GCSE

Edexcel GCSE in Astronomy

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Coursework guide

Edexcel GCSE in Astronomy

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Contents

Introduction

This coursework guide is designed to support both teaching staff and students involved in the preparation and assessment of coursework portfolios for GCSE Astronomy.

As well as giving some general guidance on how to produce high-quality coursework, it also provides some specific guidance on each of the project titles suggested in the GCSE Astronomy specification.

Three examples of coursework completed by students in previous years are included, followed by a commentary explaining how the marking criteria were applied to these projects.

The coursework component

This guide is organised around the three sections within the coursework component of GCSE Astronomy:

- List A – Observations
- List B1 – Graphical and computational work
- List B2 – Constructional work.

Within each section the following guidance is provided:

• **Common errors**	This lists some of the common mistakes made by students
• **High-quality tips**	Suggestions for achieving the highest grades in the coursework projects
• **Suggested project titles**	As given in the specification, this lists the project titles from which students choose their two pieces of coursework
• **Additional guidance**	This gives further information and suggestions for completing each of the project titles
• **Exemplar coursework**	An example of coursework completed by a student in the past
• **Marking criteria**	As given in the specification, these show how marks are to be awarded for each piece of coursework
• **Moderator's marks and comments**	Details of the marks which the sample coursework gained, along with comments explaining each mark awarded.

Safe practice

Attention is drawn to the need for safe practice when students carry out practical activities or observe demonstrations. Reference must be made to *Control of Substances Hazardous to Health (COSHH)* regulations and any specific Local Education Authority restrictions. The *Consortium of Local Education Authorities for the Provision of Science Services (CLEAPPS)* has a lot of information on safety precautions on their website (www.cleapps.org.uk).

Relevant advice can be obtained from the following publications:

COSHH Guidance for Schools (HSE, 1989) ISBN 0118855115

Topics in Safety (Association for Science Education (ASE), 2001) ISBN 0863573169

CLEAPPS Laboratory Handbook and Hazards (available from CLEAPPS School Science to members or associates only).

The nature of the coursework and its assessment

The coursework component is weighted at 25% of the total assessment.

Two pieces of work are to be chosen, **one** from list A **and one** from lists B1 or B2:

	Choose **one** task from this column	**and**	Choose **one** task from this column
List A	Observations	List B1	Graphical and computational work
		List B2	Constructional work

The two tasks have equal weighting.

The assessment of tasks may be carried out by teachers at any time during the period of study leading to the GCSE examination. Practical work involving the skills and processes associated with astronomy will normally be related to the specification content.

Criteria for the assessment of the coursework component

For this specification, teachers must make a judgement of students' coursework using the performance criteria provided in the specification. Teachers should check carefully that the student's work is their own work, and is not copied from source material without any attempt by the students to make the material their own.

A mark for the quality of written communication must also be awarded according to the criteria given in the specification.

General guidance on producing good coursework

There are a number of general points about GCSE Astronomy coursework that will help students to produce their best possible work.

Project description

Some students lose marks almost before they have started the project by failing to read the exact wording of the project description given in the specification. For example, in the *Moon phase* project (List A – project 1), forgetting to include the rising and setting times of the Moon, as requested, will lose marks.

Occasionally, some students may wish to complete a project that is an original idea of their own or differs slightly from those given in the specification. In such cases, it is essential that approval is sought from Edexcel by the centre **before** the student starts work on the project. Contact customer services on 0870 240 9800. Centres should allow two to four weeks for this.

Statement of task

Some students seem to regard this as merely copying the title of the project at the start of their written report. A full statement of task, which would gain two marks, should make it clear to the non-astronomer exactly what the project is about. Any astronomical concepts should be explained in full, usually with the aid of a diagram.

For example, the *sundial project* (List B2 – project 2) should begin with a clear explanation, with diagrams, of how a sundial uses the position of the Sun to determine the time of day.

Presentation

Since the presentation of their final written report is worth four marks in each project, students are strongly advised to give sufficient time and effort to this aspect of their work.

The key factor in high-quality presentation is that information is laid out in a logical order so that it is easily accessible by the reader. Before commencing on their final write-up, students are encouraged to spend time arranging their observations, background theory, constructional details, references etc into a logical order. The final report should then be split up into clearly labelled sections, with a contents page at the start.

Although the use of a computer to produce the final report will not in itself gain extra marks for presentation, there is no doubt that competent use of word processing or desk-top publishing software can be a great help in producing a clear and well-structured report.

Similarly, the inclusion of photographs to illustrate the stages of completion of a project, particularly in List B2 – Constructional work, can make the whole report much clearer and easier to follow.

Finally, students should ensure that their work has been checked for spelling and grammatical errors (another area where the use of a computer can be helpful) and that all astronomical terms are spelt correctly.

Use of published material

There is an enormous amount of astronomical data, text and images available via books, magazines and the internet. Students will need to make use of some of these resources in order to complete their coursework projects. However, it is essential that students are selective in the material that they choose to include.

In recent years, the trend has been for students to include too much rather than too little published material in their reports, leading to work that is far too heavily padded and a decrease in the presentation marks awarded.

If a piece of coursework has been set out in a logical order it should be clear where some background text, a satellite image or other published material would improve presentation and understanding. Simply including published material which is not clearly linked to the work being described will gain no extra credit.

In the List B projects in particular, it is essential that all published material is clearly referenced. The reader of the project report should be able to see exactly which work is original and which parts have been taken from published material. Exact details of where to find any published material used should be included, eg book titles, authors and publication dates, website addresses etc.

Observations

Centres are reminded of the importance of ensuring that the observations submitted by students are entirely their own work. When it is necessary for optical instruments to be shared, each student should make their own sketches or take their own photographs.

This is a particularly important issue when students are using one of the various robotic telescopes that are now available via the internet. These may be accessed via the links on the *Useful Websites* page for GCSE Astronomy on the Edexcel website.

List A — Observations

The purpose of the projects in this list is to give students the opportunity to make some astronomical observations for themselves. The list of suggested titles is designed to ensure that all students are catered for, irrespective of the optical instruments and other equipment they have access to. Students may attempt observations using binoculars, telescopes or cameras if they wish but can gain equal credit for carefully observed drawings involving the naked eye.

Common errors

- Students often lose marks by forgetting to include all the necessary observational details with every one of their observations. Each observation **must** be accompanied by:
    - location
    - date
    - time
    - weather
    - seeing conditions
    - full details of optical instruments (if used).
- Students often lose marks by making their drawings too small so that all necessary detail cannot be shown clearly.
- Students' observational work should show evidence of having been carried out throughout the course. Lower quality work often results when observations are rushed in the final weeks before the coursework deadline. This results in either observations taken when the seeing is poor or no observations able to be taken at all.

High-quality tips

★ The essential element in gaining the highest marks for projects in this section is the quality of the drawings or photographs which are produced. Interestingly, some of the best observational work is produced by students working with the naked eye. Although more sophisticated equipment allows access to more astronomical objects, producing the best quality results using this equipment often takes considerable skill and practice.

★ High-quality observational work often involves returning to the same celestial object on several occasions, resulting in several sketches of the same object.

