



Leaving Certificate

Technology

Project Management

Student Workbook

Project Management

Student notes

Introduction

Project management is the name given to a number of techniques used in industry to manage complex activities such as road and bridge building. However, they can also be used for simpler projects such as 'Design and Make' projects found in the Technology room.

Project management is different to the 'Design Process' that you are already familiar with. It is different because it focuses on the *planning of activities* and the *management of resources* and not on the design aspect of the project. It is important to know that the project management tools described here are not meant to replace the design process. Instead, they are used alongside it as an aid to the smooth running of the project from design through to manufacture and testing.

The aspects of project management that are of most interest to us here are those concerned with *project planning*.

Before looking at the project planning tools, it is helpful to look at what makes a project different from other tasks you may have met in the classroom.

All projects have a number of things in common. These are:

1. A project has a specific *deliverable* item when complete
2. This project is aimed at meeting a *specific need or purpose*. I.e. the project brief.
3. There is usually a *specific due date for completion* of the project.
4. The project can be broken down into a number of tasks that need to be completed in order to complete the project.

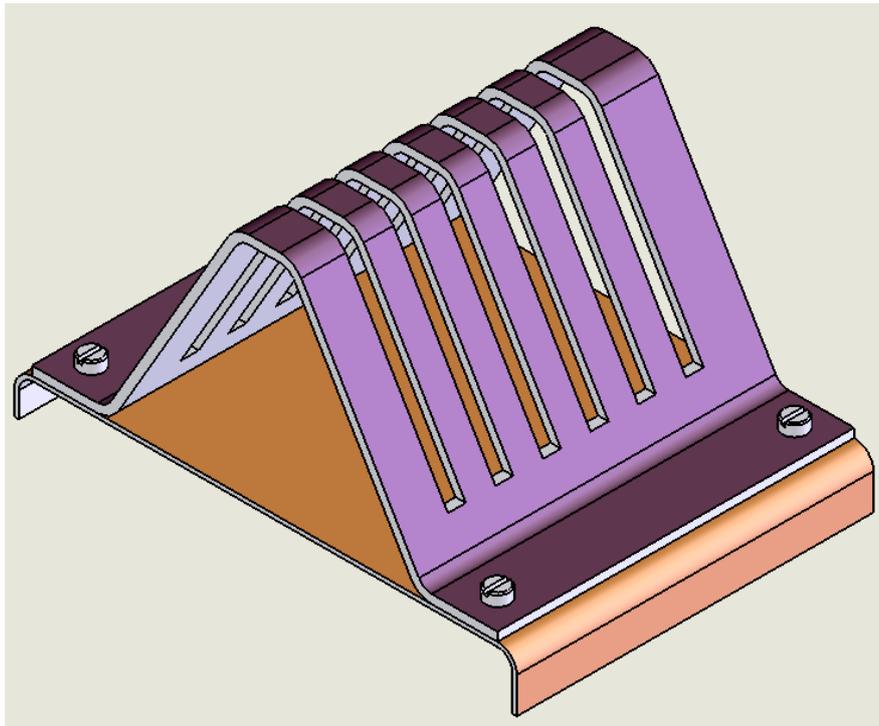
If a project is broken down into a number of tasks, then a plan can be made for carrying these out. A good project plan will allow for any delays and problems that might occur and will make sure that all the tasks are carried out in the correct order, without missing or duplicating any of them.

The project plan:

A project plan can be as simple as a list of tasks that need to be carried out or it can be more complex depending on how project itself is.

The first stage of planning a project is to define the *objectives* or *goals* of the project. You would usually do this during the 'analysis of the brief' stage of the design process, or for simpler projects, the tasks can be found from examining the drawings you may have been given. Once you have determined what the *primary tasks* are, they can usually be broken down again into *sub-tasks*.

Example 1:

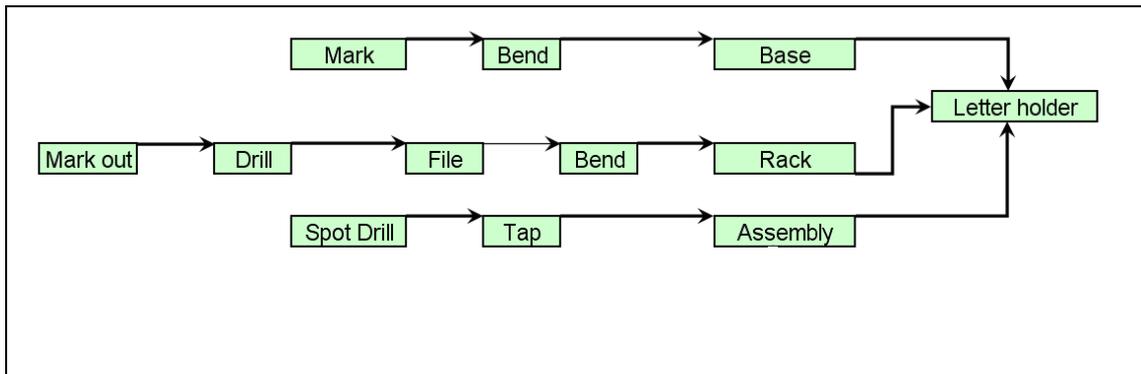


For the letter rack project shown, make a list of the tasks that need to be carried out in order to complete it.

Item	Step	Task Type
Holder		Primary Task
	Mark Out	Sub Task
	Drill holes	Sub Task
	File slots	Sub Task
	Bend	Sub Task
Base		Primary Task
	Mark out	Sub Task
	Bend	Sub Task
Assembly		Primary Task
	Spot holes on base	Sub Task
	Drill & Tap	Sub Task
	Assemble	Sub Task

This type of analysis is known as a *Work Breakdown Structure (WBS)*. The WBS can be drawn as a chart that shows the primary tasks associated with the project and then the sub tasks that form them. We can draw a diagram for this example as follows:

Work Breakdown Structure (WBS) for the Letter Rack.

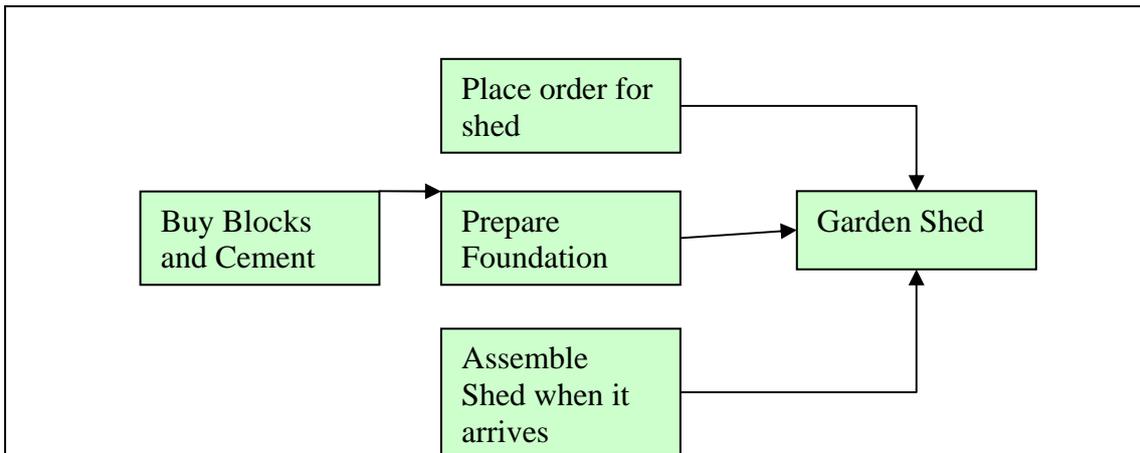


Another Example:

Draw up a Work Breakdown Structure for the erection of a garden shed. The shed will come prefabricated but will need to be assembled when it arrives. A foundation will need to be prepared for it beforehand.

