GCSE (9-1) Astronomy

Specification

Pearson Edexcel Level 1/Level 2 GCSE (9-1) in Astronomy (1AS0)

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Issue 3

About Pearson

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Summary of Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy (1AS0) specification Issue 3 changes

Summary of changes made between previous issue and this current issue	Page number
Removed requirement and area for teacher signature for Observational Fieldwork Declaration form.	61

If you need further information on these changes or what they mean, contact us via our website at: qualifications.pearson.com/en/support/contact-us.html

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1 Introduction

Why choose the Edexcel GCSE in Astronomy?

Supporting success in science

Most people are fascinated by the night sky and are interested in stories about our continuing exploration of our Solar System and Universe. This course has been developed to build on that interest and to give an introduction to the subject of astronomy.

The course will enable students to understand our position in the Universe, the movements of planets and stars, the cycles in the night and daytime sky, and the way in which we use technology to observe and interact with space. Students will follow an incredible story of how scientists, from ancient civilisations to the modern day, have used their imagination and carefully recorded visual measurement to explore the Universe in which we live.

As with our GCSE (9–1) Science specifications, our Astronomy specification is straightforward to deliver. And we've selected a range of observational activities to suit schools that are well equipped with telescopes and those that are more modestly resourced. Of course, when it comes to our assessments, they are shaped to encourage all students to best show what they know and can do.

Every student is different. But we hope that, across the astronomical content and the suggested observational activities, you can build an inclusive course, to allow your students to enjoy their first steps in astronomy – and maybe turn those steps into giant leaps…!

Supporting you in planning and implementing this qualification

Planning

- Our **Getting Started** guide gives you an overview of the new GCSE qualification to help you to get to grips with the changes to content and assessment and to help you understand what these changes mean for you and your students.
- **Our mapping documents** highlight key differences between the new and 2009 qualifications.

Teaching and learning

There will also be some free teaching and learning support to help you deliver the new qualifications, including:

- a **course planner** and **schemes of work** that you can adapt to suit your department
- support in delivering a range of **observational activities** which form part of the specification content.

Preparing for exams

We will also provide a range of resources to help you prepare your students for the assessments, including:

- access to past papers to allow you to develop homework and test resources,
- marked exemplars of student work with examiner commentaries.

ResultsPlus

ResultsPlus provides the most detailed analysis available of your students' exam performance. It can help you identify the topics and skills where further learning would benefit your students.

Get help and support

Our subject advisor service, led by Stephen Nugus and Julius Edwards will ensure you receive help and guidance from us and that you can share ideas and information with other teachers.

Learn more at qualifications.pearson.com

Qualification at a glance

Content and assessment overview

The Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy consists of two externally-examined papers.

Students must complete all assessment in May/June in any single year.

Paper 1: Naked-eye Astronomy (*Paper code: 1AS0/01)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 1 – Planet Earth • Topic 2 – The lunar disc • Topic 3 – The Earth-Moon-Sun system • Topic 4 – Time and the Earth-Moon-Sun cycles • Topic 5 – Solar System observation • Topic 6 – Celestial observation • Topic 7 – Early models of the Solar System • Topic 8 – Planetary motion and gravity
Assessment overview A mixture of different question styles, including multiple-choice questions, short-answer questions, calculations, graphical and extended-open-response questions.

*See *Appendix 8: Codes* for a description of this code and all other codes relevant to this qualification.

Paper 2: Telescopic Astronomy (Paper code: 1AS0/02)
Written examination: 1 hour and 45 minutes ***50% of the qualification*** ***100 marks***
Content overview • Topic 9 – Exploring the Moon • Topic 10 – Solar astronomy • Topic 11 – Exploring the Solar System • Topic 12 – Formation of planetary systems • Topic 13 – Exploring starlight • Topic 14 – Stellar evolution • Topic 15 – Our place in the Galaxy • Topic 16 – Cosmology
Assessment overview A mixture of different question styles, including multiple-choice questions, short-answer questions, calculations, graphical and extended- open-response questions.

2 Subject content and assessment information

The subject content sets out the knowledge, understanding and skills relevant to this qualification. Together with the assessment information, it provides the framework within which centres create their programmes of study.

Qualification aims and objectives

The aims and objectives of this qualification are to enable students to:

- understand the structures of the Earth, Moon and Sun; and how their interactions produce many of the astronomical cycles and phenomena of our natural world
- understand the Earth's place within the Solar System and the universe; and the forces, which have shaped both our own, and other planetary systems
- understand the forces governing the life cycles of stars; and demonstrate a knowledge of how stars appear in the night sky
- understand how astronomers discovered the Earth's position within our galaxy and the Universe; and understand current theories for the evolution of the Universe
- understand the challenges inherent in making observations in astronomy; and the ways in which technology has aimed to overcome them
- apply observational, enquiry and problem-solving skills, through the use of information from aided and unaided astronomical observations; and use these skills to evaluate observations and methodologies
- develop an informed interest in current astronomical investigations, discoveries and space exploration
- acquire knowledge and understanding of astronomy theory and practice, and the skills needed to investigate a wide range of astronomical contexts
- understand that the study and practice of astronomy are interdependent and iterative activities, and appreciate the links between astronomy and other branches of science
- develop an awareness that the study and practice of astronomy are subject to limitations by e.g. economic, technical, ethical and cultural influences
- progress to further and higher education courses in the fields of astronomy or physics.

Working scientifically

The GCSE in Astronomy requires students to develop the skills, knowledge and understanding of working scientifically. Working scientifically will be assessed through the examinations.

1 Development of scientific thinking

a understand how scientific methods and theories develop over time

b use a variety of models – such as representational, spatial, descriptive, computational and mathematical – to solve problems, make predictions and develop scientific explanations, and understand familiar and unfamiliar facts and observations

c appreciate the power and limitations of theories in astronomy

d explain how every day and technological applications of science are used in astronomy; evaluate associated personal, social and economic implications; and make decisions based on the evaluation of evidence and arguments

e recognise the importance of peer review of results and of communicating results to a range of audiences.

2 Observational skills and strategies

a use scientific theories and explanations to develop hypotheses

b plan observations to test hypotheses, check data or explore phenomena

c apply knowledge of a range of techniques, instruments and apparatus to select those appropriate to the observation

d understand how to carry out observations appropriately with due regard to the correct manipulation of equipment, the accuracy of measurements, and health and safety considerations

e understand how to make and record observations and measurements using a range of apparatus and methods

f evaluate methods and suggest possible improvements and further iterations.

3 Analysis and evaluation

Apply the cycle of collecting, presenting and analysing data, including:

a presenting observations and other data using appropriate methods

b translating data from one form to another

c carrying out and representing mathematical and statistical analyses

d representing distributions of results and making estimations of uncertainty

e interpreting observations and other data (presented in verbal, diagrammatic, graphical, symbolic or numerical form), including identifying patterns and trends, making inferences and drawing conclusions

f presenting reasoned explanations including relating observations and data to hypotheses

g being objective, evaluating data in terms of accuracy, precision, repeatability and reproducibility, and identifying potential sources of random and systematic error

h communicating the scientific rationale for observations, methods used, findings, and reasoned conclusions through paper-based and electronic reports, and presentations using verbal, diagrammatic, graphical, numerical and symbolic forms.

4 Scientific vocabulary, quantities, units, symbols and nomenclature

a use scientific vocabulary, terminology and definitions

b recognise the importance of scientific quantities and understand how they are determined

c use SI units and related derived units (e.g. kg, km, l.y., pc, AU)

d use prefixes and powers of ten for orders of magnitude (e.g. tera, giga, mega, kilo, centi, milli, micro and nano)

e interconvert units

f use an appropriate number of significant figures in calculation.

Mathematics

Maths skills will be assessed in the examinations. Those skills that can be assessed in relation to a specification point are referenced in the maths column, next to the specification point. Please see *Appendix 1: Mathematical skills* for full details of each maths skill.

At the end of most topics in this specification, there are details relating to the 'Use of mathematics' which give the astronomy-specific mathematic skills that are found in each topic of content in the document *Astronomy GCSE subject content*, published by the Department for Education (DfE) in March 2016. The reference in brackets after each statement refers to the mathematical skills from *Appendix 1*.

Please see *Appendix 3: Calculators* for information on the use of calculators in the assessments of this qualification.

Equations

Students are not required to recall any equations. The equations that students are expected to be able to use are listed in the specification points and in *Appendix 2: Formulae and data sheet*. The formulae and data sheet for each examination are given in the examination paper.