★ Some of the most demanding marks awarded for projects in list A are for detailed observations or deductions. Students aiming for the highest grades should therefore ensure that these features are clearly emphasised in the work they submit. For example, in *shadow stick* (project 4) or *star trail* (project 8), ensuring that the calculations performed on the observational data are completed accurately, showing clearly how the final values for longitude, sidereal day etc are obtained, will gain the higher marks.

Suggested project titles

Naked eye observations

1 Observe and draw the Moon's phases over a period of at least one lunar month, recording the dates, times, seeing and weather conditions, and rising and setting times.

2 Observe and make detailed drawings of three different constellations, recording dates, times, seeing and weather conditions and noting colours (if possible) and magnitudes by comparison with reference stars.

3 Observe a meteor shower. Record meteor trails on a drawing of the stellar background from sketches and estimate magnitudes of the meteors. Locate and show the position of the radiant.

4 Use a shadow stick to record the direction of the Sun at different times on at least two days and hence determine (a) the time of local noon and (b) the observer's longitude.

Photographic, binocular and telescopic observations

5 Observe the Moon with the aid of a suitable optical instrument and present photographs and/or drawings of lunar craters and/or other surface phenomena on at least two occasions, including details of the instrument(s) used with dates, times, and seeing and weather conditions.

Please note: If the full Moon is observed directly using a telescope at high magnification then, owing to its brightness, a student's ability to make other observations directly afterwards will be impaired.

6 Observe three different celestial objects with the aid of binoculars or a telescope and present photographs and/or drawings of these objects, including details of the instrument(s) used with dates, times, and seeing and weather conditions.

7 Project the image of the Sun onto a suitable background and either observe and record sunspots over a sufficiently long period of time to determine the Sun's rotation period or observe and record the various stages of a partial or total solar eclipse.

WARNING: The Sun must NOT be viewed directly, either with or without optical aids.

8 Take long-exposure photographs of the circumpolar stars around Polaris or the south celestial pole and use them to explain and determine the length of the sidereal day.

Additional guidance

Naked eye observations

1 **Moon phases**

This is a very popular project title that centres around keeping a log of the exact phase of the Moon over a period of several months. Allowing for the effects of the weather, this should enable students to observe the majority of the 28 different phases.

It's clearly essential to keep complete details of every observation, as outlined in the project description on the previous page.

A good way to improve sketches of the Moon's phase is to print out a number of photographs of the full Moon and use them as a template on which to draw the shadow terminator. This allows its position to be plotted much more accurately than on a blank circle.

2 **Constellation drawing**

Although this seems a relatively straightforward project, many students lose marks by not completing all the observations required in the project description on the previous page.

In particular, estimating magnitudes by comparison with reference stars of known magnitude is often neglected, particularly as it is quite a demanding observational task. In the days before photography this would have been an essential skill for an astronomer and students should be encouraged to make this a key part of their project.

3 **Meteor shower**

Given that the most prolific meteor shower (the Perseids) is during August, this can make an excellent introductory activity for school and college students to complete during their summer holidays.

Once again, many students do not include all the required details of each meteor, as listed in the project description on the previous page.

With a suitable wide-angle lens, this project can be completed very effectively using a camera pointing towards the radiant of the shower.

4 **Shadow stick**

This activity can make a very effective introduction to the topic of the Earth's motion relative the Sun which has obvious links to the early historical development of astronomy.

As with any scientific measurement, students should be encouraged to take sufficient shadow measurements on each occasion to enable an accurate determination of local noon.

Students can also use their data to determine the direction of the north celestial pole. They can then use a compass and an Ordnance Survey map to compare this with magnetic north.

Photographic, binocular and telescopic observations

5 Lunar photography

Recent advances in affordable telescopes and digital cameras have produced a substantial improvement in the standard of images being submitted for this project title. Some excellent images can be recorded simply by placing a digital camera at the eyepiece of a telescope or by replacing the eyepiece with a camera.

Students should ensure that they observe the same lunar feature at two or more very different phases of the Moon, thus recording the marked effect on its appearance.

Once again, a significant number of students lose marks unnecessarily by failing to include all necessary observational details with each image or drawing. This must include full details of the optical instrument used, perhaps including an explanation of how it is suitable for lunar observation.

6 Three celestial objects

This project works particularly well for students with access to a small telescope as it will allow them to observe objects such as the Orion nebula, Galilean satellites of Jupiter and Saturn's rings. Once again, full observational and instrument details are essential with all observations.

A very effective variant of this project is for students to produce two or more drawings or images of the same celestial object using different optical instruments. A drawing of a small lunar feature through binoculars combined with a drawing of the same feature through a small telescope can produce effective project work. As an endpoint, these drawings could then be compared with a NASA image of the same feature.

Recently, some students have successfully used one of the robotic telescopes available via the internet to complete this project. Centres are reminded of the importance of confirming that each student makes use of the telescope to obtain their own image(s).

7 Sunspots

Obviously centres must ensure that they make all their students aware of the essential safety precautions must be followed when attempting this project. Students' attention is drawn to the requirement that they observe the same group of sunspots on several occasions over a sufficiently long period of time to enable an estimate of the solar rotation period for the appropriate latitude.

8 Star trails

Star trails should be recorded for at least two hours in order to ensure that they are of sufficient length to enable accurate estimation of the Earth's rotation period. Students will also need to measure the angle covered by several star trails so that an average angle for the photograph can be produced. It is therefore important that a reasonably wide angle of sky around Polaris is recorded.

Students should also be aware of the potentially harmful effects of leaving cameras, particularly those with electronic circuitry, outside for extended periods at night.

Exemplar coursework

Astronomy Project

Aided Observation

Moon Observations

Statement of Task

For my aided observation astronomy project I will observe the moon on at least two different occasions. I will include drawings of the moon and remark on the lunar craters and the different surfaces that can be seen.

Background Information on Moon Observations

When the Moon orbits the Earth and the different Moon phases are shown, shadows can be seen on the surface.