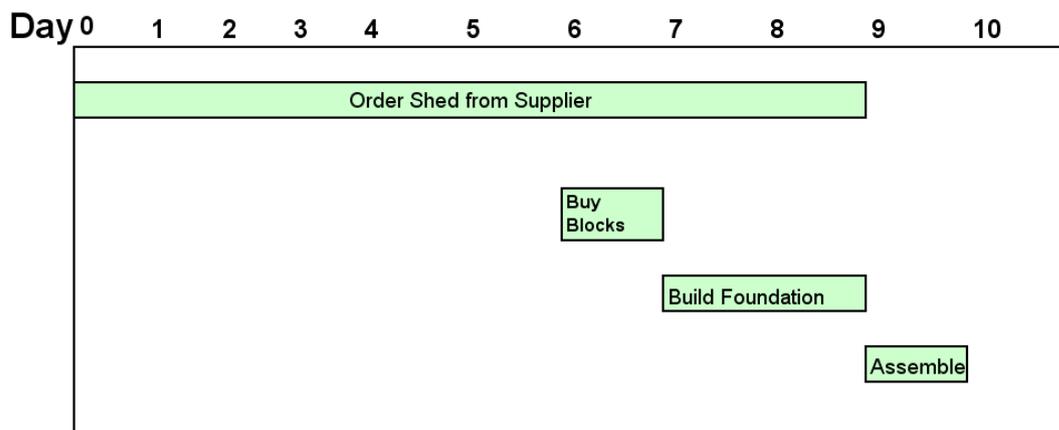


Work Breakdown Structure for the Erection of a Garden Shed



Gantt Charts – a preview

For simple projects like this one, the activities can be arranged along a timeline using a *Gantt chart* to show the timing for each of the tasks. A Gantt chart is simply a horizontal bar chart showing the start and finish time of the tasks. It is a useful aid when planning the tasks in a project.



Notice that the delivery time for the shed is nine days and the total project time is ten days. The times estimated for the other tasks are: one day for buying the blocks and cement needed for the foundation, two days to make the foundation and one day to assemble the shed once it arrives. Using the Gantt chart, the start times for each of these activities can be chosen so that the foundation is ready just in time as the shed arrives. Of course, the foundation could have been started at an earlier time and allowed to age while waiting for the shed to arrive if this was needed.

It is important to realise that the tasks involved in building the foundation are taking place in parallel to the order and delivery of the shed, but the assembly task only takes place once the shed has arrived and the foundation is complete.

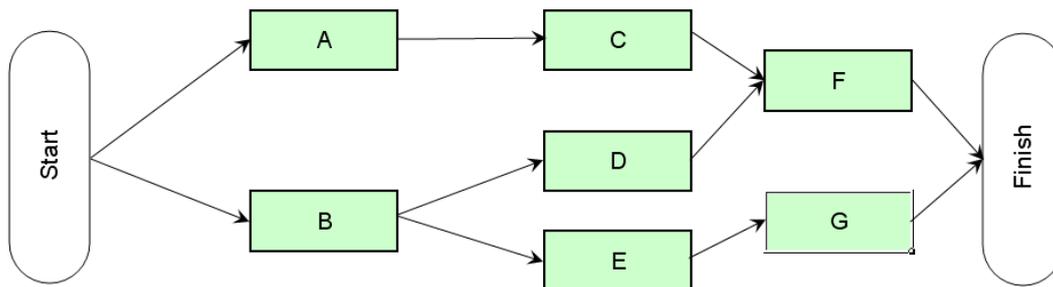
Network Diagrams and the Critical Path

For projects that involve more than just a few steps, it is usual to list the tasks and then to create a *network diagram* that shows how the tasks relate to one another. A network diagram is useful because it shows the sequence in which each task is performed and which tasks must be completed before others can start.

Some definitions used with network diagrams:

- **Activity** – A task or set of **tasks** required by the project.
- **Network** – Diagram of **nodes** representing activities connected by directional arrows that defines the project and shows the relations between all of the activities. Networks are usually drawn with a 'Start' node on the left and a 'Finish' node on the right.
- **Path** – A series of connected activities in the network
- **Critical Path** – the set of activities on a path from the project's start event to its finish event that if delayed, will delay the completion date of the project.
- **Critical Time** – The time required to complete all activities on the critical path.
- **Predecessor** – Any task that must be finished before a particular task can start.

A network diagram is a type of flow-chart that shows how each task depends on the others that relate to it. For example, in a simple project, it might not be possible to carry out a bending operation until all the holes are drilled on a particular component. The network diagram is used to show these relations clearly in a simple format. The network diagram for a particular project might look like the following.



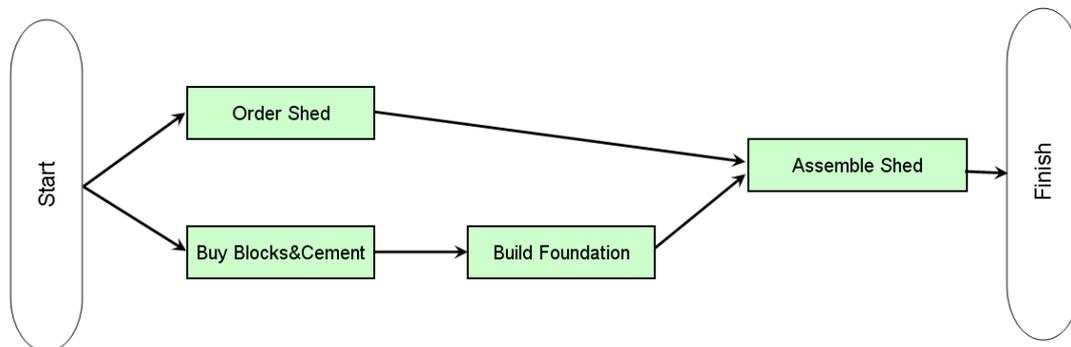
In this example, for simplicity, the activities have been given letters to identify them, although it is more common to use a descriptive name such as those used in the Work Breakdown Structure. In the example above:

- Task 'C' cannot start until task 'A' is complete.
- Task 'B' must be finished before either 'D' or 'E' can start.
- Task 'F' must wait until both 'C' and 'D' are complete before starting and so on.

Drawing a network diagram is not very difficult. Usually you will need to arrange and then re-arrange the tasks until the most efficient way of ordering them is found. To make this easier, each task can be written on a piece of paper (such as a 'post-it' note) and then stuck to a whiteboard. Lines and arrows can be drawn between the pieces of paper to show which tasks follow on from others. The pieces of paper can be re-arranged and the lines re-drawn until the most efficient way of ordering them is found.

Example:

Draw up a network diagram for the garden shed project described previously.



Notice that in comparison to the WBS diagram, the network diagram shows which task follows on from which.

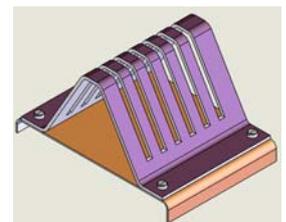
Finding the critical path and the critical time.

While the network diagram is useful in showing the relationships between the tasks, it can be made much more useful if the times taken for each task are added to the diagram. If this is done then the start and finish dates can be calculated for each of the tasks. In the following example, the tasks are named using letters for simplicity.

Returning to the letter holder project that we looked at earlier, the tasks can be stated as in the following table.

Table 1 Finding the Critical Path and Critical Time for the letter holder

Task	Name	Predecessor	Duration
A	Mark Holder	-	1 (Class)
B	Drill Holes	A	1
C	File Slots	B	2
D	Bend	C	1
E	Mark Base	-	1
F	Bend	E	1
G	Spot holes	C,E	1
H	Drill & Tap	G	1
I	Assemble	H	3



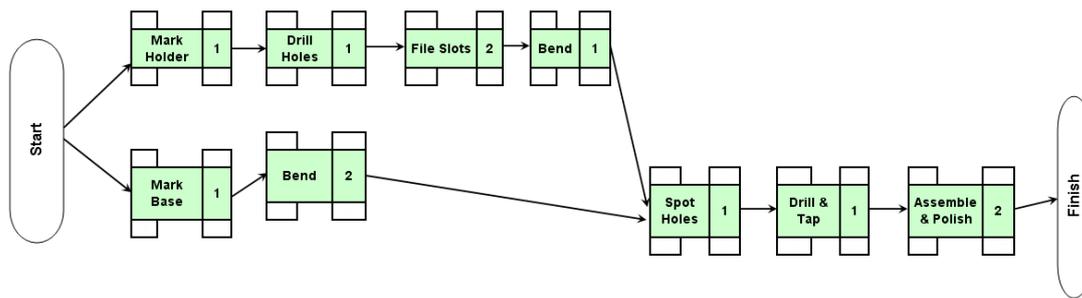


Figure 1 Network showing activities and times

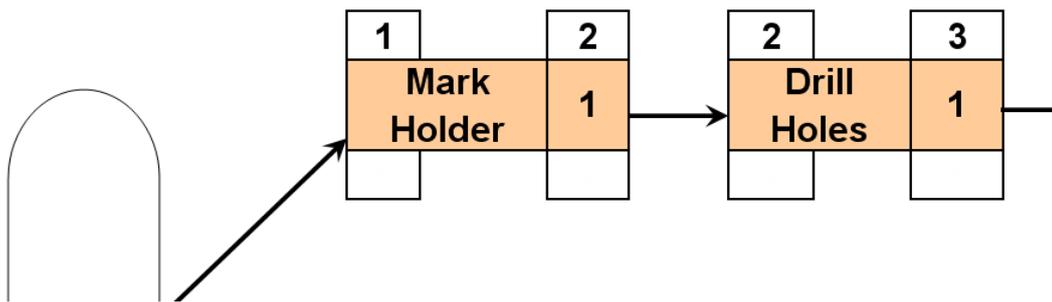
The assumption being made is that at least two people are working on the project as a team. Therefore two tasks can be carried out during the same class simultaneously.