Content

The specification points all begin with either 'know', 'understand' or 'be able to'. These command words indicate the depth to which the content must be studied.

A 'know' statement is limited to recalling the facts in the specification content. An 'understand' statement includes all aspects of 'know' and additional depth to reach an understanding of the content. A 'be able to' statement includes all aspects of 'know' and 'understand', as well as application of skills for the specification content.

For example specification statement 1.4 states 'Be able to use the latitude and longitude co-ordinate system'. This means that students can be expected to use the longitude and latitude system in questions relating to positions on Earth. They could also be asked to explain how longitude and latitude are different to each other and also to recall a definition for longitude and latitude.

Paper 1: Naked-eye Astronomy

Topic 1 – Planet Earth

Students will gain an understanding of the planet Earth and its internal structure. They will learn about the major divisions on Earth's surface and how its atmosphere affects observations.

Students should:		Maths skills
1.1	Know that the shape of the Earth is an oblate spheroid	
1.2	Be able to use information about the mean diameter of the Earth (13 000 km)	2a, 2b
1.3	Understand the Earth's major internal divisions and their features: a crust b mantle c outer core d inner core	
1.4	Be able to use the latitude and longitude co-ordinate system	5a, 5d
1.5	Be able to use the major divisions of the Earth's surface as astronomical reference points, including: a Equator b Tropic of Cancer c Tropic of Capricorn d Arctic Circle e Antarctic Circle f Prime Meridian g North Pole h South Pole	5a, 5d
1.6	Understand the effects of the Earth's atmosphere on astronomical observations, including sky colour, skyglow (light pollution) and 'twinkling' (seeing)	

Use of mathematics

- use angular measures in degrees (5a)
- use ideas of latitude and longitude (5d)

Topic 2 – The lunar disc

Students will gain an understanding of the Moon and its surface formations, and be able to identify some of the main features on its surface. Students will study the rotation and revolution of the Moon and the effect of libration.

Students should:		Maths skills
2.1	Know the shape of the Moon	
2.2	Be able to use information about the mean diameter of the Moon (3500 km)	1a, 1b 2f
2.3	Be able to recognise the appearance of the principal naked-eye lunar surface formations, including: a craters b maria c terrae d mountains e valleys	
2.4	Understand the structure and origin of the principal naked-eye lunar surface formations, including: a craters b maria c terrae d mountains e valleys	
2.5	Be able to identify the following features on the lunar disc: a Sea of Tranquility b Ocean of Storms c Sea of Crises d Tycho e Copernicus f Kepler g Apennine mountain range	
2.6	Be able to use the rotation and revolution (orbital) periods of the Moon	1a
2.7	Understand the synchronous nature of the Moon's orbit	
2.8	Understand the causes of lunar libration and its effect on the visibility of the lunar disc	

Use of mathematics

- use ratios to determine the relative sizes of the Moon, Earth and Sun (1c)
- translate information between graphical and numerical forms, for example when working with data on shadow lengths and directions from shadow sticks and sundials or on tides (4a)

Topic 3 – The Earth-Moon-Sun system

Students will gain an understanding of the relationship between the Earth, Moon and Sun and how they affect each other. They will also study tides, precession and eclipses.

Students should:		Maths skills
3.1	Be able to use the relative sizes of the Earth, Moon and Sun	1c 2f
3.2	Be able to use the relative distances between the Earth, Moon and Sun	1b, 1c 2f
3.3	Understand how Eratosthenes and Aristarchus used observations of the Moon and Sun to determine successively: a diameter of the Earth b diameter of the Moon c distance to the Moon d distance to the Sun e diameter of the Sun	1b, 1c 3a 5a, 5b, 5c
3.4	Be able to use information about the mean diameter of the Sun (1.4×10^6 km)	1b, 1c
3.5	Understand the relative effects of the Sun and Moon in producing high and low, spring and neap tides	
3.6	Understand how the gradual precession of the Earth's axis affects the appearance of the Sun, Moon and stars, when observed from Earth, and its use in archaeoastronomy	
3.7	Be able to use data relating to the rate of precession of the Earth's axis	1a 5a, 5b, 5d
3.8	Understand the appearance of the Sun during partial, total and annular solar eclipses, including the terms first, second, third and fourth umbral contact	
3.9	Understand the appearance of the Moon during partial and total lunar eclipses, including the terms first, second, third and fourth umbral contact	
3.10	Understand the causes of solar and lunar eclipses	

Use of mathematics

- substitute numerical values into algebraic equations using appropriate physical quantities, for example in reproducing Eratosthenes' calculations or when using the Equation of Time (3c)
- use angular measures in degrees (5a)
- recognise and use expressions in standard form, for example when considering the actual size and relative scale of the Earth-Moon-Sun system (1b)
- use ratios to determine the relative sizes of the Moon, Earth and Sun (1c)
- use specialist units such as the AU (2c)
- use degrees, minutes and seconds of arc (5b)
- substitute numerical values into algebraic equations using appropriate physical quantities, for example in reproducing Eratosthenes' calculations (3c)
- change the subject of an equation (3b)
- substitute numerical values into algebraic equations using appropriate physical quantities (3c)
- solve simple algebraic equations (3d)
- use angular measure in degrees when using the declination system (5a)
- use degrees, minutes and seconds of arc when working with the celestial and horizon coordinate systems (5b)
- translate information between graphical and numerical forms, e.g. when working with data on shadow lengths and directions from shadow sticks and sundials or on tides (4a)

Topic 4 – Time and the Earth-Moon-Sun cycles

Students will gain an understanding of astronomical definitions and measurements of time. They will study synodic and sidereal time, solstices and equinoxes and the need for time zones.

Students should:		Maths skills
4.1	Understand the difference between sidereal and synodic (solar) days	
4.2	Understand the role of the Sun in determining Apparent Solar Time (AST)	
4.3	Understand the role of the Mean Sun in determining Mean Solar Time (MST) and Local Mean Time (LMT)	
4.4	Be able to use: the Equation of Time = Apparent Solar Time (AST) − Mean Solar Time (MST)	3b, 3c, 3d
4.5	Understand the annual variation of the Equation of Time	4a
4.6	Understand the causes of the annual variation of the Equation of Time	4a
4.7	Understand how to determine the time of local noon using shadows, including use of a shadow stick	1a 3b 4a, 4b
4.8	Understand the structure and use of sundials	
4.9	Understand the lunar phase cycle	
4.10	Understand the difference between sidereal and synodic (solar) months	
4.11	Understand the annual variation in times of sunrise and sunset	4a
4.12	Understand the astronomical significance of equinoxes and solstices	
4.13	Understand the variation in the Sun's apparent motion during the year, particularly at the equinoxes and solstices	
4.14	Understand the relationship between sidereal and synodic (solar) time	
4.15	Understand the difference in local time for observers at different longitudes	
4.16	Understand the use of time zones	
4.17	Be able to use data related to time zones	1a, 1c 5a, 5b
4.18	Know that mean time at any point along the Prime Meridian is defined as Greenwich Mean Time (GMT), which is the same as Universal Time (UT)	

Students should:		Maths skills
4.19	Be able to use shadow-stick data and the Equation of Time to determine longitude	1a 3b 4a 5a
4.20	Understand the principles of astronomical methods for the determination of longitude, including the lunar distance method	
4.21	Understand the principle of the horological method for the determination of longitude (Harrison's marine chronometer) (knowledge of internal working of chronometers not required)	

Use of mathematics

- substitute numerical values into algebraic equations using appropriate physical quantities, for example in reproducing Eratosthenes' calculations or when using the Equation of Time (3c)
- use angular measures in degrees (5a)
- use ideas of latitude and longitude (5d)
- translate information between graphical and numerical forms, for example when working with data on shadow lengths and directions from shadow sticks and sundials or on tides (4a)
- change the subject of an equation, for example the Equation of Time (3b)
- solve simple algebraic equations (3d)
- convert between hours, minutes and seconds, and decimal fractions of hours (5b)

Topic 5 – Solar System observation

Students will gain an understanding of how to observe the Sun and planets, including the locations of the planets in relation to the Earth and the Sun and safely observing the Sun.