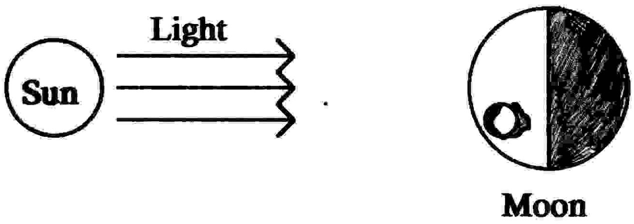
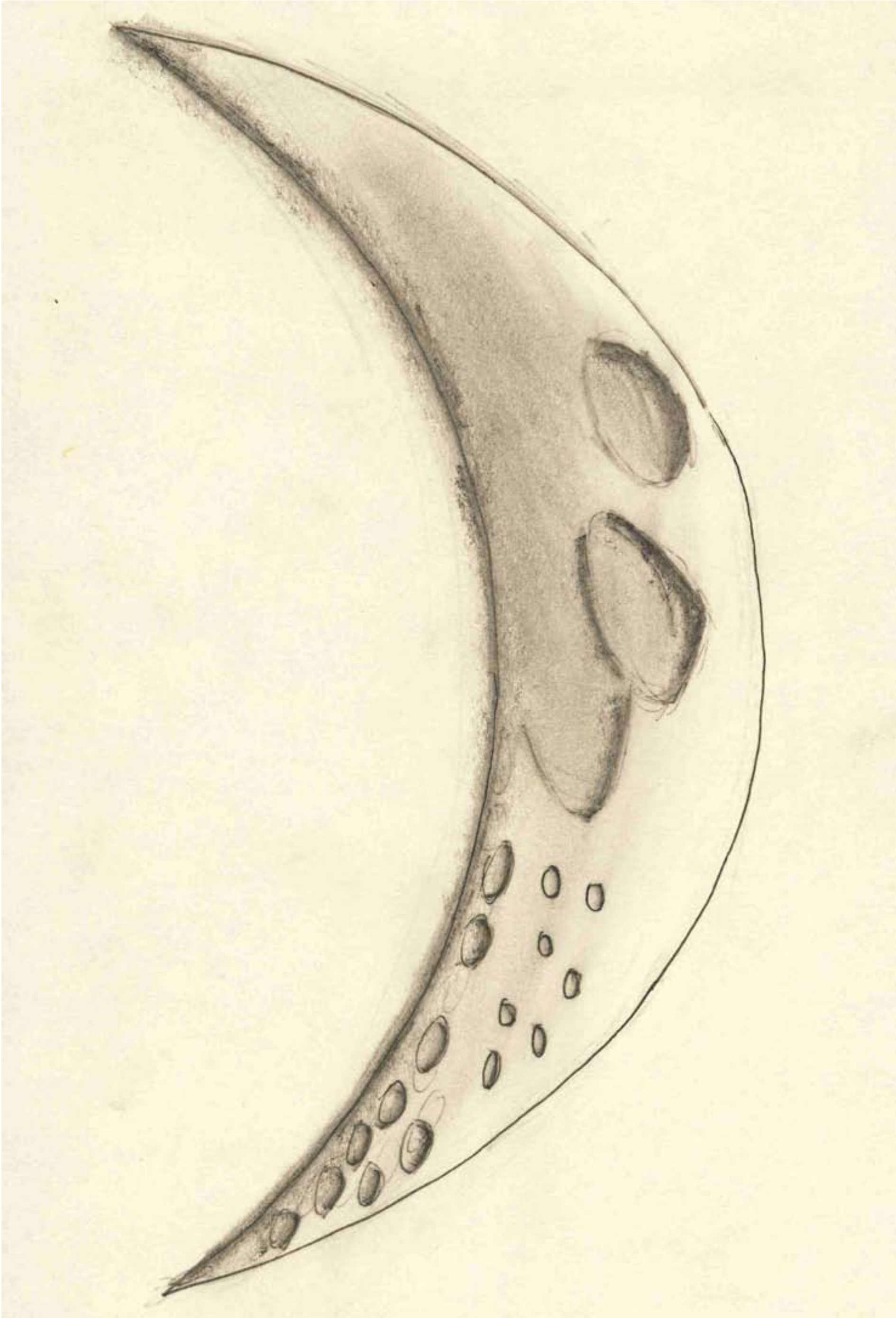


Diagram showing how shadows from craters are formed

This is because the sunlight shines onto the sides of craters that are present on the Moon which then cast the shadows. These shadows can show observers the relief of the Moon's surface by simple observations from the Earth.

From my observations I will be able to point out such shadows and comment on the apparent appearance of the surface. I will then be able to compare this with the actual surface.



The Main features of a Crescent Moon

Date:- February 22nd 2005
Seeing / Weather conditions:- Some restricted view due to cloud cover
Time:- 21.00
Rising Time:- 09.09
setting time:- 23.24

The Main features of a Gibbous Moon

Date:- February 17th 2005
Seeing / Weather conditions:- Some restricted view due to cloud cover
Time:- 23.00
Rising Time:- 10.31
Setting Time:- 03.13

Equipment used:-

Binoculars (7x50) with field 7.1°.

When I drew my observations I decided not to draw from a Full Moon firstly because it is dangerous looking at the Full Moon with an optical instrument such as Binoculars and also because there are no shadows cast when you are viewing the Moon full on. By choosing different views from between a Full Moon and a New Moon you would see shadows cast which shows the landscape that we are looking at and also backs up my statement of task.

As you can see from my readings that I have produced there are a lot of dark patches on the Moon. A lot of these patches are shadows that are being cast. you will notice from my readings and also from other Astronomy books that there are a lot of shadows that are being cast. This leads us to believe that the Moon is very mountainous and due to the shapes of some of the shadows, there are a lot of craters. This is correct. The Moon has no atmosphere due to it's small size and therefore it's low gravity. As there is no atmosphere, when meteorites hit the moon's surface and cause the craters that we can see, there is no weathering or erosion taking place which destroys the evidence of a meteorite crash. If the Earth had no atmosphere it too would look like the Moon.

However there is erosion taking place which covers up the earth's scars.

The dark and apparently flat areas of lunar landscape that are visible are named maria or seas because people used to believe that they were seas on the Moon. "They are thought to be volcanic features".

In my first drawing you will notice that there are a group of craters that can just be seen at the bottom. These have been caused from meteorites that crashed into the Moon and have not been eroded.

There are plat planes visible. The almost heart shaped plane is called Mare Tranquillitatis, or the Sea of Tranquillity as it is more commonly known as.

In my second drawing there are again more craters that are visible.

I can conclude that my drawings back up what I have found out about the Moon's landscape and relief from reference books and other sources.

Marking criteria

Criteria for tasks taken from List A – Observations	
Statement of task	**Maximum 2**
Clear and precise statement of nature and purpose of task	2
Vague statement of nature and purpose of task	1
No statement of nature and purpose of task	0
Observational details	**Maximum 3**
• Full details given, including such factors as: a) locations b) dates c) times d) weather e) seeing conditions.	3
• Some of the above details given	2
• Very few of the above details given	1
• No details given	0
Observations	**Maximum 6**
Award a mark on a linear scale from 0 to 6 for material submitted, taking into account such factors as: • size • clarity • use of colour (if applicable) • labelling • access to information • correct terminology.	
Detailed observations/deductions	**Maximum 4**
Award a mark on a linear scale from 0 to 4 for any detailed observations or calculations or deductions	
Presentation	**Maximum 4**
Material is neat and very well presented in a logical order	4
Material is fairly neat and fairly well presented in a logical order	3
Material is satisfactorily presented	2
Material is poorly presented	1
Material is poorly presented in a haphazard order	0

Moderator’s marks and comments

Title of task and marks awarded						TOTAL
List A: Observations Title: **Moon observations**						
Statement of task **1** /2	Observational details **2** /3	Observations **3** /6	Detailed obs. /deductions **1** /4	Presentation **3** /4		**10**/19

Statement of task **1**

The student has made a basic statement of the task to be completed. He has attempted to provide some of the astronomical theory behind the project, rather than simply re-stating the project title.

The diagram showing how shadows are cast by lunar features is a good idea.

A major part of the project is to sketch the changing appearance of lunar features at different phases of the Moon. The student would have needed to explain this more fully, perhaps with a second diagram, to gain full marks in this section.

Observational details **2**

Most of the major details required for an astronomical observation are included here. However, the observer’s location is missing, the time of each observation is not accompanied by its time zone (eg GMT) and the description of the seeing conditions could be improved by the use of a numerical scale such as the Antoniadi scale.