Now that the duration for each task is known, the following information can be added so that the each of nodes now looks like this:

EST		EFT
Activity Name		Duration
LST		LFT

Just above each node it is common to show what is called the *earliest start time* (EST) and the *earliest finish time* (EFT). Just below each node is shown the *latest start time* (LST) and the *latest finish time* (LFT) for the activity.

Looking at the diagram, the earliest time the marking the holder task can start is during the first class period of the project. This is marked on the top left of the node as shown below. The duration of the task is one class period so the earliest finish time for this task is the beginning of period 2. This is the earliest time the following task can commence. The drilling operation will not finish until period 3 when the filing task can commence and so on until period 10 when the project is finished.



In each case, we fill in the times as follows.

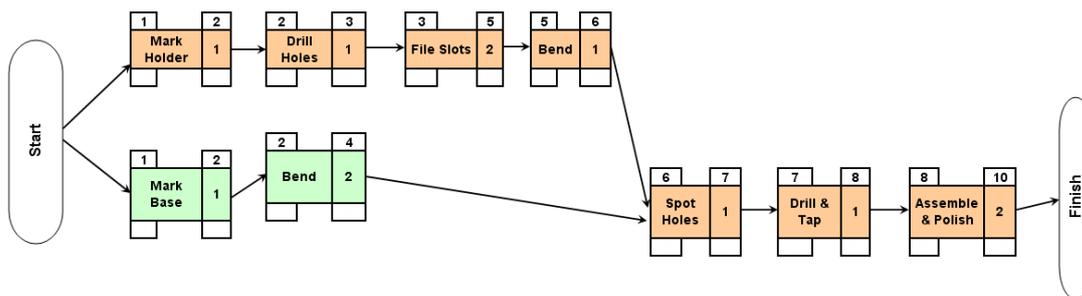
$$EFT = EST + Duration$$

i.e Early Finish Time = Early Start Time + Task Duration

Looking at the second branch in the network diagram, marking out of the base can commence during the first period and filing on the radii can start when this task is complete at the start of period 2. The filing will be complete at the end of period 4.

(Notice however, that the base will not be required until period six when the other part of the project is ready for assembly.)

At this stage all of the early start and early finish times have been complete and the diagram will look like this:



All activities and thus all paths must be completed to finish the project. The shortest time to completion is equal to the longest path through the network, in this case **the path highlighted in orange.**

If any activity on this path is delayed, then the project will be delayed. **This identifies it as the critical path and 10 class periods as the critical time.**

In this example, we found the critical path by beginning at the start node and moving from left to right over the network. This is called a *forward pass* and makes it easy to find the critical path and critical time.

In order to find the LST and LFT for the nodes, a *backward pass* is carried out, beginning at the finish node.

When calculating the latest start and finish times they are found as follows:

$$LST=LFT-Duration$$

i.e Latest Start Time = Latest Finish time – Duration

For the assembly and polish task, the latest finish time is period 10 (the same as the earliest finish time for the project)

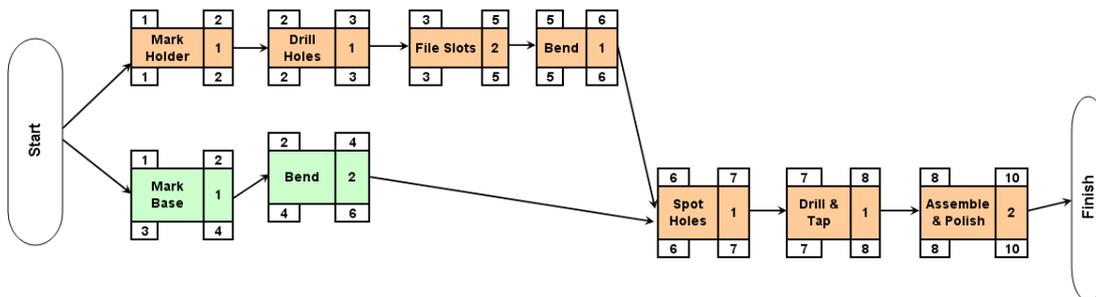
By subtracting the duration of the task, the latest start time will be

$$10-2= \text{class period } 8$$

For the Drill & Tap task, the latest finish time that will not delay the task following it is period 8 i.e. the latest start time for the next operation.

Therefore the latest start time possible will be period 7 and so on for each node.

Notice that the hole spotting operation has two tasks preceding it, i.e. the bending tasks for the rack and the bending task for the base. The latest start time for the hole spotting task is period 6, so this becomes the latest start time for both of the operations that come before it. This gives a late start time of period 4 for the filing task and a late start time of period 3 for marking out the base. In practical terms, this means that these two processes can be **delayed for up to three class periods between them without affecting the finishing date of the project**. This free time is known as *slack* or *float*

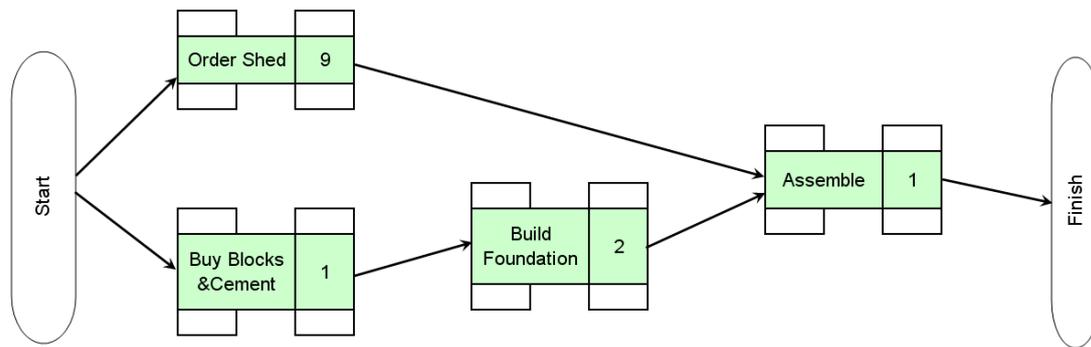


Activity:

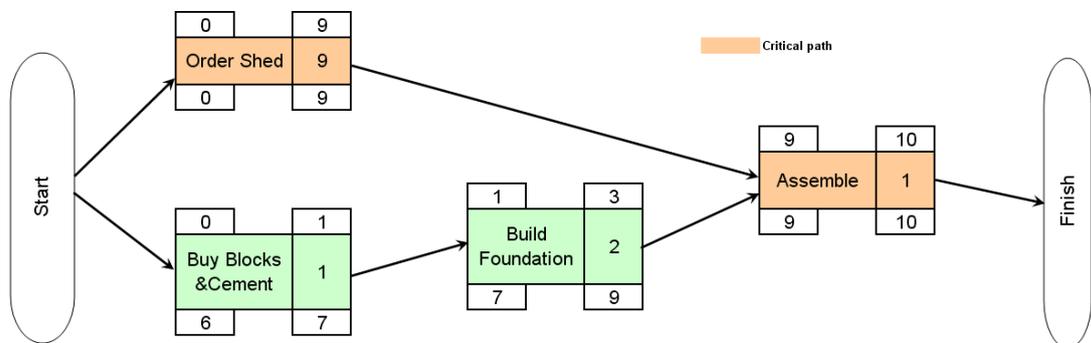
The network diagram below shows the garden shed project with the estimated times for each activity.

Complete the EST/EFT and then the LST/LFT dates for them.

Find the critical path and highlight it.



Solution



Calculating Activity Slack.

While activities on the critical path cannot be delayed without causing the entire project to be delayed, the activities that are not on the critical path can be delayed – within limits – without affecting the finish time. The amount of time that a non-critical task can be delayed without affecting the project is called the *slack* or *float*. The slack for any activity is easily calculated as *the Latest Start Time* minus the *Earliest Start Time* or the *Latest Finish Time* minus the *Earliest Finish Time* i.e.

$$Float = LST - EST = LFT - EFT$$

For any activity on the critical path the late start time and the early start time are the same. i.e. $LST=EST$ and therefore the slack is zero. If any of the activities on the critical path finish later than the EFT the next activity will be delayed and the project will be late.

However, for activities not on the critical path, the LST and EST will differ and this difference is the activity slack.

Activity:

For each of the activities in the garden shed project, write down the slack time.

Task	Slack time
Order Shed	
Buy Blocks	
Build Foundation	
Assemble	

Project Planning for Technology Projects.