Students should:		Maths skills
5.1	Understand how to use pinhole projection to observe the Sun safely	
5.2	Understand the observed motion of the Sun follows an annual path called the ecliptic	
5.3	Understand the changing position of the planets in the night sky	4a
5.4	Understand the observed motion of the planets takes place within a narrow Zodiacal Band	4a
5.5	Understand the observed retrograde motion of planets	4a
5.6	Understand the terms First Point of Aries and First Point of Libra	
5.7	Understand the appearance and cause of meteors and meteor showers, including determination of the radiant	
5.8	Understand the terms: a conjunction (superior and inferior) b opposition c elongation d transit e occultation	2c 4a 5a

Use of mathematics

- use specialist units such as the AU (2c)
- translate information between graphical and numeric form (4a)

Topic 6 – Celestial observation

Students will gain an understanding of how to observe a variety of naked-eye astronomical phenomena. They will study how to plan their observations to be at the best time and location, taking into account effects such as weather and light pollution.

Students should:		Maths skills
6.1	Be able to recognise the following astronomical phenomena visible to the naked eye, including: a Sun b Moon c stars (including double stars, constellations and asterisms) d star clusters e galaxies and nebulae f planets g comets h meteors i aurorae j supernovae and artificial objects, including: k artificial satellites l aircraft	
6.2	Be able to recognise and draw the following constellations and asterisms, including their most prominent stars: a Cassiopeia b Cygnus c Orion d Plough e Southern Cross f Summer Triangle g Square of Pegasus	
6.3	Understand the use of asterisms as pointers to locate specific objects in the night sky, including: a Arcturus and Polaris from the Plough b Sirius, Aldebaran and the Pleiades from Orion's Belt c Fomalhaut and the Andromeda galaxy from Square of Pegasus	
6.4	Understand why there is a range of constellation, asterism and star names among different cultures	

Students should:		Maths skills
6.5	Be able to use information from star charts, planispheres, computer programs or 'apps' to identify objects in the night sky	
6.6	Understand the causes and effects of light pollution on observations of the night sky	
6.7	Understand the meaning of the terms: a celestial sphere b celestial poles c celestial equator	5a
6.8	Understand the use of the equatorial coordinate system (right ascension and declination)	5a, 5b, 5c
6.9	Understand the use of the horizon coordinate system (altitude and azimuth)	5a, 5b, 5c
6.10	Understand how the observer's latitude can be used to link the equatorial and horizon coordinates of an object for the observer's meridian	1a 4a 5a, 5b, 5c
6.11	Understand how the observer's meridian defines local sidereal time and an object's hour angle	1a 4a 5a, 5b, 5c
6.12	Be able to use information on equatorial and horizon coordinates to determine: a the best time to observe a particular celestial object b the best object(s) to observe at a particular time	1a 4a 5a, 5b, 5c
6.13	Understand, in relation to astronomical observations, the terms: a cardinal points b culmination c meridian d zenith e circumpolarity	
6.14	Understand the diurnal motion of the sky due to the Earth's rotation	4a 5a
6.15	Be able to use a star's declination to determine whether the star will be circumpolar from an observer's latitude	4a 5a, 5b
6.16	Understand the apparent motion of circumpolar stars, including upper transit (culmination) and lower transit	4a 5a, 5b

Students should:		Maths skills
6.17	Be able to use information about rising and setting times of stars to predict their approximate position in the sky	1c 4a
6.18	Be able to find the latitude of an observer using Polaris	5a, 5b, 5c
6.19	Understand naked eye techniques such as dark adaptation and averted vision	
6.20	Understand the factors affecting visibility, including: a rising and setting b seeing conditions c weather conditions d landscape	
6.21	Understand the appearance of the Milky Way from Earth as seen with the naked eye	

Use of mathematics

- use angular measures in degrees (5a)
- use ideas of latitude and longitude (5d)
- change the subject of an equation (3b)
- substitute numerical values into algebraic equations using appropriate physical quantities (3c)
- solve simple algebraic equations (3d)
- translate information between graphical and numeric form such as on the Hertzsprung-Russell diagram (4a)
- use angular measure in degrees when using the declination system (5a)
- use degrees, minutes and seconds of arc when working with the celestial and horizon coordinate systems (5b)
- use the concept of subtended angle when working with the celestial and horizon coordinate systems (5c)
- use concepts of 3D motion, rotation and coordinates on a sphere when working with the celestial and horizon coordinate systems (5d)

Topic 7 – Early models of the Solar System

Students will gain an understanding of how ancient civilisations observed the Solar System. They will also study how early astronomers modelled the Solar System.

Students should:		Maths skills
7.1	Understand the use of detailed observations of solar and lunar cycles by ancient civilisations around the world for: a agricultural systems b religious systems c time and calendar systems d alignments of ancient monuments	
7.2	Understand that the current celestial alignment of ancient monuments differs from their original celestial alignment due to the precession of the Earth's axis	
7.3	Understand early geocentric models of the Solar System	
7.4	Understand the advantage of the addition of epicycles, as described by Ptolemy	
7.5	Be able to use information about the scale of the Solar System	2c, 2f
7.6	Be able to use the astronomical unit (1 AU = 1.5×10^8 km), light year (l.y.) and parsec (pc)	2c

Use of mathematics

- use specialist units: AU, l.y. and pc when considering the size of Solar System and the distances to other stars (2c)
- translate information between graphical and numeric form (4a)

Topic 8 – Planetary motion and gravity

Students will gain an understanding of the motion of the planets around the Sun and the role of gravity. They will study Kepler's laws of planetary motion and Newton's law of universal gravitation.

Students should:		Maths skills
8.1	Understand the contribution of the observational work of Brahe in the transition from a geocentric to a heliocentric model of the Solar System	
8.2	Understand the contribution of the mathematical modelling of Copernicus and Kepler in the transition from a geocentric to a heliocentric model of the Solar System	
8.3	Understand the role of gravity in creating stable elliptical orbits	
8.4	Understand Kepler's laws of planetary motion	4a 5a
8.5	Understand the terms 'aphelion' and 'perihelion' (solar orbits), 'apogee' and 'perigee' (Earth orbits) for an elliptical orbit	4a 5a
8.6	Be able to use Kepler's third law in the form: $\frac{T^2}{r^3} = \text{a constant}$ where T is the orbital period of an orbiting body and r is the mean radius of its orbit	1e 3b, 3c, 3d 4b
8.7	Understand that the constant in Kepler's third law depends inversely on the mass of the central body	1c, 1e 3b, 3c, 3d
8.8	Know that Newton was able to explain Kepler's laws using his law of universal gravitation	
8.9	Understand that the gravitational force between two bodies is proportional to the product of their masses and inversely proportional to the square of their separation (algebraic expression of Newton's law of universal gravitation not required)	1c, 1e

Use of mathematics

- use specialist units: AU, l.y. and pc when considering the size of Solar System and the distances to other stars (2c)
- use ratios and inverse square relationships when using Newton's law of universal gravitation (1c)
- solve algebraic equations such as Kepler's third law of planetary motion (3d)
- translate information between graphical and numeric form (4a)
- plot two variables from experimental or other data (4b)
- use a calculator to determine squares, square roots and cubes of positive numbers when using Kepler's third law of planetary motion (1e)

Assessment information

- First assessment: May/June 2019.
- The assessment is 1 hour and 45 minutes.
- The assessment consists of ten questions.
- The assessment is out of 100 marks.
- Students must answer all questions.
- The paper will include multiple-choice, short-answer questions, calculations, graphical and extended-open-response questions.
- Calculators may be used in the examination. Information regarding the use of calculators during the examinations for this qualification can be found in *Appendix 3: Calculators*.

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area. Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject.

This paper assesses synopticity.

Sample assessment materials

A sample paper and mark scheme for this paper can be found in the *Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy Sample Assessment Materials (SAMs)* document.

Please see *Appendix 4* for a description of what the command words used in the SAMs mean.

Paper 2: Telescopic Astronomy

Topic 9 – Exploring the Moon

Students will gain an understanding of the Moon, its internal structure and features on the far side. They will study how the constant drive to improve the accuracy, detail and range of observations has provided a context for the exploration of the Moon.

Students should:		Maths skills
9.1	Understand the Moon's major internal divisions in comparison with those of the Earth	
9.2	Understand the major differences between the appearance of the Moon's near and far sides	
9.3	Understand how information has been gathered about the Moon's far side	
9.4	Understand that a spacecraft traveling to the Moon must reach the Earth's escape velocity, the energy requirements of which can be met only by the use of rockets	
9.5	Understand the Giant Impact Hypothesis and alternative theories of the Moon's origin, including Capture Theory and Co-accretion Theory	

Topic 10 – Solar astronomy

Students will gain an understanding of the structure of the Sun, its energy production process and the solar wind. Students will also use sunspot data to determine information about the Sun's rotation period and the solar cycle.