A little more detail about the optical instrument used (7 x 50 binoculars) would be helpful, eg what do the 7 and the 50 stand for and how does this affect its suitability for lunar drawings?

Observations **3**

The drawings are clear and show effective use of shading. However, only the very largest features of the Moon are shown and are almost the same as those which are visible to the naked eye. Rather more detail would be required for the very highest marks in this section. In addition, another couple of drawings would have helped to show more fully the changing appearance of lunar features at different Moon phases.

Detailed observations/ deductions	**1**	As mentioned above although they are well shaded lunar drawings, they do not contain very much detail. Identifying some of the more prominent features by labelling them with their names would also have gained marks in this section.
Presentation	**3**	The standard of presentation is good, with all information set out clearly, although the sequence in which information is presented in the final section could be improved, perhaps using some sub-headings.

In total this project would score 10 marks out of 19 making it approximately grade C standard.

List B1 — Graphical and computational work

The purpose of the projects in this section is to allow students to use graphical or computer resources and skills to produce display materials illustrating an aspect of astronomy. As the marking criteria shows, students should concentrate on ensuring that their finished project presents high-quality astronomical material in a clear and accessible manner.

An effective way to help ensure this is for students to use their project work from this list as the basis for a short presentation to other students from their centre. This can help students to identify irrelevant material and concepts which are not clearly explained in their work.

Completed project work from this list can also be used as impressive display materials by the centre.

Common errors

- Some students include a considerable amount of information in their projects but forget to give much thought to how clearly it is presented. Remembering that the idea is to present astronomical material to a non-astronomical audience is an important focus.
- Lower-quality projects in this section often include material that has not been clearly linked to the rest of the project.
- Some students lose marks unnecessarily in this section by not including a full list of references.
- Some students clearly spend a great deal of time working on aspects of computer programs that have little effect on the final result. This effort is wasted.

High-quality tips

★ The highest quality projects from this list are produced by students who have put a great deal of thought into how to present the astronomical ideas as clearly as possible.

★ For the highest marks, the **selection** of information to include is the key factor. Top-scoring projects include only text or images that will help to explain the astronomy involved.

★ High-quality Moon and star charts are generally fairly large, as this allows all material to be laid out clearly without the final display becoming cramped and confusing to the viewer.

Suggested project titles

1 Construct a star chart on a large rectangular grid using stars of the main constellations. Plot the positions and path(s) of at least one planet using either original observations or published ephemerides (eg Handbook of the BAA).

2 Draw a large chart of the Moon from references to photographic material, marking in and naming principal features and positions of Apollo and other notable lunar landing sites.

3 Use a spreadsheet and/or a graphing package or write a computer program to plot the stars of the main constellations and plot the positions and path(s) of at least one planet using either original observations or published ephemerides (eg Handbook of the BAA).

4 Use a spreadsheet and/or a graphing package or write a computer program which simulates the scaled orbits of either at least four planets around the Sun or the major satellites of a named planet.

Additional guidance

1 **Star chart**

To enable sufficient information to be displayed clearly, these should be A3 or larger in size. Students can be encouraged to produce these charts for display within the centre in corridors or foyers. This helps to emphasise that the finished chart should make the key astronomical points clear to a non-astronomical audience.

Students should also be encouraged to make full use of colour and to devise a system for making the relative magnitude of the brightest stars clear on their chart.

The plotting of planetary positions is enhanced if it covers a period of retrograde motion.

Some students have found the production of their star chart on polar rather than Cartesian graph paper to be a very effective variant of this project.

2 **Moon chart**

The most effective Moon chart projects combine a high-quality labelled drawing of the full Moon with additional information about the various lunar features and landing sites. The use of a key system or arrows can help to make it clear how this information relates to various locations on the Moon chart.

Integrating suitably referenced photographs of the various landing craft into the Moon chart can also improve its appearance.

Given the substantial amount of information to be displayed, the most effective Moon charts are normally at least A2 in size. Once again, they can be used to provide impressive display materials within the centre.

3 **Star and planet simulation**

Quite straightforward use of a simple spreadsheet program can be sufficient to complete this project, although some students have written their own program to produce the same effect.

Centres should ensure that students are clear that this project will be marked for its astronomical merit, rather than for the sophistication of its computer programming. In other words, the key objective is to produce an output which conveys astronomical information clearly and effectively.

As with the hand-drawn star chart (project 1) the use of colour can enhance the final result, as can including a period of retrograde motion in the planetary positions.

Along a similar vein to this project, some students have used spreadsheet programs to produce Hertzsprung-Russell diagrams for their coursework portfolios.

4 **Orbit simulation**

As with the *star and planet simulation* (project 3) in this list, the emphasis is on the clarity with which the finished output conveys astronomical ideas. Particularly impressive attempts at this project have allowed the user to choose the viewpoint from which they watch the orbit simulation, ie allow switching between a view from the Earth to a plan view above the ecliptic plane.

Note to centres — submitting computational work

When submitting students’ computer files or programs as part of the coursework sample, it is helpful if an executable version can be included on a CD ROM so that the moderator can view the output directly. Alternatively, screenshots can be printed out and submitted.

Some students have also found it useful to place their files on a suitable web page, allowing viewing via the internet.

Note to centres — submitting large items

Centres are reminded that items substantially larger than A4 in size should not be posted to the moderator as part of the coursework sample.

Photographs of finished star or Moon charts are almost always sufficient for the purposes of moderation. Centres are thus encouraged to photograph these large items and include the labelled photographs with the students’ written report.

The moderator will contact the centre should it be necessary to see the original item.

Exemplar coursework

GCSE ASTRONOMY COURSEWORK

Graphical and Computational Work (List B1)

Moon Chart – 2

Aim:

My aim is to produce a lunar chart, depicting the main features of the lunar landscape and the position of the sites of lunar landings, manned and unmanned.

The Moon has a volume of approximately 1/64 of the Earth and a diameter (3500km) of just over ¼ that of Earth. The Moon is in a captured orbit around the Earth. During one orbit of the Earth the Moon completes one rotation about its axis and therefore the same face of the Moon is always viewed from Earth.

Even with the naked eye or small binoculars, there are some noticeable features of the lunar landscape:

Craters

Craters, mainly circular and ranging in size from 1 metre to over 100km, cover the surface of the Moon. On the near side of the Moon they are mostly restricted to the higher areas, but they cover the far side of the Moon. Some craters may be volcanic in origin, but the majority probably are the result of impact of asteroids during the early life of the Moon. Some of the craters are surrounded by rays of material that has been ejected during their formation and that can clearly be seen from Earth (e.g. Copernicus, 97km diameter).

Maria
The seas of the Moon are so called because of their apparently relatively smooth surfaces. They cover about 15% of the Moon's surface and are thought to be covered in lava, which has flowed into low impact basins from cracks in the Moon's crust, and then solidified. Because there are few craters in the maria, they are presumed to have been formed after the higher land. Most maria are on the near side of the Moon and are joined together. The largest is the Oceanus Procellarum, a large irregularly shaped area.

Mountains
Mountains on the Moon occur singly and in small groups within craters. There are also mountain chains bordering some of the maria (e.g. Montes Apenninus and Montes Alpes bordering Mare Imbrium.)

