 3 days, rather than the estimated 2 days?** The whole project should not be delayed as there is a float of 3 days and it is only 1 day late (even if it lasted 5 days instead of 2 days the schedule would not be affected).

– **Task B: Appoint Interviewers could not start until day 7, 4 days later than expected?** The whole project will be delayed by 1 day. Task B is 4 days late, but it only has 3 days float.

Further elaboration of delays to events is shown in the Gantt chart. The red bars have been added to illustrate actual progress and task B and E are shown with added LS and LF, shown in green.
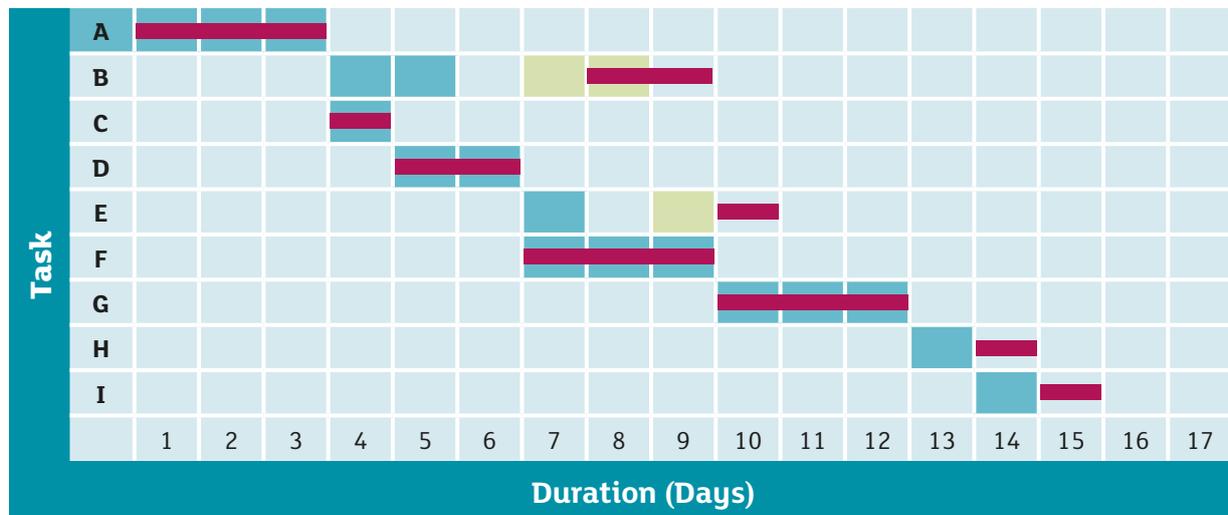

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17

Table 3.12 – Gantt Chart showing delays.

Tasks C, D and F which are not dependent on task B being completed have gone ahead as planned. Task E which does depend on task B has been delayed by 3 days (1 day after its latest start date) and this results in tasks G, H and I also being delayed by 1 day. The whole project has a new estimated duration of 15 days (1 extra day required). This was all because task B started one day after its latest start date.

</> In Summary

Creating a PERT chart:

START	First Task: Insert zero for start of project into ES. Add duration for EF.
FORWARD PASS	• Work Left to Right. • Along top boxes ES and EF. • Look at predecessors and if more than one choose highest value of EF. • Copy highest value into ES. • Add duration for EF.
DURATION OF PROJECT	• Last Task, Look at EF. • Copy into LF.
BACKWARD PASS	• Work Right to Left. • Along bottom boxes LF and LS. • Look at successors and if more than one choose lowest value of LS. • Copy lowest value into LF. • Subtract duration for LS.
CRITICAL PATH	• Those tasks where: ES=LS and EF=lf; • Float is Zero

Table 3.13 – Steps to create a PERT Chart.