Students should:		Maths skills
10.1	Understand methods of observing the Sun safely, including: a telescopic projection b H-alpha filter	
10.2	Know the location and relative temperatures of the Sun's internal divisions, including: a core b radiative zone c convective zone d photosphere	
10.3	Understand the role of the Sun's internal divisions in terms of energy production and transfer	
10.4	Understand the principal nuclear fusion process in the Sun (the proton-proton cycle)	
10.5	Know the location, temperature and relative density of components of the solar atmosphere, including: a chromosphere b corona	
10.6	Understand the structure, origin and evolution of sunspots	
10.7	Be able to use sunspot data to determine the mean solar rotation period	1c 2b 4a 5a, 5b
10.8	Be able to use sunspot data relating to the solar cycle	4a
10.9	Understand the different appearance of the Sun when observed using radiation from the different regions of the electromagnetic spectrum	
10.10	Understand the nature, composition and origin of the solar wind	

Students should:		Maths skills
10.11	Understand the principal effects of the solar wind, including: a aurorae b cometary tails c geomagnetic storms d the effects on satellites, aircraft travel and manned missions	
10.12	Know the shape and position of the Earth's magnetosphere including the Van Allen Belts	

Use of mathematics

- use angular measures in degrees (5a)
- translate information between graphical and numerical forms, for example when working with data on shadow lengths and directions from shadow sticks and sundials or on tides (4a)
- solve simple algebraic equations (3d)

Topic 11 – Exploring the Solar System

Students will investigate the main bodies in the Solar System and their characteristics. They will gain understanding that the constant drive to improve the accuracy, detail and range of observations has provided a context for the invention of the telescope, the development of the space telescope and probes to the outer reaches of our Solar System and has provided a context for the manned exploration of the Moon.

Students should:		Maths skills
11.1	Be able to use data about the names and relative locations of bodies in the Solar System, including: a planets b dwarf planets c Small Solar System Objects (SSSOs): asteroids, meteoroids and comets	2a, 2c 4b
11.2	Understand the structure of comets (nucleus, coma and tails)	
11.3	Understand the orbits of short-period comets and their likely origin in the Kuiper Belt	
11.4	Understand the orbits of long-period comets and their likely origin in the Oort Cloud	
11.5	Understand the location and nature of the Kuiper Belt, Oort Cloud and the heliosphere	
11.6	Understand the following principal characteristics of the planets: a relative size b relative mass c surface temperature d atmospheric composition e presence of satellites f presence of ring systems	
11.7	Understand the main theories for the formation and current position of the gas giant planets in our Solar System	
11.8	Be able to use information about the size of the Solar System	2c
11.9	Be able to use the astronomical unit (1 AU = 1.5×10^8 km), light year (l.y.) and parsec (pc)	2c
11.10	Understand the origin and structure of meteoroids and meteorites	
11.11	Know that most bodies in the Solar System orbit the Sun in, or close to, a plane called the ecliptic	
11.12	Understand the use of transits of Venus (as proposed by Halley) to determine the size of the astronomical unit and thus the absolute size of the Solar System	5a, 5b

Students should:		Maths skills
11.13	Understand the main theories for the origin of water on Earth	
11.14	Know that the human eye is limited in astronomical observations by its small aperture and limited sensitivity in low light	
11.15	Understand how the objective element of a telescope captures and focuses light so that the image can be magnified by an eyepiece	
11.16	Know that convex (converging) lenses and concave (converging) mirrors can be used to collect and focus light from astronomical objects	
11.17	Understand how simple telescopes can be made by combining an objective (lens or mirror) with an eyepiece	
11.18	Understand the basic design of the following in terms of their key elements: a Galilean refracting telescope b Keplerian refracting telescope c Newtonian reflecting telescope d Cassegrain reflecting telescope (detailed ray diagrams not required)	
11.19	Understand that the 'light grasp' of a telescope is directly proportional to the area of the objective element and thus the square of the diameter of the objective element	1c, 1e
11.20	Know that the aperture of a telescope is related to the diameter of the objective element	
11.21	Know that the field of view is the circle of sky visible through the eyepiece, measured in degrees or arcmin	5a, 5b
11.22	Understand the resolution of a telescope is: a proportional to the diameter of the objective element b reduced by observing at a longer wavelength	1c 5b, 5c
11.23	Be able to use the formula for the magnification of a telescope: $\text{magnification} = \frac{f_o}{f_e}$ where f_o is the focal length of the objective element and f_e is the focal length of the eyepiece	3a, 3b, 3c, 3d
11.24	Understand the importance of Galileo's early telescopic observations in establishing a heliocentric (Sun-centred) model of the Solar System	

Students should:		Maths skills
11.25	Understand the advantages of reflecting telescopes compared to refracting telescopes, in terms of: a chromatic aberration b very long focal lengths c using large aperture objectives d use of multiple mirrors	
11.26	Understand the advantages and disadvantages of the major types of space probe: a fly-by b orbiter c impactor d lander	
11.27	Know an example of each type of space probe, including target body and major discoveries, including: a fly-by – New Horizons (Outer Solar System) b orbiter – Juno (Jupiter) or Dawn (asteroids Vesta and Ceres) c impactor – Deep Impact (comet Tempel 1) d lander – Philae (comet 67P/Churyumov–Gerasimenko)	
11.28	Understand that a space probe must reach the Earth's escape velocity, the energy requirements of which can be met only by the use of rockets	
11.29	Understand the advantages and disadvantages of direct observation via manned missions	
11.30	Understand the main features of the Apollo programme to land astronauts on the Moon	

Use of mathematics

- use angular measures in degrees (5a)
- use specialist units: AU, l.y. and pc when considering the size of Solar System and the distances to other stars (2c)
- plot two variables from experimental or other data (4b)
- determine the slope of a linear graph such as when determining Hubble's constant (4c)
- change the subject of an equation such as when using the equation for telescopic magnification (3b)
- substitute numerical values into algebraic equations using appropriate physical quantities (3c)
- solve simple algebraic equations (3d)
- translate information between graphical and numeric form (4a)
- use ratios and inverse square relationships such as when calculating telescopic magnification and light grasp (1c)
- use degrees, minutes and seconds of arc such as when considering telescopic resolution (5b)
- use the concept of subtended angle (5c)

Topic 12 – Formation of planetary systems

Students will gain an understanding of how the interaction of gravitational and tidal forces led to the formation of our Solar System. They will use this information to study exoplanets and also the possibility of life existing elsewhere.

Students should:		Maths skills
12.1	Be able to identify the operation of each of the following in our Solar System: a gravitational attraction producing regular motion, including the orbits of planets and moons b tidal gravitational forces producing effects, including ring systems, asteroid belts and internal heating c gravitational interactions of multiple bodies producing effects such as gradual shifts in orbits, chaotic motion, resonances and the significance of Lagrangian Points (detailed mathematical descriptions not required) d accidental collisions causing impact craters, changes to orbital motions or planetary orientations e solar wind affecting comets, planetary atmospheres and the heliosphere	
12.2	Be able to identify the operation of each of the following interactions in the formation of planets and moons: a the interaction between tidal gravitational and elastic forces to determine whether a body is broken apart (Roche Limit) b the interaction between attractive gravitational and elastic forces in determining a body's spherical or irregular shape c the interaction between gravitational and thermal factors in determining the presence of an atmosphere	
12.3	Understand the main theories for the formation of gas giant planets in planetary systems	
12.4	Understand the current methods for discovering systems of exoplanets, including transit method, astrometry and radial velocity measurements	
12.5	Understand the requirements for life and the possibility of life-forms existing elsewhere, including: a on Titan b on Europa c on Enceladus d outside our Solar System	
12.6	Understand the relevance of the Goldilocks (Habitable) Zones	
12.7	Understand how factors in the Drake equation can be used to allow us to estimate the number of civilisations in our Galaxy	2a, 2e

Students should:		Maths skills
12.8	Understand the search for extra-terrestrial intelligence, by receiving radio waves (SETI), including the benefits and dangers of discovering extra-terrestrial life	

Use of mathematics

- solve simple problems using numerical probability (2e)
- understand the principles of calculations involving light years (2d)

Topic 13 – Exploring starlight

Students will gain an understanding of how stars are observed and how we can obtain information about them from just observing the light they emit. They will study the evolution of stars and different types of stars. Students will also find out why we observe stars in different parts of the electromagnetic spectrum and where telescopes are located to enable better observations to be made.