In this section, the WBS, Network diagram and Gantt chart will be applied to a typical design & make project in Technology.

Design Brief

Design and manufacture a personal alarm that will incorporate an electronic circuit as well as the manufacture of a suitable casing.

Prior to embarking on the project planning process, the brief will have been analysed and a general plan for the project will have been formulated. The tasks that make up this broad plan will be the basis of the Work Breakdown Schedule

From the analysis of the brief, it is considered desirable to conduct a survey of some sort among potential users to establish what features the device should have before starting any detailed design. However it is clear that an electronic circuit will be needed to produce the alarm sound and some research will be needed in this area before the circuit design can begin.

The first step is to look at the project in terms of the constituent tasks and generate a Work Breakdown Structure that might look like the following:

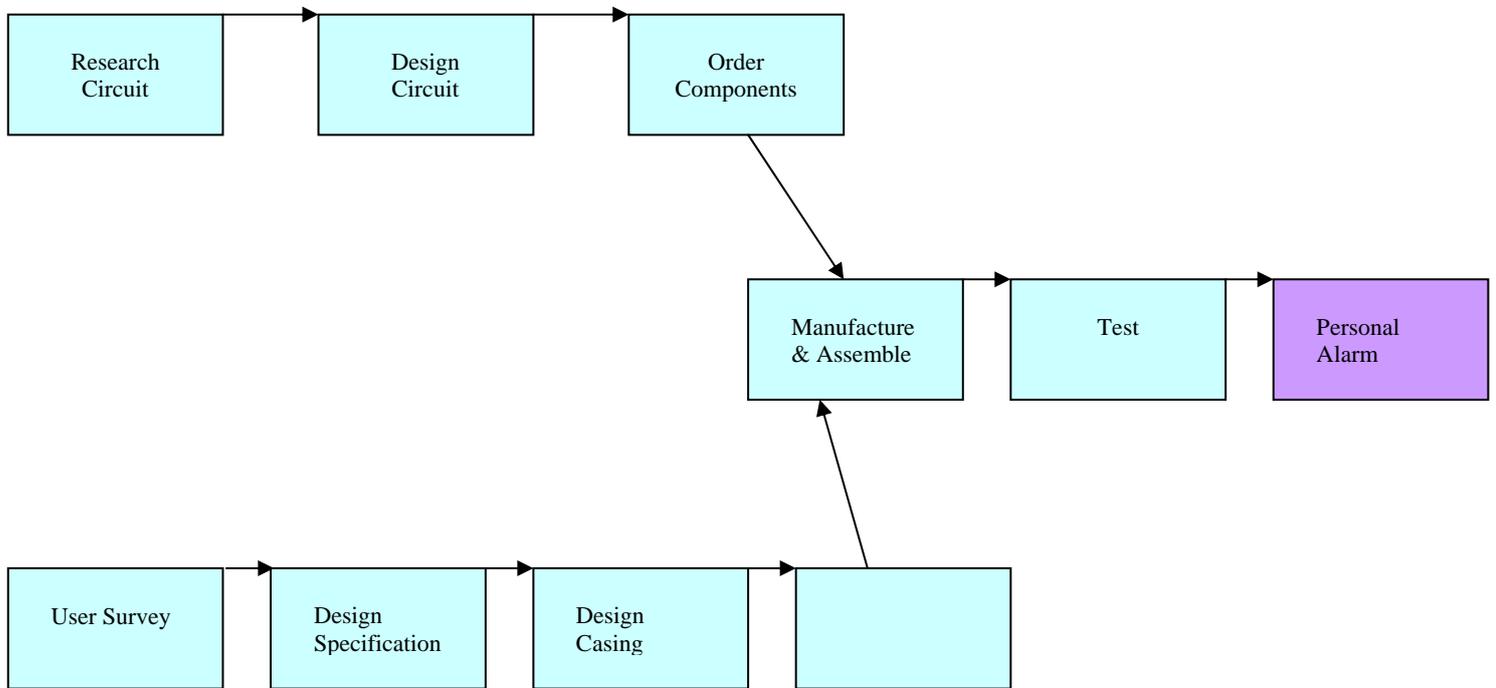


Figure 2: WBS for Alarm Project

The next step is to generate a network table for the tasks in the WBS.

Table 2 Tasks with predecessors for network diagram

Task	Description	Duration (No. of classes)	Predecessor
1	Research Circuit	14	-
2	User Survey	7	-
3	Device Spec	1	2
4	Circuit Design	3	1
5	Order Components	10	4
6	Design Casing	7	2
7	Order Materials	7	6
8	Manufacture and assembly	7	6,4
9	Test	4	8

Once the precedence of the tasks has been established, drawing up the network diagram is straightforward as shown in Figure 3

The critical path diagram is obtained by completing the times for each activity as shown in figure 4.

The critical path is defined by the nodes shaded in pink. The critical time is 38 days. The final step is to create a Gantt chart from the information given in the critical path diagram. This is shown in figure 5. Note that arrows have been added to the chart to show which tasks are dependent on other tasks.