Some definitions:

Milestone	Scheduled event that indicates the completion of a deliverable – measurable and observable; progress markers of zero duration (no work, consumption associated with them).
Critical Path	Longest sequence of activities in a project each of which must be completed on time for the project to finish on the due date.
Task Dependency	A task dependency specifies which activities control the scheduling of another. The predecessor determines the scheduling of the dependent, the successor.
Float	Also called slack. The amount of time an activity can be delayed without causing a delay in subsequent tasks or the whole project. LS-ES or LF-EF.

Table 3.14 – Definitions used in a PERT Chart.

Advantages of Gantt versus PERT charts

Gantt	PERT
Simple to create and understand.	Dependencies between tasks are explicitly shown.
Good communication tool for a range of stakeholders, especially those without project management experience giving good visual overview of project.	Critical Path easy to identify.
Good for all team members as they can easily see all tasks that need to be completed and progress made.	Float/Slack easy to calculate.
Easy to see which tasks are concurrent; i.e. can run simultaneously.	Good for project managers who want to plan, monitor and control the project as it identifies high priority tasks on the critical path and float.

Table 3.15 – Advantages of Gantt Chart versus a PERT Chart.

Questions

1 Place a tick beside any of the following statements that could be regarded as a characteristic of a project.

1	Temporary	
2	Goes on Indefinitely	
3	Requires resources	
4	Unique	
5	Repetitive	
6	Planned	

**2** Place these project management activities in the appropriate phase of the project lifecycle.

A. Create Project Plan.
B. Record Lessons Learnt.
C. Estimate Budget required.
D. Celebrate Success.
E. Feasibility Study.
F. Take Corrective Action.
G. Determine Variance (Hint: Actual Figures compared to Estimated Figures).
H. Determine the amount of work completed.
I. Create the Terms of Reference.
J. Motivate the Team.
K. Estimate duration of tasks by examining similar projects.
L. Identify Team Members with the appropriate skill sets.
M. Ensure that procedures and standards are followed.
N. Ask staff to complete timesheets.

Initiation	Planning	Execution	Closure

? Questions

3 Name and place the 3 major constraints that must be managed on the Project Manager's Iron Triangle.

The Project Manager's 'Iron Triangle'
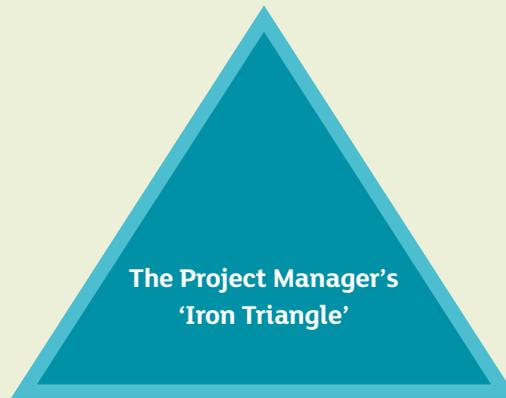
4 Tick all the activities that are carried out by a person with the sole role of Project Manager.

1	Create ER Diagrams.	
2	Perform Unit Testing.	
3	Create a Gantt Chart.	
4	Identify and assess risks.	
5	Check that the team has created a test plan.	
6	Produce Storyboards.	
7	Ask stakeholders how often they would like information about the project.	
8	Check the number of defects found in acceptance testing.	
9	Code the software.	

? Questions

5 Place a tick beside items that might be included in the project plan.

1	How often meetings with the customer will be held.	
2	Team structure and roles.	
3	Objectives of Project.	
4	Test data.	
5	Schedule of tasks.	
6	Planned resources and their costs.	
7	ER diagrams.	
8	Who will identify risks and what will be contained in the risk log.	
9	The configuration management software used to control versions.	
10	Emails from the customer.	
11	A definition of the scope/work to do in the project.	

6 Describe two ways in which managing an Agile project differs from managing a traditional project.

Difference 1

....

....

Difference 2

....

....