	Students should:	Maths skills
13.1	Understand the astronomical magnitude scale and how apparent magnitude relates to the brightness of stars as viewed from Earth	1a, 1c
13.2	Understand the term absolute magnitude	1c
13.3	Be able to use the distance modulus formula to determine the absolute (M) or apparent magnitude (m) of a star, given the distance to the star (d): $M = m + 5 - 5\log d$ where d is the distance in parsec	1a, 1d 2c 3b, 3c, 3d
13.4	Understand what information can be obtained from a stellar spectrum, including a chemical composition b temperature c radial velocity	
13.5	Understand how stars can be classified according to spectral type	
13.6	Understand how a star's colour and spectral type are related to its surface temperature	
13.7	Be able to sketch a simple Hertzsprung-Russell diagram, including labelled axes and indicate the positions of the following: a main sequence stars b the Sun c red and blue giant stars d white dwarf stars e supergiant stars	
13.8	Understand how a star's life cycle relates to its position on the Hertzsprung-Russell diagram, for stars similar in mass to the Sun and those with masses that are much greater	
13.9	Understand the inverse square relationship between distance and brightness/intensity	1c, 1e

Students should:		Maths skills
13.10	Understand that an angle of one degree (°)comprises 60 minutes of arc (arcmin) (60’) and that each arcminute is comprised of 60 seconds of arc (arcsec) (60")	5b
13.11	Understand the term parsec (pc)	2c, 2d
13.12	Be able to determine astronomical distances using heliocentric parallax	1a, 1c 2c
13.13	Understand how to use a Hertzsprung-Russell diagram to determine distances to stars	4a
13.14	Understand the light curves of the following variable stars: a short/long period b eclipsing binary c Cepheid d novae and supernovae	
13.15	Understand the causes of variability in the light curve of eclipsing binary stars	
13.16	Understand how Cepheid variables can be used to determine distances	4a
13.17	Understand the structure of gravitationally bound stellar groupings such as binary stars and clusters	
13.18	Understand how the period of an eclipsing binary star can be deduced from its light curve	4a
13.19	Be able to use star trail photographs to determine the length of the sidereal day	1c 5a, 5b, 5c
13.20	Know that most modern astronomical observations are recorded using digital sensors that convert light into electrical signals, which can then be processed and stored as data files	
13.21	Understand how astronomers obtain and study the patterns of spectral lines in the light from astronomical objects	
13.22	Know that the Earth’s atmosphere blocks almost all of the radiation of different wavelengths in the electromagnetic spectrum, except visible light and radio waves	4a
13.23	Know that only optical and radio telescopes should be located at sea level on the Earth’s surface	
13.24	Understand how a simple radio telescope operates	
13.25	Understand why radio telescopes need extremely large apertures in order to maintain a useful resolution	1c
13.26	Understand how multiple radio telescopes can operate as an aperture synthesis system (array)	

Students should:		Maths skills
13.27	Know that radio astronomy has been important in the discovery of quasars, jets from black holes, the structure of the Milky Way and protoplanetary discs	
13.28	Understand why some infrared telescopes can operate in high-altitude locations, on the Earth's surface	
13.29	Know that infrared astronomy has been important in the discovery of protostars, dust and molecular clouds and hotspots on moons	
13.30	Understand the detrimental effect of the Earth's atmosphere on the quality of images formed by telescopes on the Earth’s surface	
13.31	Understand why telescopes operating outside the optical and radio ‘windows’ need to be sited above the Earth’s atmosphere	
13.32	Understand the advantages and disadvantages of space telescopes and detectors, including orbital observing platforms	
13.33	Understand how gamma ray, x-ray and ultraviolet astronomy have been important in the discovery of gamma ray bursts, black hole accretion discs and the corona and chromosphere structure of young stars	
13.34	Understand how a telescope alters the appearance of: a stars b double stars c binary stars d open clusters e globular clusters f nebulae g galaxies	

Use of mathematics

- change the subject of an equation (3b)
- substitute numerical values into algebraic equations using appropriate physical quantities (3c)
- solve simple algebraic equations (3d)
- translate information between graphical and numeric form such as on the Hertzsprung-Russell diagram (4a)
- plot two variables from experimental or other data such as when using the right ascension (RA) and declination (dec) coordinate system or when plotting a stellar light curve or Hertzsprung-Russell diagram (4b)
- use specialist units such as l.y, pc and kpc when considering the distances to stars (2c)
- understand the principles of calculations involving light years (2d)
- use ratios and inverse square relationships such as when considering the decreasing apparent brightness of stars with increasing distance (1c)
- use degrees, minutes and seconds of arc when working with the celestial and horizon coordinate systems (5b)
- understand and use logarithms (base 10) in equations and as scales and graphs such as when using the distance modulus formula (1d)

Topic 14 – Stellar evolution

Students will gain an understanding of how and why stars evolve. They will study how stars form and how they end their life, depending on their size.

Students should:		**Maths skills**
14.1	Be able to use the Messier and New General Catalogue (NGC) in cataloguing nebulae, clusters and galaxies	
14.2	Be able to use the Bayer system for naming the brightest stars within a constellation	
14.3	Understand the effects of the interaction between radiation pressure and gravity in a main sequence star	
14.4	Understand changes to the radiation pressure-gravity balance at different stages in the life cycle of a star with a mass similar to the Sun	3a
14.5	Understand the balance between electron pressure and gravity in a white dwarf star	
14.6	Understand changes to the radiation pressure-gravity balance at different stages in the life cycle of a star with a mass much greater than the Sun	3a
14.7	Understand the balance between neutron pressure and gravity in a neutron star	
14.8	Understand the effect the Chandrasekhar Limit has on the outcome on the final stages of the life cycle of a star	
14.9	Understand the principal stages and timescales of stellar evolution for stars of similar mass to the Sun, including: a emission and absorption nebula b main sequence star c planetary nebula d red giant e white dwarf f black dwarf	

Students should:		Maths skills
14.10	Understand the principal stages and timescales of stellar evolution for stars of much larger mass than the Sun, including: a) emission and absorption nebula b) main sequence star c) red super giant d) supernova e) neutron star f) black hole	
14.11	Understand how astronomers study and gather evidence for the existence of black holes	

Topic 15 – Our place in the Galaxy

Students will gain an understanding of the Milky Way, our place in it and how it fits into the Universe. They will study different types of galaxies and the main theories for their evolution.

Students should:		Maths skills
15.1	Understand the appearance of the Milky Way from Earth as seen with binoculars or a small telescope	
15.2	Know the size and shape of our Galaxy and the location of the Sun, dust, sites of star formation and globular clusters	
15.3	Understand how 21 cm radio waves, rather than visible light, are used to determine the structure and rotation of our Galaxy	
15.4	Know that the group of galaxies gravitationally linked to the Milky Way is called the Local Group	
15.5	Know the composition and scale of the Local Group, including its principal components: a Andromeda Galaxy (M31) b Large and Small Magellanic Clouds (LMC and SMC) c Triangulum Galaxy (M33)	
15.6	Be able to classify galaxies using the Hubble classification system, including: a spiral b barred spiral c elliptical d irregular	
15.7	Know how the different types of galaxies were placed by Hubble on his 'Tuning Fork' diagram	
15.8	Know that the Milky Way is a barred spiral (SBb) type galaxy	
15.9	Know that some galaxies emit large quantities of radiation in addition to visible light	
15.10	Know that an Active Galactic Nucleus (AGN) is powered by matter falling onto a super-massive black hole	
15.11	Know types of active galaxies, including: a Seyfert galaxies b quasars c blazars	

Students should:		Maths skills
15.12	Know that information about AGNs can be obtained from many regions of the electromagnetic spectrum	
15.13	Understand why galaxies are grouped in larger clusters and superclusters	
15.14	Understand the main theories for the formation and evolution of galaxies	

Topic 16 – Cosmology

Students will gain an understanding of redshift and Hubble's law for distant galaxies. They will also study the evidence and explanation for the expanding Universe. Students will explore dark matter and dark energy and the possible fate of the Universe.