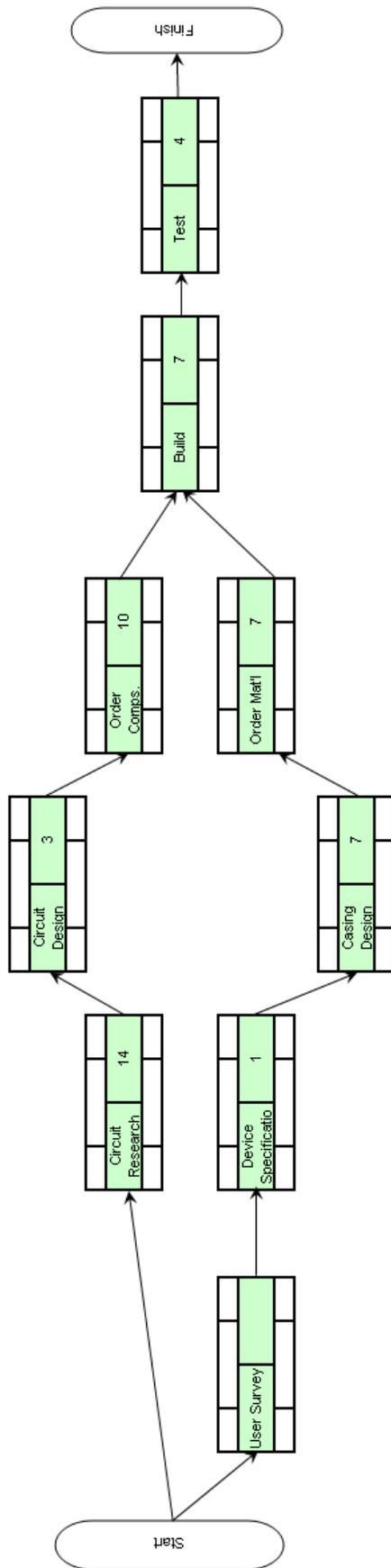


Figure 3 Network Diagram

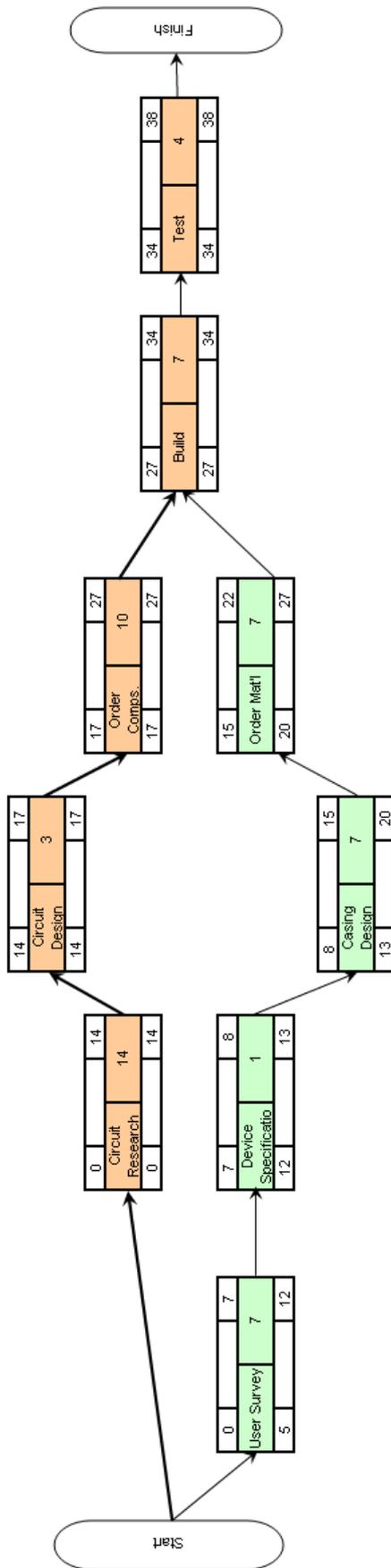


Figure 4: Critical Path Diagram

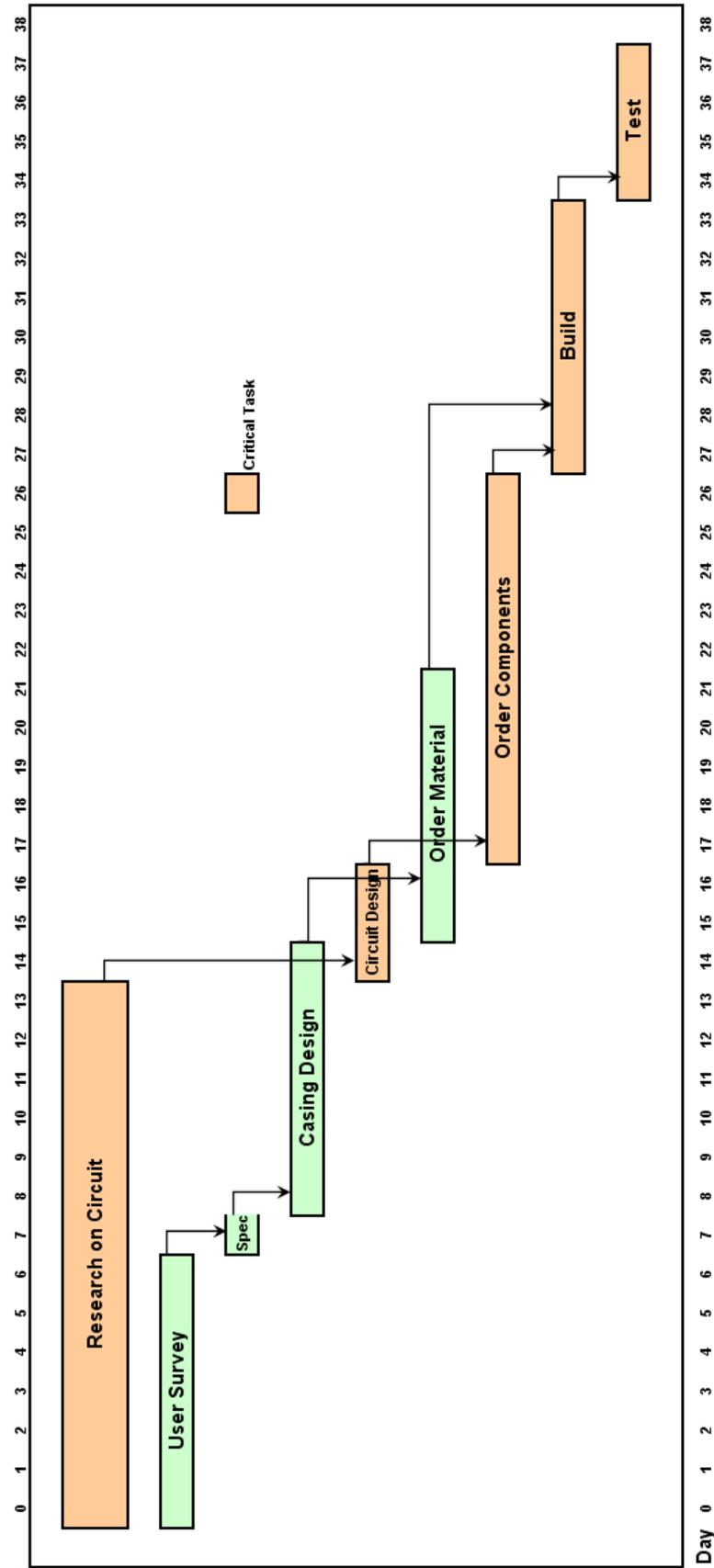


Figure 5: Gantt Chart for Project

Exercise 1:

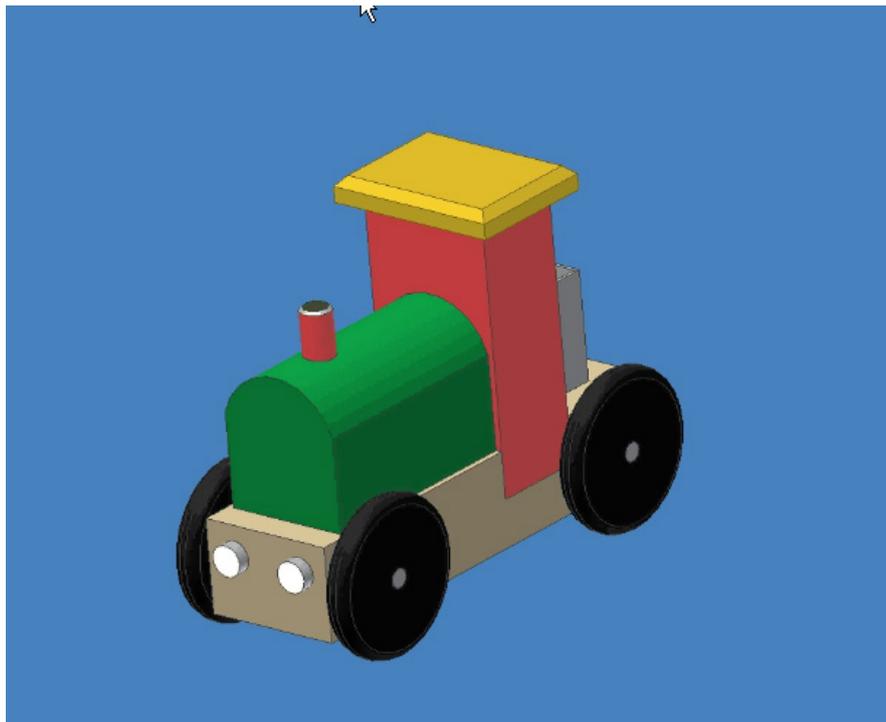
Redraw the Gantt chart on page 4 so that the maximum amount of time is allowed for the ageing of the foundation.

Exercise 2:

Draw up a network diagram for the toast rack on page 2 and the shed on page 4.

Exercise 3:

- For the project shown below:
- List the tasks involved
 - Estimate times for each of them
 - Draw up a WBS for the project
 - Draw a Gantt chart showing the timeline for the project.
 - Try to run as many tasks as possible in parallel.
 - State how long the project will take to complete.



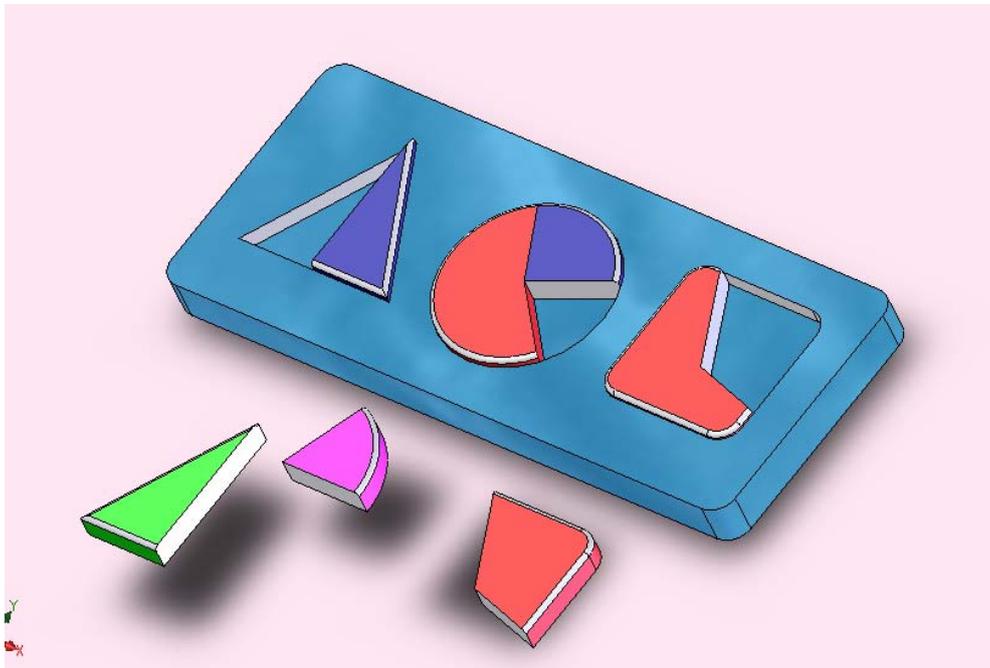
Exercise 4

The project in the picture below is a puzzle aimed at a young child. If all of the pieces are assembled and put into the correct places, a buzzer will sound to mark the end of the game. The details of the electronic circuit are not shown but you will need to take them into account when completing this exercise:

For this project:

- List the tasks involved
- Estimate times for each of them
- Draw up a WBS for the project
- Draw a Gantt chart showing the timeline for the project.
- Try to run as many tasks as possible in parallel.
- State how long the project will take to complete.