? Questions

7 Choose appropriate words from the list below and insert them into the spaces provided in the paragraph that follows.

tasks	PORT	risk	finance	dependencies
availability	schedule	variable	critical	prototyping
PERT	scope	fixed	requirements	duration
timeboxing	resources	productivity	parallel	milestones

A project manager can manage the _____ (work to be completed) of the project by minimising changing customer _____. In agile projects time and cost is _____ and scope is managed by the use of a technique called _____ which results in only the higher priority requirements being implemented. Project managers typically break the scope down into smaller _____ and estimate a _____ for each. They identify the _____ (staff, hardware, software etc.) and their _____ so that they can allocate them to each task. Software such as Microsoft Project may be used to create a _____ for the project. It allows _____ between tasks to be shown and the _____ path to be highlighted. Gantt or _____ charts can be drawn.
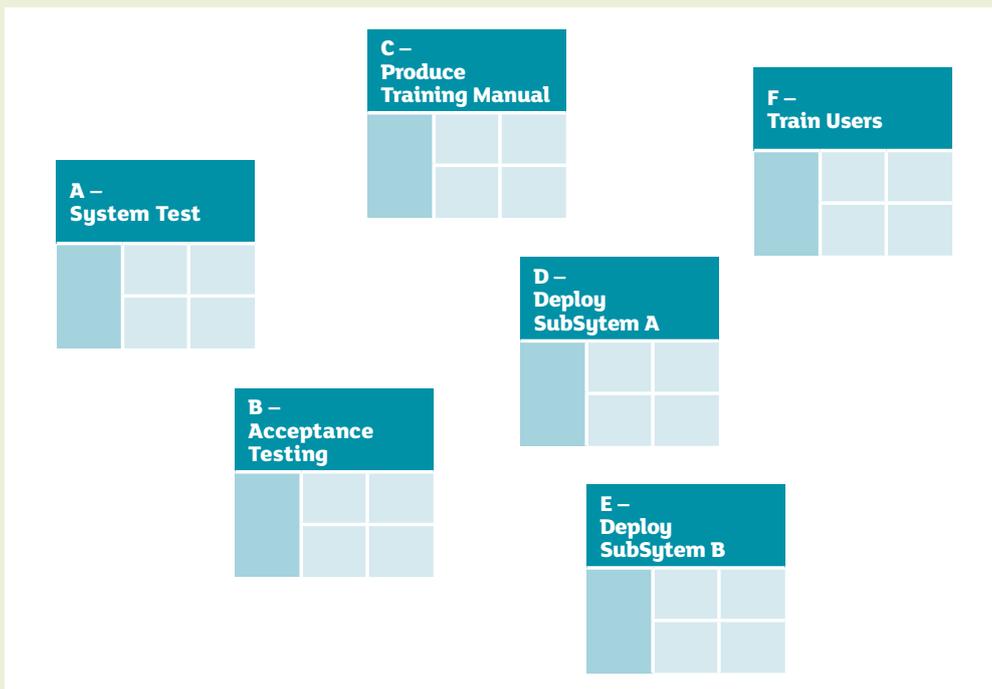
? Questions

8 Transform this task list into a Gantt and PERT chart using the templates provided, determine the total duration of the project, highlight the critical path and determine the amount of float in each activity.