Wrinkle Ridges
When the lava in the maria cooled and contracted, the lava formed ridges around the margins. Some of the ridges can be hundreds of kilometres long, up to 30km wide and up to 200 metres high.

Rilles
Rilles are depressions on the lunar surface that form trenches. Some are relatively straight and are thought to be formed by faults in the crust; others curving are probably lava channels or collapsed lava tubes.

Domes
These are found near the edges of maria or in larges craters and were probably formed when either lava flowed out on to a relatively flat surface and cooled into a convex shaped mound. An alternative explanation may be that they were formed by lifting of the surface by underlying molten rock. They can be up to 25km in diameter and up to 750 metres high.

SPACE EXPLORATION

Space exploration can be possible following the development of rocket technology during and after the Second World War. The main problems of launching a rocket are to escape the Earth's atmosphere without being burned up by the friction when passing through it.

The principles of rocket propulsion were formulated by a Russian, Konstantin Tsiolkovskii, in the 19th century. The first liquid-propellant rocket was launched by Robert Goddard (American) in 1926. Following the developments in the first half of the 20th century, Russia launched a satellite in 1957, Sputnik 1, starting a stage when, particularly the United States of America and the Union of Soviet Socialist Republics, were prepared to invest the vast amounts of funding that space exploration required.

Lunar Landings

The first landings on the Moon were unmanned spacecraft launched by the USSR. The 24 Luna missions took place between 1959 – 1976, with 11 being successful. Luna 3 sent the first pictures of the far side of the Moon back to Earth in 1959 and Luna 9, in 1966, made a landing in the Oceanus Procellarum, a hard surface, dispelling the suggestions that expeditions were going to be hampered by several metres depth of soft dust that was thought to cover the Moon's surface.

In 1970, Luna 16 was the first to return soil from the Moon's surface and Luna 17 launched the first unmanned rover 'Lunokhod'.

The USA also sent unmanned craft: the 4 successful Ranger missions between 1964 – 1965 investigated lunar surfaces in the mare terrain and the lunar highlands; followed by the 4 successful Surveyor missions between 1966 – 1968. A probe 'Clementine' was launched by America in 1994 which allowed detailed mapping of the lunar surface.

The USSR also launched 5 successful probes in the Zond series between 1965-79; partially to test for future missions to Mars.

Five Lunar Orbiter missions (1966-67) successfully mapped 99% of the Moon's surface. The object of the first three missions was to locate possible landing sites.

In 1999, a probe 'Prospector' was launched and deliberately crashed into a crater near the Moon's pole to try to establish whether there was any frozen water on the surface.

Japan was the third nation to make an unmanned lunar landing in 1993 with the Hiten spacecraft.

In 1961 President Kennedy announced the USA's intention to land an man on the Moon. The impetus for the Apollo project was fuelled by the cold war and was to a great extent a political exercise. There had already been manned spaceflights – the first by Uri Gagarin from the USSR in April 1961 when he orbited the Earth in Vostock 1.

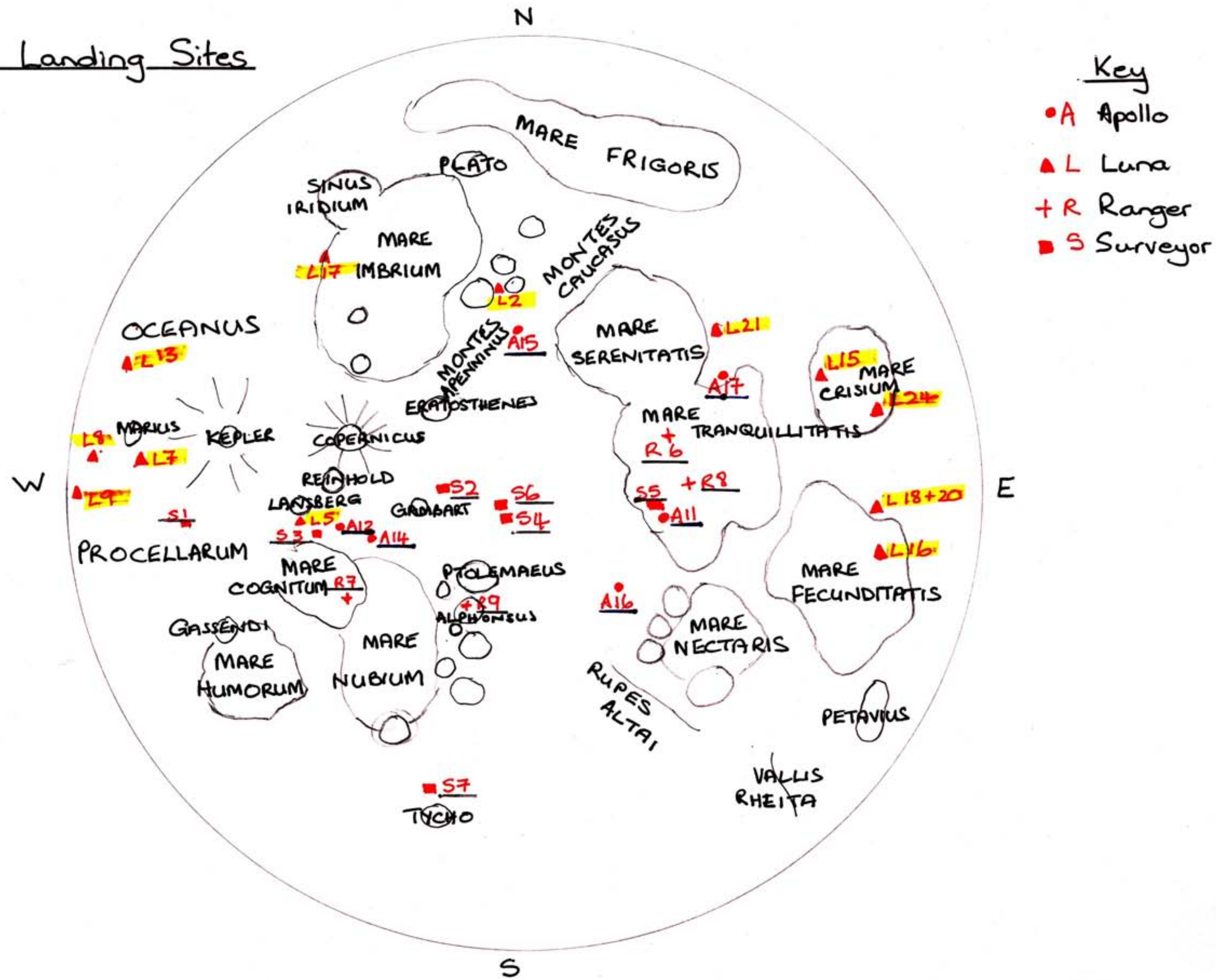
The first Apollo mission in January 1967 ended in disaster when three astronauts were killed at the launch, in a fire in the spacecraft. In December 1968, three astronauts in Apollo 8, successfully orbited the Moon.
The first successful manned lunar landing was by the Americans in Apollo 11 on 20 July 1969. Apollo 11, with Michael Collins on board, orbited the Moon, while Buzz Aldrin and Neil Armstrong, in the lunar module 'Eagle', landed on the Moon's surface. The module landed in Mare Tranquillitatis and Neil Armstrong was the first human to set foot on the Moon.
They stayed on the surface for 2 hours, long enough to set up signalling equipment, a seismometer and to collect rock samples for analysis.
There were 5 more manned landings in the Apollo project, only Apollo 13 being unsuccessful and narrowly avoiding another tragedy.