Students should:		Maths skills
16.1	Know that observations of galaxies outside the Local Group show that light is shifted to longer wavelengths (redshift)	
16.2	Understand that redshift is caused by galaxies receding from us	
16.3	Be able to use the formula: $\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$ where λ is the observed wavelength, λ_0 is the emitted wavelength, v is the radial velocity of the source, c is the speed of light	1a, 1b 2a, 2c 3a, 3b, 3c, 3d 4a
16.4	Understand the evidence to confirm the discovery of the expanding universe	
16.5	Be able to use the relationship between distance and redshift of distant galaxies (Hubble's law) including the formula: $v = H_0 d$ where v is the radial velocity of the recession of the galaxy, H_o is the Hubble constant and d is the distance of the galaxy from Earth.	1a, 1b, 1c 2c 3a, 3b, 3c, 3d 4a, 4b, 4c
16.6	Understand the estimation of the age and size of the Universe using the value of the Hubble constant	2c, 2f 3b, 3c, 3d
16.7	Understand how the expansion of the Universe supports both the Big Bang theory and the Steady State theory	
16.8	Understand the major observational evidence in favour of the Big Bang theory: a quasars (QSOs) b cosmic microwave background (CMB) radiation c Hubble Deep Field image	
16.9	Understand the significance of the fluctuations in the CMB radiation for theories of the evolution of the Universe, including discoveries by the Wilkinson Microwave Anisotropy Probe (WMAP) and the Planck mission	

Students should:		Maths skills
16.10	Understand the significance and possible nature of dark matter and dark energy	
16.11	Understand the difficulties involved in the detection of dark matter and dark energy	
16.12	Understand that current models of the Universe predict different future evolutionary paths	

Use of mathematics

- change the subject of an equation such as Hubble's law (3b)
- substitute numerical values into algebraic equations, such as Hubble's law, using appropriate physical quantities (3c)
- solve simple algebraic equations such as Hubble's law (3d)
- translate information between graphical and numeric form such as when working with data on the distances and recessional speeds of distant galaxies (4a)
- plot two variables from experimental or other data such as when working with data on the distances and recessional speeds of distant galaxies (4b)
- determine the slope of a linear graph such as when determining Hubble's constant (4c)
- use specialist units such as l.y., pc and kpc when working with distances to objects within our Galaxy and (Mpc) when considering the distances to other galaxies (2c)
- understand the principles of calculations involving light years (2d)
- use ratios and inverse relationships such as when using Hubble's law (1c)

Assessment information

- First assessment: May/June 2019.
- The assessment is 1 hour and 45 minutes.
- The assessment consists of ten questions.
- The assessment is out of 100 marks.
- Students must answer all questions.
- The paper will include multiple-choice, short-answer questions, calculations, graphical and extended-open-response questions.
- Calculators may be used in the examination. Information regarding the use of calculators during the examinations for this qualification can be found in *Appendix 3: Calculators*.

Synoptic assessment

Synoptic assessment requires students to work across different parts of a qualification and to show their accumulated knowledge and understanding of a topic or subject area. Synoptic assessment enables students to show their ability to combine their skills, knowledge and understanding with breadth and depth of the subject.

This paper assesses synopticity.

Sample assessment materials

A sample paper and mark scheme for this paper can be found in the *Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy Sample Assessment Materials (SAMs)* document.

Please see *Appendix 4* for a description of what the command words used in the SAMs mean.

Observational skills

Requirements

Throughout their study of this qualification, students should develop their observational skills. Students must undertake at least **one unaided and one aided** observation, from the selection listed in this section. Students will need to use their knowledge and understanding of observational techniques and procedures in the written assessments.

Students need to record the work that they have undertaken for these observations. The observation record must include the knowledge, skills and understanding they have derived from the observational activities.

Centres must confirm that each student has completed at least one unaided and one aided observation by completing and submitting an Observation Statement (see *Appendix 5*). This must be submitted to Pearson by 15th April in the year that the students will sit their examinations. Any failure by centres to provide this Observation Statement will be treated as malpractice and/or maladministration.

It is important to realise that these mandatory observations are the minimum number of observations that should be taken during the course.

Safety is an overriding requirement for all observational work. Centres are responsible for ensuring appropriate safety procedures are followed whenever their students complete observational activities.

Pearson may review and amend these observational activities if necessary. Centres will be told as soon as possible about any changes to them.

Skills

Astronomical observation is an iterative cycle of design, observation, analysis and evaluation. Through the evolution of each set of observations, students suggest improvements that form the foundation of the design of the next set of observations.

Astronomical observations require students to:

1 Design observations

2 Make observations

3 Analyse observations

4 Evaluate observations.

1 Design observations

There are many uncontrollable variables in astronomical observations and reliability is improved by iteratively refining the observation programme. All astronomical observations require the informed selection of target object, observing site, time and date along with their choice of observing equipment. Students should, therefore, be involved in selecting these features of their observing programme, as well as refining them.

Students should:

a produce a list of feasible target objects, location, date, time and observing instrument, as appropriate to their chosen task

b use astronomical data to select the most appropriate target object, location, date, time or observing instrument

c generate an initial observing programme that will allow them to solve the problem posed by the title of their chosen task, including health and safety considerations

d make refinements or improvements to their observing programme, following the results of initial trials.

2 Make observations

There are many variables affecting astronomical observations which are outside the control of the observer. Students will need to undertake a series of observations in order to generate sufficient data to support valid conclusions. This is the observational programme. Students should gain experience of undertaking an observational programme in both unaided ('naked eye') and aided situations, as follows:

a conduct unaided observations, using techniques such as averted vision, dark adaptation

b conduct aided observations, using equipment such as binoculars, telescopes and cameras

c ensure that all observations are accompanied by the necessary observational details, including:

   i. date

   ii. time

   iii. location

   iv. seeing conditions

   v. optical instruments used

d ensure that sufficient observations are taken to produce accurate data for the specific task.

3 Analyse observations

Students will need to analyse their observations to produce reliable and valid conclusions for the specific observation. This will involve a wide range of skills, depending on the nature of the original observations, as follows:

a identify patterns or trends from a series of drawings or photographs

b present numerical data in the form of graphs or charts

c perform calculations

d perform basic digital image processing, including the adjustment of image brightness, dynamic range and the use of false colour.

4 Evaluate observations

Students will need to compare the results of their observations with those obtained by professional astronomers or with accepted values. This will enable them to evaluate the reliability and accuracy of their resulting conclusions and suggest improvements for further observations. This should include the following:

a compare the results of their observations with professional images or accepted values in order to assess their accuracy

b where possible, calculate a quantitative assessment of their accuracy

c identify the effects of light pollution on naked-eye observations

d identify the effects of light pollution, exposure time and filtering on photographic observations

e recognise some of the major artefacts that can affect astronomical images, such as scattered light, diffraction spikes, cosmic rays and trails from satellites, aircraft or meteors

f identify the major causes of error in the conclusions

g suggest and implement improvements to the observing programme.

Observational tasks

Each of the following observational tasks sets out a problem, which can be solved by a programme of observations. Completion of these tasks will give students an understanding of the cycle of astronomical observation and help them to develop the key observational skills.

Centres must ensure that each student completes at least **one unaided and one aided** observation task from the following list. Students may not select both of their observational tasks (unaided and aided) from the same row on the observational task table. For example, not A1 and B1.

Unaided tasks		Aided tasks	
A1	**Demonstrate the changing appearance of lunar features** Use a series of naked-eye drawings of individual lunar features to demonstrate their changing appearance during the lunar phase cycle	**B1**	**Demonstrate the changing appearance of lunar features** Use a series of telescopic drawings or photographs of individual lunar features to demonstrate their changing appearance during the lunar phase cycle
A2	**Finding the radiant point of a meteor shower** Use naked-eye drawings of the paths of meteors to determine the radiant point of a meteor shower	**B2**	**Finding the radiant point of a meteor shower** Use photographs of the paths of meteors to determine the radiant point of a meteor shower
A3	**Assess the accuracy of stellar magnitude estimates** Using reference stars, estimate the magnitude of a range of stars from naked-eye observations and thus assess the accuracy of this technique	**B3**	**Assess the accuracy of stellar magnitude measurements** Using reference stars, estimate the magnitude of a range of stars from photographs and thus assess the accuracy of this technique
A4	**Estimate a celestial property using drawings of a suitable event** Use naked-eye drawings or measurements of a celestial event such as a comet or eclipse to determine a celestial property such as the relative size of the Earth and Moon	**B4**	**Measure a celestial property using telescopic drawings or photographs of a suitable event** Use telescopic drawings, measurements or photographs of a celestial event such as a comet, transit, eclipse or occultation to determine a celestial property such as the Earth-Sun distance or the orbital period of a Jovian satellite
A5	**Estimating levels of light pollution** Use estimates of the magnitude of the faintest stars visible with the naked eye to conduct a survey of the astronomical effects of light pollution in an area	**B5**	**Measuring levels of light pollution** Use estimates of the magnitude of the faintest stars visible on photographs to conduct a survey of the astronomical effects of light pollution in an area