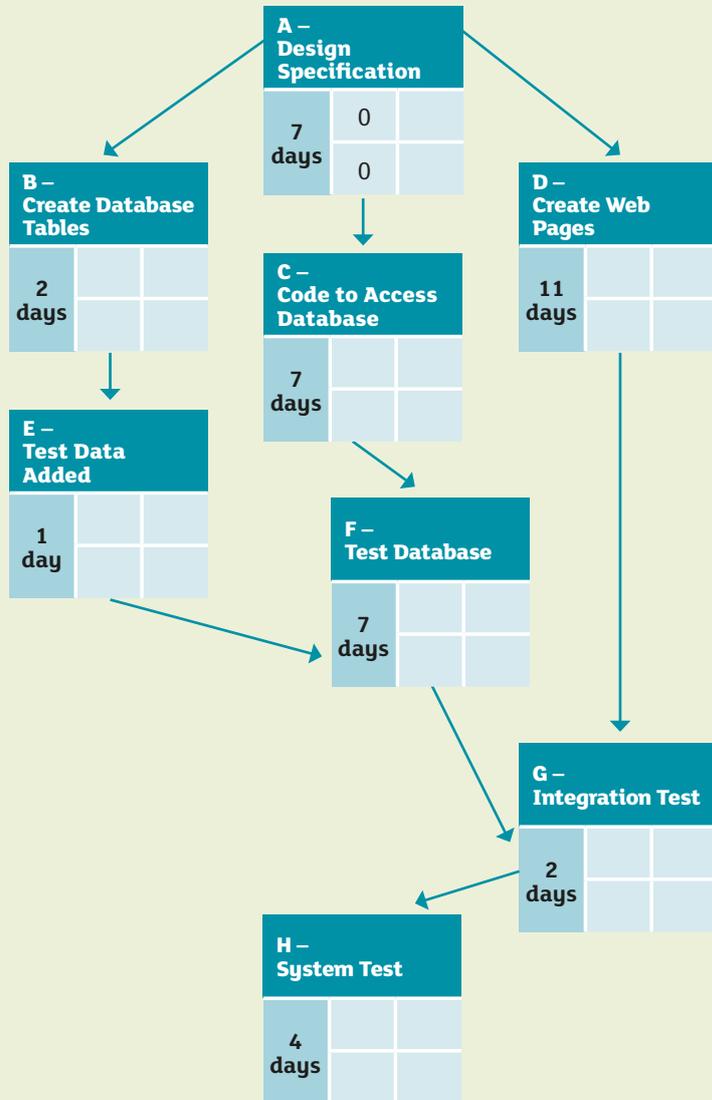| ID	Activity	Duration (days)	Predecessors	Float
A	System Test	7	---------------	
B	Acceptance Testing	3	A	
C	Produce Training Manual	6	A	
D	Deploy Subsystem A	6	B	
E	Deploy Subsystem B	5	B	
F	Train Users	3	C;D;E	
	Total Duration of Project (days)			

? Questions

9 Examine the PERT chart below and place the word TRUE or FALSE into the space beside each statement in the table below.
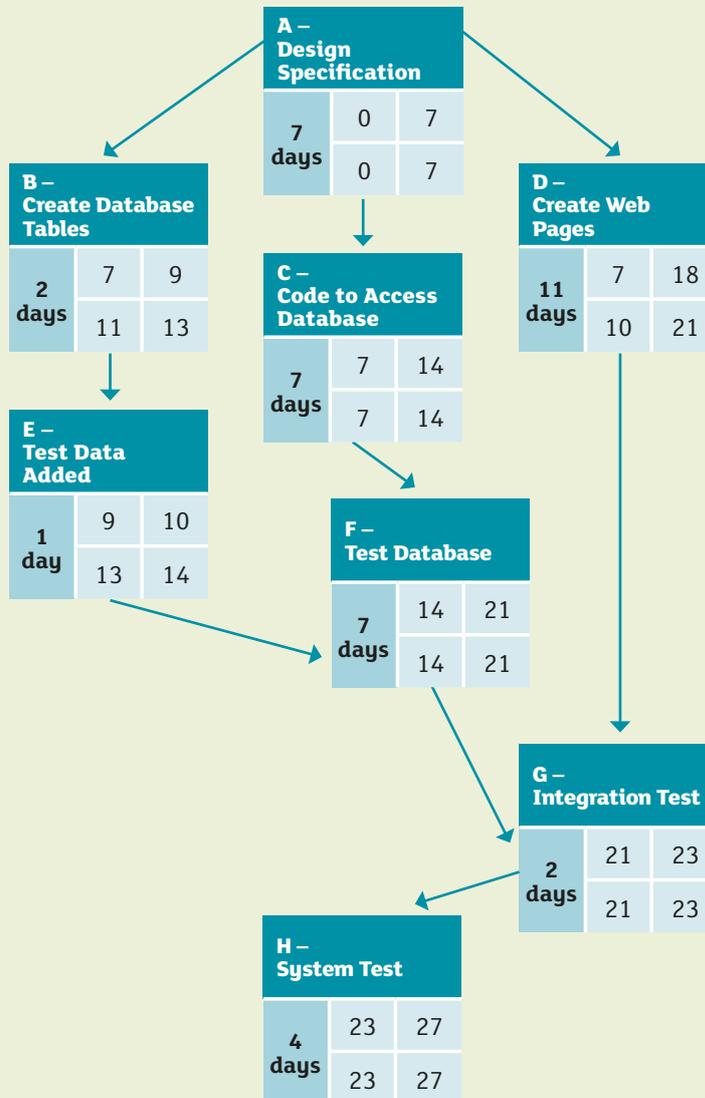
	STATEMENT	TRUE/FALSE
I	The total project duration is 23 days.	
II	Activity G is dependent on activities F, D and H.	
III	The float available in activity E is 1 day.	
IV	The critical path is given by the activities A, C, F, G, and H.	
V	If activity B is delayed by 5 days the estimated finish date would increase by 1 day.	
VI	The predecessor of task C is task A	
VII	The successor of task E is B.	