This enormous expense, risk and limited returns of manned flights means that there have been no more manned lunar landings since 1972. The possibility that a Lunar Base could be established for scientific research and astronomical observation is one proposal for the future.

Reference Sources

GCSE course notes
NASA website
University of Leicester website
GCSE Astronomy. Marshall, Nigel (2001) Mickledore publishing
Astronomy for GCSE. Moore, Patrick and Lintott, Chris. (2001) Duckworth
Philip's Moon Map (Lunar landing sites)

Lunar Landing Sites



Marking criteria

Criteria for tasks taken from List B1 - Graphical and computational work	
Statement of task	**Maximum 2**
Clear and precise statement of nature and purpose of task	2
Vague statement of nature and purpose of task	1
No statement of nature and purpose of task	0
Quality of material	**Maximum 6**
Award a mark on a linear scale from 0 to 6 for the quality of material, taking into account such factors as: • size • clarity • use of colour (if applicable) • labelling.	
Information displayed	**Maximum 5**
Award a mark on a linear scale from 0 to 5 for the information contained on the chart or on the print-outs, taking into account such factors as: • relevance of information • access to information • correct terminology and units.	
References	**Maximum 2**
Good references giving full information	2
Incomplete references	1
No references	0
Presentation	**Maximum 4**
Material is neat and very well presented in a logical order	4
Material is fairly neat and fairly well presented in a logical order	3
Material is satisfactorily presented	2
Material is poorly presented	1
Material is poorly presented in a haphazard order	0

Moderator's marks and comments

Title of task and marks awarded						TOTAL
List B1: Graphical and computational work Title: **Moon chart**						
Statement of task 1 /2	Quality of material **3** /6	Information displayed **2** /5	References **2** /2	Presentation **3** /4		**11** /19

Statement of task **1** The student has stated the aim of the project and has begun to explain some of the astronomical ideas involved. For full marks in this section, a fuller explanation of the Moon's orbit around the Earth would be needed, supported by clear diagrams.

Quality of material **3** The student has included some good explanations of how the major lunar features are formed. For the higher marks in this section, the student would need to have supported the explanations with diagrams.

Some variation in colour has been used to highlight key information on the Moon map. This can be developed further, along with the use of different fonts and extension of the key system to indicate different lunar features.

As the project description suggests, photographs of each of the lunar features could also be included (suitably referenced), as they are now readily available from the internet.

Information displayed **2** Although there is some useful information contained within this piece of coursework, much of it is in the form of text which is not clearly linked to the Moon chart produced. Improvements could be made by:

- identifying an example of each type of lunar feature on the Moon chart itself
- producing a Moon chart of A3 size or larger (the original is A4)
- placing the sections of text or sample photographs at appropriate points around the drawing of the Moon to produce a display poster.

References	**2**	A list of references is provided at the end of the project. It is also helpful to outline what information has been taken from each source, as the student has already done with the *'Phillips Moon Map (Lunar landing sites)*'. It is also useful to include web addresses when listing websites.
Presentation	**3**	The presentation is very clear, with all key information included in a logical order. For full marks, the information contained in the text would need to be more closely linked to the Moon chart, as explained above.

In total this project would score 11 marks out of 19
making it approximately grade C standard.

List B2 — Constructional work

The project titles in this list are designed to give students the opportunity to construct a simple astronomical instrument or a working model to illustrate an astronomical principle. The list of suggested titles is designed to cater for students with access to only the most basic materials, as well as those with more sophisticated skills and resources.

When completing a constructional project, students are encouraged to include photographs showing their project under construction as well as the finished article. These remove the need for the finished instrument or model to be sent to the moderator as part of the coursework sample.

Common errors

- One of the most common causes of lost marks for projects in this list is from students not allowing sufficient time for full testing/use of their instrument or model. Telescopes and sundials should be used on several occasions with their performance and accuracy being determined. A model can be used as part of a demonstration to a small group of other students in order to determine its effectiveness.
- Less effective projects chosen from this list often use materials which are not suitable for the construction of accurate instruments/models. For example, cardboard sundials and telescopes using cardboard tubes do not score very highly, either for design or construction.
- Students should ensure that their instrument or model is made sufficiently large to enable accurate measurement or demonstration.
- Some students lose marks unnecessarily in this section by not including a full list of references.

High-quality tips

★ As explained above, to achieve the highest marks in this section, students must allow as much time for the testing/use of their project as for its construction.

★ High scoring projects often include a clear explanation of how the particular design of the instrument/model was chosen, as well as the choice of materials etc.

★ High-quality written reports in this section generally provide a clear explanation, supported by photographs, of each stage of the construction and testing processes.

Suggested project titles

1 Design and make a simple telescope using a variety of tubes, lenses and/or mirrors. Test the instrument in the night sky and estimate its power of magnification, field of view, magnitude limit and angular resolution.

2 Design and make a sundial. Use the sundial to record the times of day on at least three widely separated occasions and compare these with the mean local times.

3 Design and make a model of an eclipsing binary system using a motor, lamps and simple electronic components (eg LDR). Obtain measurements suitable for drawing a light curve for the model and compare this with the light curve of a real eclipsing binary system.

4 Design and make a model of the Sun-Earth-Moon system using lamps, spheres etc to illustrate how solar and lunar eclipses occur. Use it to account for the relative occurrences and durations of each type of eclipse.

Additional guidance

1 **Telescope**

This is a very popular project which allows students to construct their own simple refracting telescope from two convex lenses and a piece of plastic tubing. Some students have combined large lenses from magnifying glasses with microscope or telescope eyepieces to produce quite impressive instruments.

However effective the final telescope, students' attention should be drawn to the fact that there is an equal number of marks for the testing/use section in the mark criteria as there is for construction. Students should reflect this in their written reports, giving ample evidence of an assessment of the telescope's performance. The telescope's approximate magnification, field of view and limiting magnitude should all be estimated and accompanied by some sketches of celestial bodies observed.

2 **Sundial**

In a similar way to the *telescope* (project 1) this project allows students to use very simple materials to construct an instrument of fundamental importance in the development of astronomy.

Most students construct a simple horizontal dial, with the gnomon aligned with the north celestial pole. This simply requires two pieces of wood, the base and a small triangle for the gnomon, to be glued at right angles to each other and the base marked with hourly divisions.

Students should be encouraged to ensure that their dial is sufficiently large and clearly marked to allow accurate measurement of the shadow's exact position. Since the sundial is essentially an outdoor device, it should be made from wood, plastic or metal, rather than cardboard.

Some students lose marks because they are unclear about how their sundial should be aligned, often simply using a compass to align it with magnetic north. Others convert their sundial's time to mean time incorrectly whilst others neglect to mention the equation of time altogether.