Hint: there are three **primary** tasks that need to be completed:



Exercise 5:

Design Brief:

'Design and make a toy that lights up and makes a noise.'

Perform a short analysis of the brief, choose a final solution and list the main features of your solution.

Use these to determine a list of tasks and state how long you expect each to take

Draw up a WBS based on these tasks

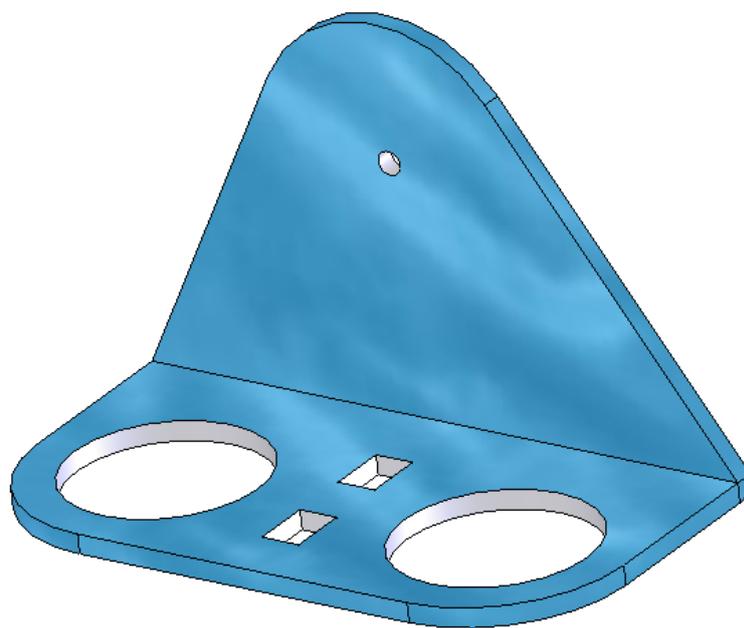
Draw up a Gantt chart, putting as many tasks as possible in parallel.

Estimate how long you expect the project to take to complete.

For each of the projects shown below,

- a) List the tasks involved
- b) Estimate times for each of them
- c) Draw up a WBS for the project
- d) Draw a Gantt chart showing the timeline for the project.
- e) Try to run as many tasks as possible in parallel.
- f) State how long the project will take to complete.

Exercise 6: Bathroom toothbrush and tumbler holder. Material Acrylic.

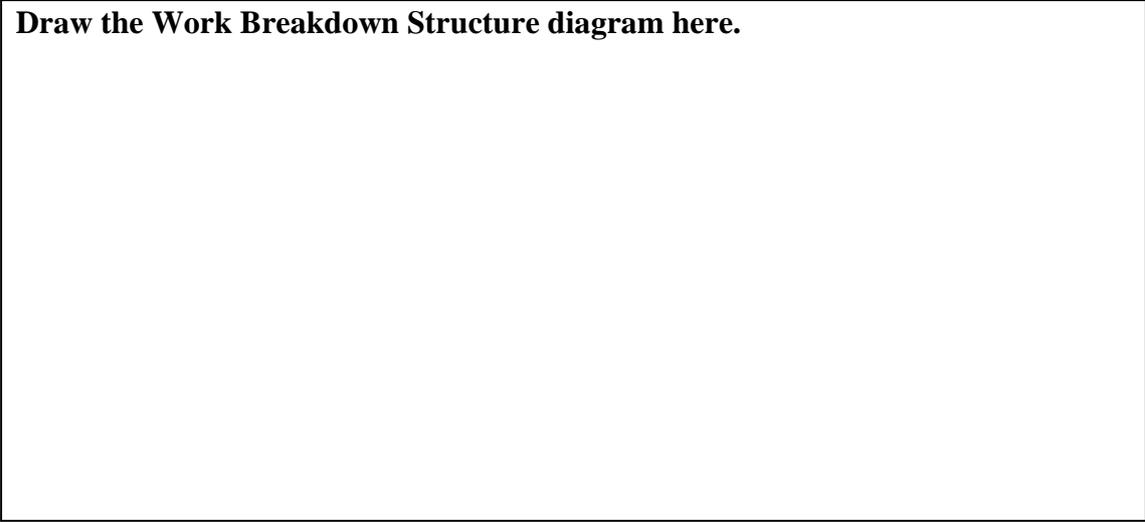


Tasks and Times

Task	Description	Estimated Time in class periods

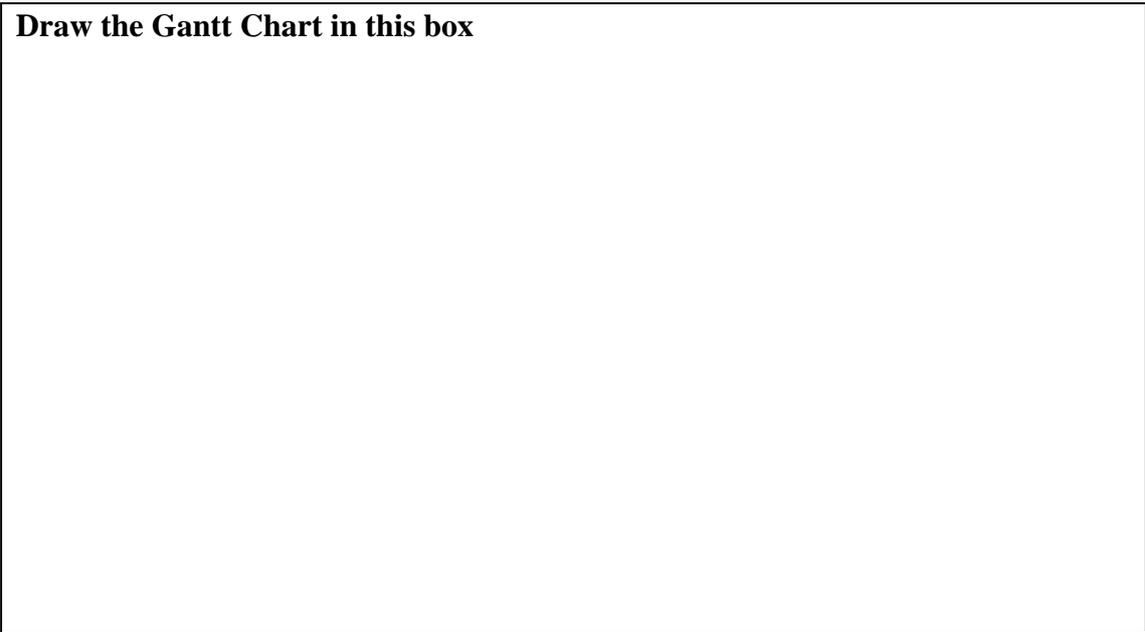
Work Breakdown Structure

Draw the Work Breakdown Structure diagram here.