Unaided tasks		Aided tasks	
A6	**Estimate the solar rotation period using drawings of sunspots** Use a series of drawings from pinhole projections of sunspots to estimate the length of the Sun's average rotation period	**B6**	**Determine the solar rotation period using photographs of sunspots** Use a series of photographs or drawings from telescopic projections of sunspots to estimate the length of the Sun's average rotation period
A7	**Estimating the period of a variable star** Use estimates of stellar magnitude from naked-eye observations to produce a light curve for a variable star and thus estimate its period	**B7**	**Measuring the period of a variable star** Use estimates of stellar magnitude from telescopic observations or photographs to produce a light curve for a variable star and thus estimate its period
A8	**Comparing stellar density estimates** Use naked-eye estimates of stellar density taken in and outside the plane of the Milky Way to estimate their relative sizes	**B8**	**Comparing stellar density measurements** Use telescopic measurements of stellar density taken in and outside the plane of the Milky Way to estimate their relative sizes
A9	**Finding longitude using a shadow stick** Use measurements of shadow length around local noon to estimate the observer's longitude	N/A	
A10	**Assess the accuracy of a sundial** Use a log of sundial and clock times to assess the accuracy of a sundial	N/A	
N/A		**B11**	**Demonstrate the range of objects in the Messier Catalogue** Use detailed drawings or photographs of objects from the Messier Catalogue to demonstrate the range of different objects it contains
N/A		**B12**	**Calculation of the length of the sidereal day** Use long-exposure photographs of the area around the celestial pole to produce an accurate measurement of the length of the Earth's sidereal period

Assessment Objectives

Students must:		% in GCSE
AO1	Demonstrate knowledge and understanding of: • scientific ideas • scientific techniques and procedures.	40
AO2	Apply knowledge and understanding of: • scientific ideas • scientific techniques and procedures.	40
AO3	Analyse information and ideas to: • interpret and evaluate astronomical observations, data and methods • make judgements and draw conclusions • develop and improve observational procedures	20
	Total	**100%**

Breakdown of Assessment Objectives

Paper	Assessment Objectives			Total for all Assessment Objectives
	AO1 %	AO2 %	AO3 %	
Paper 1: Naked-eye Astronomy	20	20	10	50%
Paper 2: Telescopic Astronomy	20	20	10	50%
Total for GCSE	**40%**	**40%**	**20%**	**100%**

3 Administration and general information

Entries

Details of how to enter students for the examinations for this qualification can be found in our *UK Information Manual*. A copy is made available to all examinations officers and is available on our website: qualifications.pearson.com

Discount code and performance tables

Centres should be aware that students who enter for more than one GCSE, or other Level 2 qualifications with the same discount code, will have only the grade for their 'first entry' counted for the purpose of the school and college performance tables (please see *Appendix 8: Codes*). For further information about what constitutes 'first entry' and full details of how this policy is applied, please refer to the DfE website: www.gov.uk/government/organisations/department-for-education

Students should be advised that if they take two GCSEs with the same discount code, the schools and colleges to which they wish to progress are likely to take the view that this achievement is equivalent to only one GCSE. The same view may be taken if students take two GCSEs or other Level 2 qualifications that have different discount codes but which have significant overlap of content. Before embarking on their programmes, students or their advisers who have any doubts about their subject combinations should check with the institution to which they wish to progress.

Access arrangements, reasonable adjustments, special consideration and malpractice

Equality and fairness are central to our work. Our equality policy requires all students to have equal opportunity to access our qualifications and assessments, and our qualifications to be awarded in a way that is fair to every student.

We are committed to making sure that:

- students with a protected characteristic (as defined by the Equality Act 2010) are not, when they are undertaking one of our qualifications, disadvantaged in comparison to students who do not share that characteristic
- all students achieve the recognition they deserve for undertaking a qualification and that this achievement can be compared fairly to the achievement of their peers.

Language of assessment

Assessment of this qualification will be available in English. All student work must be in English.

Access arrangements

Access arrangements are agreed before an assessment. They allow students with special educational needs, disabilities or temporary injuries to:

- access the assessment
- show what they know and can do without changing the demands of the assessment.

The intention behind an access arrangement is to meet the particular needs of an individual student with a disability, without affecting the integrity of the assessment. Access arrangements are the principal way in which awarding bodies comply with the duty under the Equality Act 2010 to make 'reasonable adjustments'.

Access arrangements should always be processed at the start of the course. Students will then know what is available and have the access arrangement(s) in place for assessment.

Reasonable adjustments

The Equality Act 2010 requires an awarding organisation to make reasonable adjustments where a person with a disability would be at a substantial disadvantage in undertaking an assessment. The awarding organisation is required to take reasonable steps to overcome that disadvantage.

A reasonable adjustment for a particular person may be unique to that individual and therefore might not be in the list of available access arrangements.

Whether an adjustment will be considered reasonable will depend on a number of factors, including:

- the needs of the student with the disability
- the effectiveness of the adjustment
- the cost of the adjustment; and
- the likely impact of the adjustment on the student with the disability and other students.

An adjustment will not be approved if it involves unreasonable costs to the awarding organisation, or affects timeframes or the security or integrity of the assessment. This is because the adjustment is not 'reasonable'.

Special consideration

Special consideration is a post-examination adjustment to a student's mark or grade to reflect temporary injury, illness or other indisposition at the time of the examination/ assessment, which has had, or is reasonably likely to have had, a material effect on a candidate's ability to take an assessment or demonstrate their level of attainment in an assessment.

Further information

Please see our website for further information about how to apply for access arrangements and special consideration.

For further information about access arrangements, reasonable adjustments and special consideration, please refer to the JCQ website: www.jcq.org.uk.

Malpractice

Candidate malpractice

Candidate malpractice refers to any act by a candidate that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

Candidate malpractice in examinations **must** be reported to Pearson using a *JCQ Form M1* (available at www.jcq.org.uk/exams-office/malpractice). The form can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Please provide as much information and supporting documentation as possible. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice constitutes staff or centre malpractice.

Staff/centre malpractice

Staff and centre malpractice includes both deliberate malpractice and maladministration of our qualifications. As with candidate malpractice, staff and centre malpractice is any act that compromises or seeks to compromise the process of assessment or which undermines the integrity of the qualifications or the validity of results/certificates.

All cases of suspected staff malpractice and maladministration **must** be reported immediately, before any investigation is undertaken by the centre, to Pearson on a *JCQ Form M2(a)* (available at www.jcq.org.uk/exams-office/malpractice). The form, supporting documentation and as much information as possible can be emailed to pqsmalpractice@pearson.com or posted to Investigations Team, Pearson, 190 High Holborn, London, WC1V 7BH. Note that the final decision regarding appropriate sanctions lies with Pearson.

Failure to report malpractice itself constitutes malpractice.

More detailed guidance on malpractice can be found in the latest version of the document *General and Vocational Qualifications Suspected Malpractice in Examinations and Assessments Policies and Procedures,* available at www.jcq.org.uk/exams-office/malpractice.

Awarding and reporting

This qualification will be graded, awarded and certificated to comply with the requirements of Ofqual's General Conditions of Recognition.

This GCSE qualification will be graded and certificated on a nine-grade scale from 9 to 1 using the total subject mark where 9 is the highest grade. Individual papers are not graded.

Students whose level of achievement is below the minimum judged by Pearson to be of sufficient standard to be recorded on a certificate will receive an unclassified U result.

The first certification opportunity for this qualification will be 2019.

Student recruitment and progression

Pearson follows the JCQ policy concerning recruitment to our qualifications in that:

- they must be available to anyone who is capable of reaching the required standard
- they must be free from barriers that restrict access and progression
- equal opportunities exist for all students.

Prior learning and other requirements

This qualification is based on the subject content, published by the DfE. The subject content was designed to reflect or build on Key Stage 3. Consequently, students taking this qualification will benefit from previously studying physics at Key Stage 3.

Progression

Students can progress from this qualification to:

- GCEs, for example in physics
- Level 3 vocational qualifications in science, for example BTEC Level 3 in Applied Science
- employment, for example in a science-based industry where an Apprenticeship may be available.

Appendices

Appendix 1: Mathematical skills

This appendix is taken from the document *Astronomy GCSE subject content* published by the Department for Education (DfE) in June 2014.

The mathematical skills listed will be assessed in the examinations. The minimum level of mathematics in the examinations will be equivalent to Key Stage 3 mathematics.