Some students clearly spend a great deal of time in producing sundials that look very impressive. Once again centres should remind their students that there are as many marks for the testing/use of their sundial as for its construction. Students should therefore ensure that they leave time before the coursework deadline to take readings with their sundial, which they can convert to local mean time and thus compare with a clock. As the project description on the previous page states, a minimum of three such comparisons should be completed.

An interesting variant on this project is to construct a Moon dial. This has the added complication of a sliding scale on the base but can be used to determine the time from the shadow cast by the Moon.

3 **Eclipsing binary system model**

This project allows students with access to slightly more complex materials — such as motors and LDRs — to attempt to generate the well-known light curve of the eclipsing binary system. Once the model is completed, students can then vary the size and relative brightness of the two stars and record the effect on the resulting light curve.

4 **Earth-Moon-Sun system model**

The central aim of this project is to produce a simulation of the shadows formed on the Earth and Moon during solar and lunar eclipses. It is particularly effective if students can include photographs to show these shadows as formed by their models. As the project description on the previous page

states, students should then use these photographs to explain the relative frequency and duration of these eclipses.

Note to centres — submitting large items

Centres are reminded that items substantially larger than A4 in size should not be posted to the moderator as part of the coursework sample.

Photographs of finished sundials, telescopes or models are almost always sufficient for the purposes of moderation. Centres are thus encouraged to photograph these large items and include the labelled photographs with the students' written report.

The moderator will contact the centre should it be necessary to see the original item.

Exemplar coursework

Sundial Project

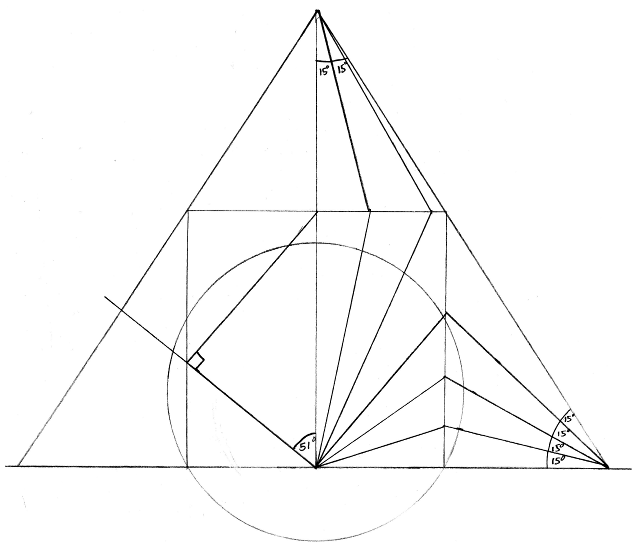
Statement of task:

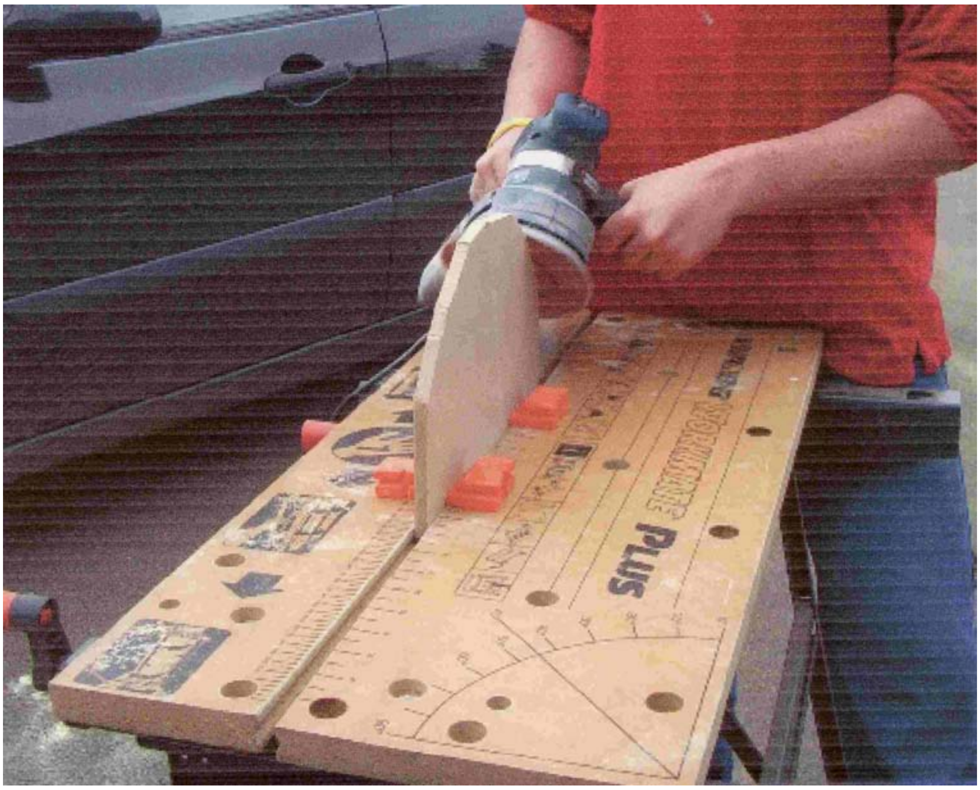
My project was to show the use of astronomical measurements as a basis of time keeping in the construction of a sundial, and to observe and record the data produced, in order to assess its accuracy against GMT (Greenwich Mean Time.)

Design:

It was with some consideration that I chose the particular size of my sundial design, as I didn't want it to be too small to read with accuracy, and yet not too big that it would be difficult to transport. For the base, I used 9mm MDF board, which I felt would be hard enough and durable, but still easy to work with. For the gnomon, I used a much thinner 4mm ply wood material, to enable a more accurate reading. To mark the graduations of time on the sundial base, I firstly scored a line with a craft knife, and then defined the marking with a fine-tipped pen.

Working out the angles on the sundial.



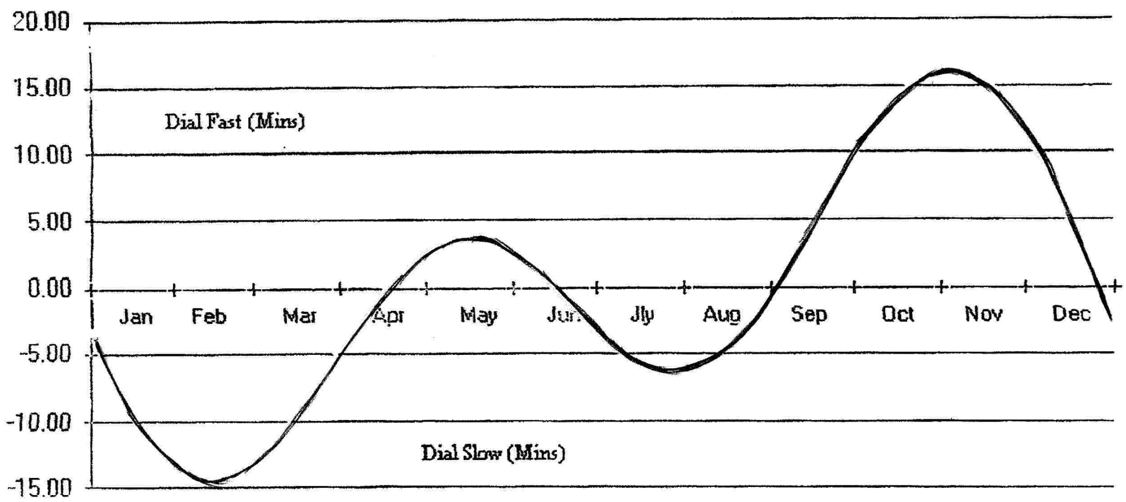


Results

Date	Mean Local Time	Sidereal time from sundial
3rd Apr. 2005	10:00 12:00 14:00	10:02:30 13:02:25 16:03:00
10th Apr. 2005	10:00 12:00 14:00	10:01:45 13:01:58 16:01:50
17th Apr. 2005	10:00 12:00 14:00	10:00:00 13:05:00 16:00:00
24th Apr. 2005	10:00 12:00 14:00	10:02:00 13:02:00 16:02:00