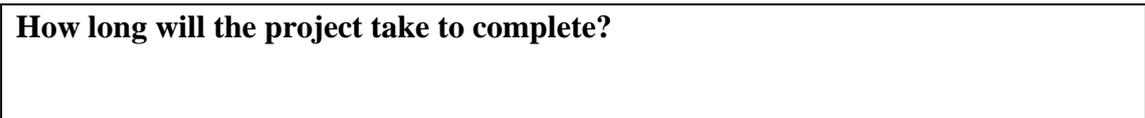


Gantt Chart

Draw the Gantt Chart in this box

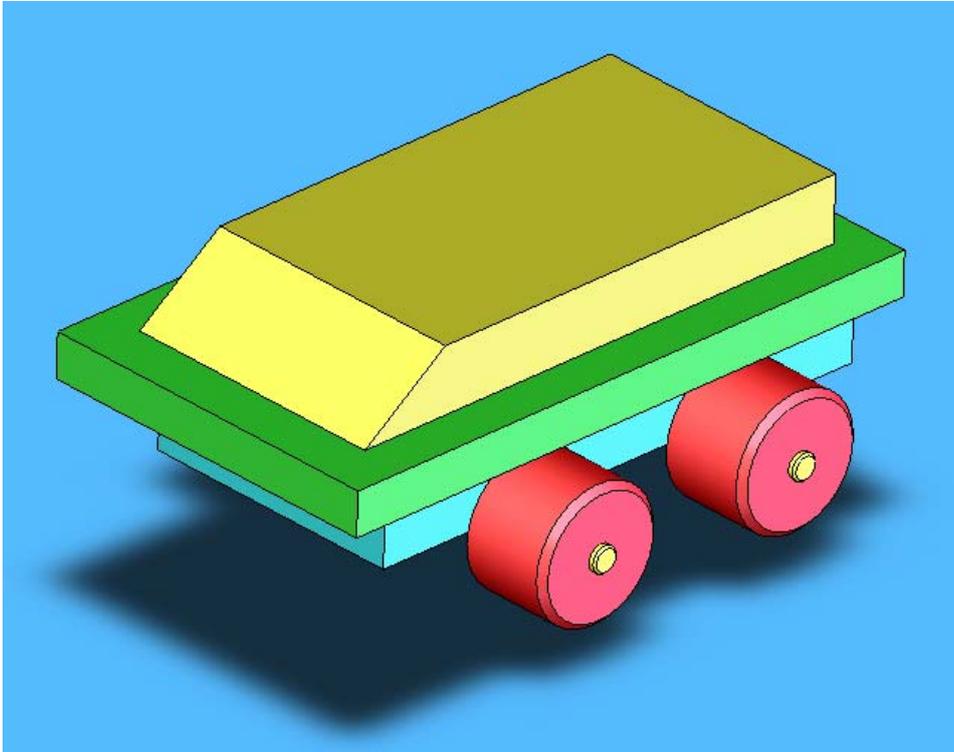


How long will the project take to complete?



Exercise 7: Motorised Vehicle.

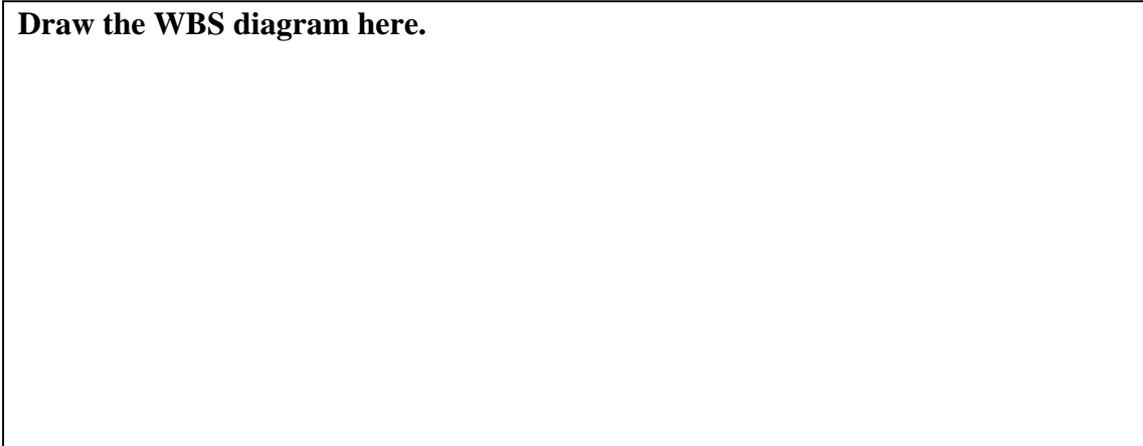
Choose your own materials. The project will need some means of driving it.

**Tasks and Times**

Task	Description	Estimated Time

Work Breakdown Structure

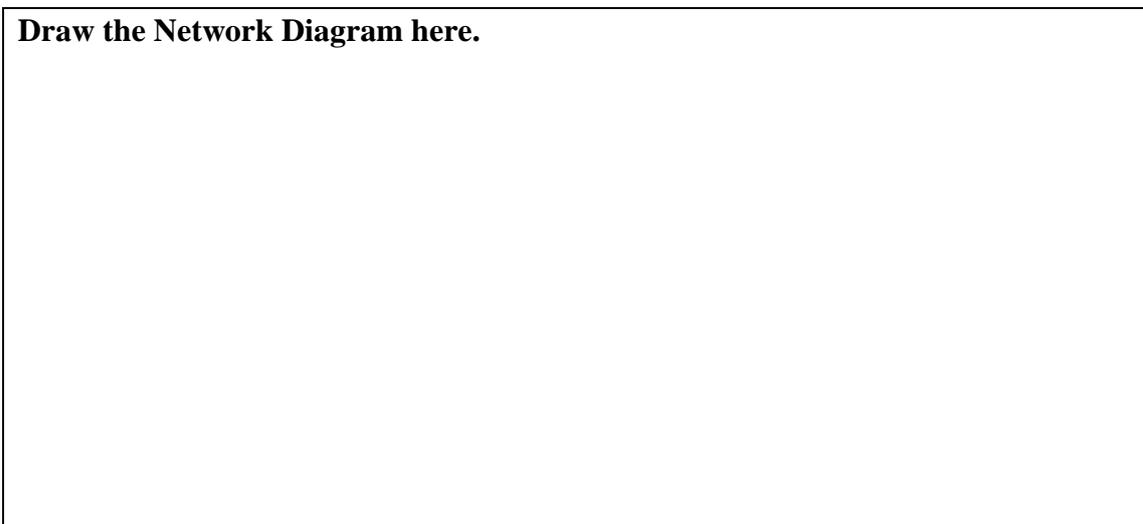
Draw the WBS diagram here.



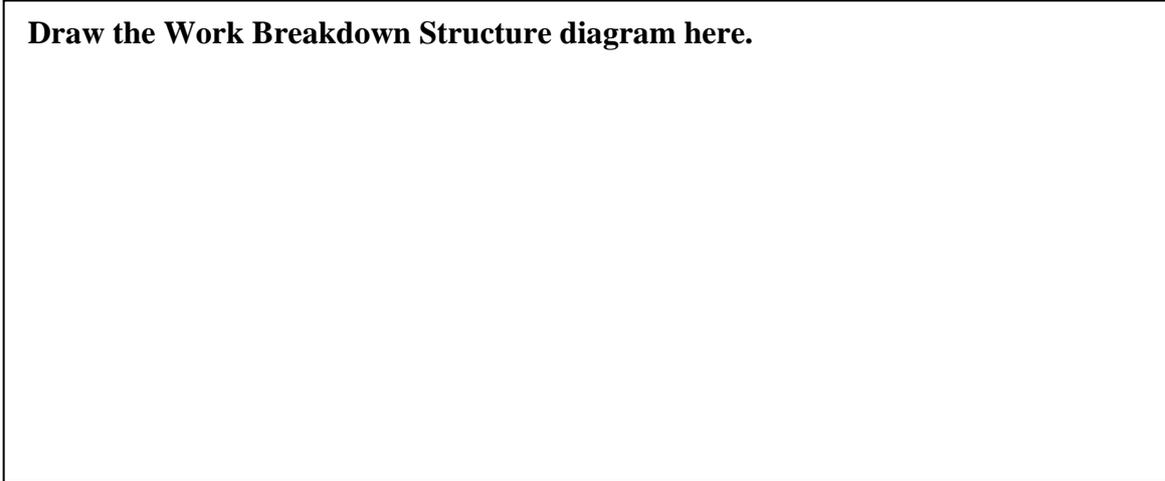
Draw the Network Table here

Task	Description	Predecessor

Draw the Network Diagram here.

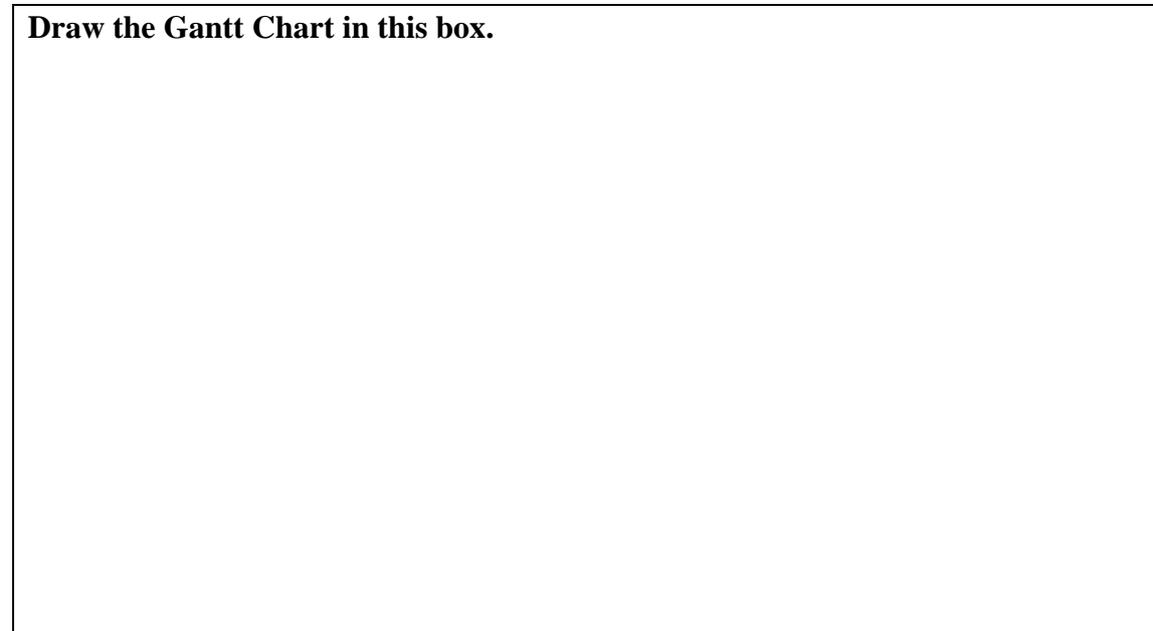


Draw the Work Breakdown Structure diagram here.