❓ Questions

10 Without looking at the answers in question 9, recreate the PERT chart.

A – Design Specification

7 days	0	
	0	

B – Create Database Tables

2 days		

C – Code to Access Database

7 days		

D – Create Web Pages

11 days		

E – Test Data Added

1 day		

F – Test Database

7 days		

G – Integration Test

2 days		

H – System Test

4 days		

? Questions

11 Look at the job description below for a project manager. Create a list of ten questions that might be asked in an interview for such a post.

Permanent Full Time Project Managers
Belfast (Northern Ireland)
Permanent full-time
Salary: £35000 - £45000

Key responsibilities:
- To act as the Project Manager for one or more projects within their allocated programme of work.
- To produce and maintain project management control documentation required for the effective initiation, delivery and closure of each project in accordance with the governing Project Management Methodology; working, where required, with other project managers to deliver best practice across all activities.
- To identify and acquire required resources, managing the project team on a day-to-day basis building, coaching and motivating team members, to ensure productivity and utilisation are maximised.
- Produce Project Plans, from project initiation, through delivery and handover into support; agreeing them with the appropriate project governance bodies; executing the plans, monitoring progress and taking the necessary corrective actions; identifying and mitigating risk, resolving issues and devising contingency plans.
- Manage and control project budgets ensuring all expenditure, commitments and payments are properly authorised, in accordance with delegated authority requirements
- Report progress at agreed intervals to the relevant governance body, advising where plan tolerance levels are exceeded and recommending the necessary corrective action.
- Chair internal and external meetings, workshops and presentations, liaising with business and IT teams to achieve project delivery.
- Plan, schedule and manage project change control procedures; maintaining records of change and acceptance certificates.
- Working closely with the Project Management Office to ensure that resource availability and project reporting information is maintained.

Essential Experience/Skills:
- Minimum of 3 years Project Management experience within the past 5 years, in a multi-disciplinary environment.
- Educated to degree level or equivalent demonstrable business experience.
- PRINCE 2 Practitioner or equivalent Project Management qualification.
- Experience of managing ICT infrastructure and/or application related projects.
- Experience of adapting the chosen project management methodology to the needs of the project.
- Experience of establishing, leading, motivating and managing cross-functional and multi-disciplinary teams, delivering projects in a managed service environment.
- Evidence of effective planning and organisational skills through the use of project management tools and techniques, including the definition of deliverables and establishment of governance models.
- Evidence of achievement of qualitative and quantitative targets, as set against project or work-stream plans.
- Evidence of responsibility for project or work-stream reporting and governance, including management of key stakeholders and controlling budgets.
- Experience of managing issues and risks, ensuring appropriate mitigating actions are in place.
- Experience of assessing task effort and contributing to, or the formulation of, resource estimates for bids and other pre-sales submissions, including building these into an overall delivery plan.
- Expert in the use of MS tools including Project, Excel, Word, Visio and PowerPoint.
- Evidence of having understanding and application of agreed quality principles.