Month	Date	mins	Month	Date	Mins
January	1	-3	July	10	-5
	9	-7		27	-6 1/3
	18	-10	August	13	-5
	24	-12		29	-1
Febuary	4	-14	September	2	0
	12	-14 1/2		14	4
	24	-13 1/2		28	9
March	4	-12	October	7	12
	16	-9		20	15
	26	-6		27	16
April	5	-3	November	4	16.5
	16	0		18	15
	25	2		29	12
May	7	3 1/2	December	4	10
	15	3 3/4		13	6
	28	4		26	0
June	10	1		30	-2
	15	0			
	29	-3			

Table showing the Equation of Time



Graph showing the Equation of Time

Local and Greenwich mean time:

A problem with have a time system based upon movements of the sun is that the 'Time' differs over long distances. The time is very slightly different even a few miles away. Because of this GMT was established giving +/– an average time for the world to base its time on.

Local time assumes the sky (sun) moves at a constant pace across the sky irrelevant of your location on the planet Places WEST of GMT are behind (–) our local time. Places EAST are ahead (+) of our local time. For every 15° of longitude that is travelled from GMT, local time will either increase or decrease by 1 hour.

Conclusion of results:

Over the duration of the experiment the time differences between the local time and the sidereal time remained about the same. If the experiment were continued for a longer duration then you would notice the 'lengthening' and 'shortening' of the sidereal day between the winter and summer seasons. It must be taken into account that the sundial used is not in comparison as accurate as the quartz watch so some inaccuracies are un-avoidable. At this point of the year (April) the sidereal time is mearly 2-4 minutes ahead of local mean time (LMT).

References: The measurements of time Table is taken from Astronomy for GCSE by Patrick Moore and Chris Lintott. Published by Gerald duckworth& CO.Ltd.

Marking criteria

Criteria for tasks taken from List B2 – Constructional work	
Statement of task	**Maximum 2**
Clear and precise statement of nature and purpose of task	2
Vague statement of nature and purpose of task	1
No statement of nature and purpose of task	0
Design	**Maximum 3**
Care and consideration for size and materials	3
Some care and consideration for size and materials	2
Little care and consideration for size and materials	1
No real thought about design	0
Construction	**Maximum 4**
Award a mark on a linear scale from 0 to 4 for the actual construction of the instrument or model, taking into account such factors as: • size • materials • robustness • cost.	
Testing/use	**Maximum 4**
The instrument or model is fully tested and evaluated	4
Some use and evaluation	3
Little use and evaluation	2
Some evaluation but no testing or use	1
No evaluation, testing or use	0
References	**Maximum 2**
Good references giving full information	2
Incomplete references	1
No references	0
Presentation	**Maximum 4**
Material is neat and very well presented in a logical order	4
Material is fairly neat and fairly well presented in a logical order	3
Material is satisfactorily presented	2
Material is poorly presented	1
Material is poorly presented in a haphazard order	0

Moderator's marks and comments

Title of task and marks awarded						TOTAL
List B2: Constructional work Title: **Sundial project**						
Statement of task	Design	Construction	Testing/Use	References	Presentation	
1 /2	**2** /3	**3** /4	**2** /4	**1** /2	**2** /4	**11** /19

Statement of task — **1** — The student has provided a brief explanation of the purpose of the sundial project. For full marks in this section a clear explanation, with diagrams, of how a sundial uses the angle of the Sun to measure time would be needed.

Design — **2** — The student has used a standard template for designing the base of the sundial, resulting in accurate markings. As explained in the design section of the report, MDF has been used to ensure a robust sundial.

Construction — **3** — As the photograph at the end of the report shows, the finished sundial is sufficiently large (27cm diameter) and has fairly accurate markings.

Incidentally, a few more photographs showing the stages of construction of the sundial (rather than its constructer) would be helpful.

In addition, placing another everyday object in the photograph of the finished sundial is very helpful to the moderator, so that its scale can be judged.

Testing/use — **2** — The student has made comparisons between the time on a clock and the time indicated by the sundial on four occasions. Although the equation of time has been mentioned, it has not been used to convert the apparent solar time of the sundial into local mean time.

Similarly there is no description of how the gnomon of the sundial was aligned with the north celestial pole.

References — **1** — The student has mentioned one source of data but would need to give a complete list of references for full marks in this section. In particular, the source of the template for the sundial base should be included.

Presentation	**2**	All material is presented clearly but the material on the equation of time is introduced after the results section, making the final conclusion section rather confusing. In addition, there are a few errors in the use of astronomical terms such as sidereal time.

In total this project would score 11 marks out of 19 making it approximately grade C standard.

Quality of written communication

For more information, see the specification (page 6).

Marks for quality of written communication will be awarded in accordance with published regulations.

For the coursework 5% of the total marks available are allocated to quality of written communication according to the performance criteria below.

Below threshold performance	**0 mark**	
Threshold performance	**1 mark**	Students spell, punctuate and use the rules of grammar with reasonable accuracy; they use a limited range of specialist terms appropriately.
High performance	**2 marks**	Students spell, punctuate and use the rules of grammar with considerable accuracy; they use a good range of specialist terms with facility.

Recording and collecting supporting evidence

Teachers must keep records of assessment for each student during the course and these must be available for use by the moderator at the end of the course. The *Coursework Record Sheet*, which should be photocopied for use in centres, is found in the specification (page 73). The assessments may be carried out by teachers at any time during the period of study leading to the GCSE examination.

Further details are given in *Appendix 2 — Procedures for moderation of internal assessment* in the specification (page 65).

Standardisation and moderation

The marks submitted to Edexcel for coursework will be moderated in accordance with the requirements of the *National General Criteria* (paragraphs 47-52) and the *Mandatory Code of Practice* for the GCSE.

Centres must ensure there is full and effective internal standardisation of the assessments made by different teachers and of different teaching groups within a centre. This will establish an overall order of merit for the students in the centre. A listing of the actual order of merit is not required.

Further details are given in *Appendix 2 — Procedures for moderation of internal assessment* in the specification (page 65).

Edexcel will provide centres with the results of moderation of their coursework assessments soon after the examination. A moderator's report on the assessment will be sent to each centre; this will provide comments and advice.

The *Examiners' Report* will contain a section on coursework. It will cover the main points arising from moderation of the coursework assessment and provide guidance on good practice. This is available on the Edexcel website (www.edexcel.org.uk), for the 2005 examination series.

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