Gantt Chart

Draw the Gantt Chart in this box.

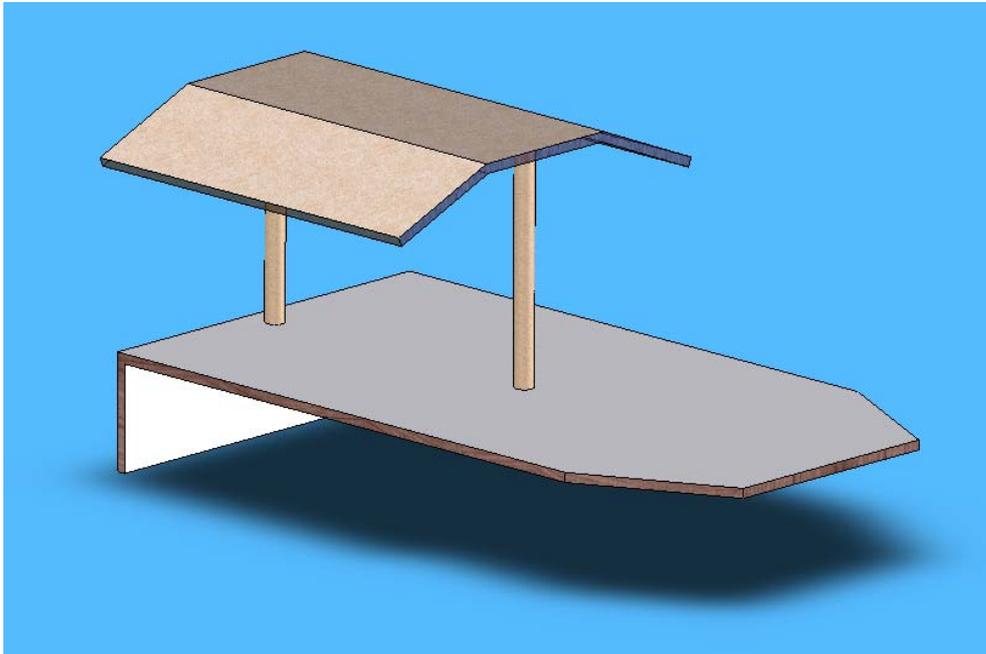


How long will the project take to complete?



Exercise 8: Bird Table

Materials: Acrylic, Brass,



Tasks and Times

Task	Description	Estimated Time

Work Breakdown Structure

Draw the WBS diagram here

Network Table

Draw the Network Table here

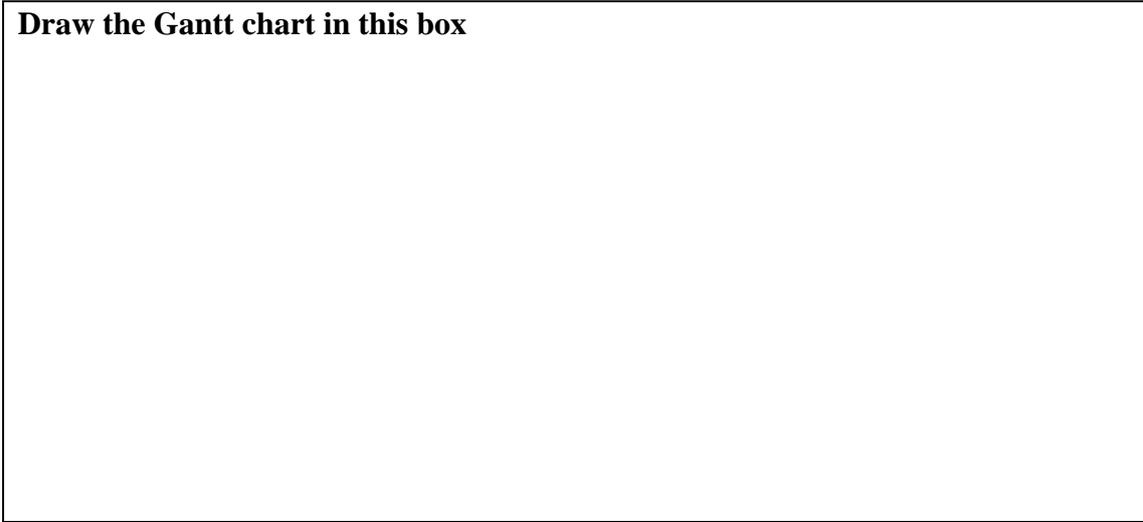
Task	Description	Predecessor

Network Diagram

Draw the Network Diagram here.

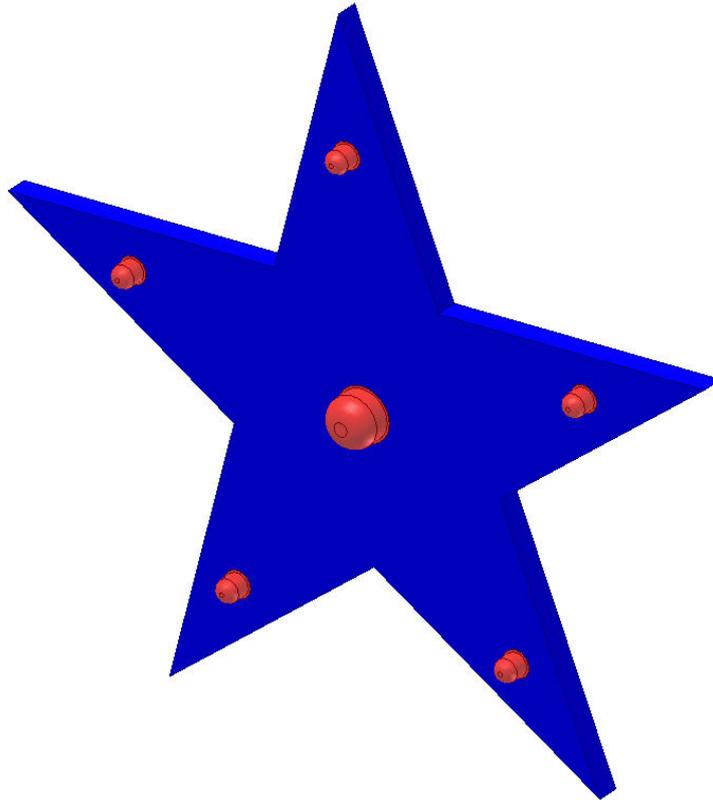
Gantt Chart

Draw the Gantt chart in this box



How long will the project take to complete?



Exercise 9: Christmas Tree Star

The Project above shows a Christmas Tree Star made from acrylic. The star contains a circuit with LED's which flash on and off.

Tasks and Times

Task	Description	Estimated Time

Work Breakdown Structure

Draw the WBS diagram here

Network Table

Draw the Network Table here

Task	Description	Predecessor

Network Diagram

Draw the Network Diagram here.

Gantt Chart

Draw the Gantt chart in this box

How long will the project take to complete?

Exercise 10: Design a water level alarm for use in a garden pond.

- First, analyse the brief and come up with a list of specifications for the project
- Next, use these specifications to generate a list of features (for example a moisture detection circuit or a water level switch) that the finished project will need to have.
- Then use these features to generate a WBS, Network diagram and Gantt chart using the headings below.

**Analysis of the Brief**

Specifications:

Example: Specification 1 - must be able to detect water level

Specification 2

Specification 3

Specification 4

Features:

Example: Feature 1 – should have moisture detection sensor and circuit.

Feature 1

Feature 2

Feature 3

Feature 4

Tasks and Times

Task	Description	Estimated Time in class periods

Work Breakdown Structure

Network Diagram – List of tasks and predecessors.

Task	Description	Predecessor

Draw the network diagram here



Gantt Chart



How long will the project take to complete?

Write down the critical path for the project _____

State what tasks have slack

For example: Task (x) has (4 class periods) of slack

Task: _____ **Slack**

1 _____

2 _____

3 _____