Mathematical skills

1	**Arithmetic and numerical computation**
a	Recognise and use expressions in decimal form
b	Recognise and use expressions in standard form
c	Use ratios, fractions, percentages and inverse square relationships
d	Recognise and use logarithms (base 10) in equations and as scales and graphs
e	Use a calculator to determine squares, square roots and cubes of positive numbers
2	**Handling data**
a	Use an appropriate number of significant figures
b	Find arithmetic means
c	Use specialist units (AU, pc and Mpc with conversions to kilometres)
d	Understand the principles of calculations involving light years (ly)
e	Understand simple probability
f	Make order of magnitude calculations
3	**Algebra**
a	Understand and use the symbols: =, <, <<, >>, >, ∝, ~
b	Change the subject of an equation
c	Substitute numerical values into algebraic equations using appropriate units for physical quantities
d	Solve simple algebraic equations
4	**Graphs**
a	Translate information between graphical and numeric form
b	Plot two variables from experimental or other data
c	Determine the slope and intercept of a linear graph
5	**Geometry and trigonometry**
a	Use angular measures in degrees
b	Use degrees, minutes and seconds of arc
c	Use concept of subtended angle
d	Use concepts of 3D motion, rotation and coordinates on a sphere: RA and Dec (celestial longitude and latitude)

Appendix 2: Formulae and data sheet

This appendix lists all the equations and data that will be provided to students in the examinations.

Formulae

Specification reference	Equation	
4.4	Equation of Time = Apparent Solar Time (AST) – Mean Solar Time (MST)	
8.6	Kepler's 3rd law:	$\frac{T^2}{r^3} = \text{a constant}$
11.23	Magnification of telescope:	$\text{magnification} = \frac{f_o}{f_e}$
13.3	Distance modulus formula:	$M = m + 5 - 5\log d$
16.3	Redshift formula:	$\frac{\lambda - \lambda_0}{\lambda_0} = \frac{v}{c}$
16.5	Hubble's law:	$v = H_0 d$

Data

Mass of Earth	6.0×10^{24} kg
Mean diameter of Earth	13 000 km
Mean diameter of Moon	3500 km
Mean diameter of Sun	1.4×10^{6} km
One Astronomical Unit (AU)	1.5×10^{8} km
Mean Earth to Moon distance	380 000 km
One light year (l.y.)	9.5×10^{12} km
One parsec (pc)	3.1×10^{13} km = 3.26 l.y.
Sidereal day	23 h 56 min
Synodic day	24 h 00 min
Temperature of solar photosphere	5800 K
Hubble constant	68 km/s/Mpc
Speed of light in vacuum	3.0×10^{8} m/s

Name	Type of body	Mean distance from Sun/AU	Sidereal period/Earth year	Mean temperature /°C	Diameter /1000 km	Mass/Earth mass	Ring systems	Moons
Mercury	planet	0.38	0.24	170	4.9	0.055	no	none
Venus	planet	0.72	0.62	470	12.1	0.82	no	none
Earth	planet	1.0	1.0	15	12.8	1.00	no	1: the Moon
Mars	planet	1.5	1.9	−50	6.9	0.11	no	2 small moons: Deimos and Phobos
Ceres	dwarf planet	2.8	4.6	−105	0.95	1.5×10^{-4}	no	none
Jupiter	planet	5.2	11.9	−150	143	318	yes	4 major moons: Ganymede, Callisto, Europa, Io >60 others
Saturn	planet	9.5	29.5	−180	121	95	yes	5 major moons: including Titan, Iapetus >55 others
Uranus	planet	19.1	84.0	−210	51	15	yes	5 major moons: including Titania, Oberon >20 others
Neptune	planet	30.0	165	−220	50	17	yes	1 major: Triton >12 others
Pluto	dwarf planet	39.5	248	−230	2.4	2.2×10^{-3}	no	1 major: Charon >4 other moons
Haumea	dwarf planet	43.1	283	−241	1.4	6.7×10^{-4}	no	2
Eris	dwarf planet	67.8	557	−230	2.3	2.8×10^{-3}	no	at least 1

Appendix 3: Calculators

Candidates may use a calculator in assessments for this qualification. Centres are responsible for making sure that calculators used by their students meet the requirements highlighted in the table below.

Candidates must be familiar with the requirements before their assessments for this qualification.

<table>
<tr>
<td>Calculators must be:
• of a size suitable for use on a desk
• either battery or solar powered
• free of lids, cases and covers that have printed instructions or formulae.</td>
<td rowspan="2">Calculators must not:
• be designed or adapted to offer any of these facilities:
o language translators
o symbolic algebraic manipulation
o symbolic differentiation or integration
o communication with other machines or the internet
• be borrowed from another candidate during an examination for any reason*
• have retrievable information stored in them, and this includes:
o databanks
o dictionaries
o mathematical formulae
o text.</td>
</tr>
<tr>
<td>The candidate is responsible for the following:
• the calculator’s power supply
• the calculator’s working condition
• clearing anything stored in the calculator.</td>
</tr>
</table>

*An invigilator may give a candidate a replacement calculator

Appendix 4: Taxonomy

The following table lists the command words used in the external assessments.

Command word	Definition
Add/Label	Requires the addition or labelling to a stimulus material given in the question, for example labelling a diagram or adding units to a table.
Calculate	Obtain a numerical answer, showing relevant working. If the answer has a unit, this must be included. This can include using an equation to calculate a numerical answer.
Comment on	Requires the synthesis of a number of variables from data/information to form a judgement.
Compare	Find the similarities and differences of two elements given in a question. Each point made must relate to both elements, and must include a comparative statement of their similarity/difference.
Complete	Requires the completion of a table/diagram.
Describe	To give an account of something. Statements in the response need to be developed as they are often linked but do not need to include a justification or reason.
Define	To set forth the meaning of a word or a phrase.
Determine	The answer must have an element which is quantitative from the stimulus provided, or must show how the answer can be reached quantitatively. To gain maximum marks there must be a quantitative element to the answer.
Design	Plan an observing programme from existing principles/ideas.
Draw	Produce a neat freehand drawing, paying attention to shape (and scale where appropriate).
Estimate	Find an approximate value, number, or quantity from a diagram/given data or through a calculation.
Evaluate	Review information (e.g. data, methods) then bring it together to form a conclusion, drawing on evidence including strengths, weaknesses, alternative actions, relevant data or information. Come to a supported judgement of a subject's qualities and relation to its context.
Explain	An explanation requires a justification/exemplification of a point. The answer must contain some element of reasoning/justification, this can include mathematical explanations.
Give/State/Name	All of these command words are really synonyms. They generally all require recall of one or more pieces of information.
Give a reason/reasons	When a statement has been made and the requirement is only to give the reasons why.

Command word	Definition
Identify	Usually requires some key information to be selected from a given stimulus/resource.
Justify	Give evidence to support (either the statement given in the question or an earlier answer).
Plot	Produce a graph by marking points accurately on a grid from data that is provided and then drawing a line of best fit through these points. A suitable scale and appropriately labelled axes must be included if these are not provided in the question.
Predict	Give an expected result.
Show that	Verify the statement given in the question by showing each step of the working for a calculation.
Sketch	For a graph this would need a line and labelled axis with important features indicated, the axis are not scaled.
State what is meant by	When the meaning of a term is expected but there are different ways of how these can be described.
Which of the following	Select one of the four answer choices given in a multiple-choice question.

Verbs preceding a command word	
Analyse data to explain	Examine the data in detail to provide an explanation.
Analyse data to comment	Examine the data in detail to form a judgement.
Analyse data to determine	Examine the data in detail to come to a conclusion.
Suggest a …	Suggest an explanation or suggest a description.

Please refer to the Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy Sample Assessment Materials (SAMs) for the application of some of these command words.

Appendix 5: Observation Statement

Pearson Edexcel Level 1/Level 2 GCSE (9–1) in Astronomy	**1AS0**
Centre name:	Centre number:
All candidates must carry out one unaided and one aided observation throughout the course of this qualification.	
Observation work	**Number of students**
Unaided Observation	
Aided Observation	

Head Teacher declaration

I declare that:

i. all candidates have completed one unaided and one aided observation, and

ii. the work submitted for assessment has been carried out without assistance other than that which is acceptable according to the rules of the specification.

I declare that the observation work recorded above has been carried out in accordance with the Pearson Edexcel Level 1/Level 2 GCSE in Astronomy (9–1) observation work requirements.

Each candidate has made a contemporaneous record of:

i. the work that they have undertaken during these observations, and

ii. the knowledge, skills and understanding which that candidate has derived from those observations.

Head teacher name:			
Head teacher signature:		**Date:**	

Appendix 6: The context for the development of this qualification

All our qualifications are designed to meet our World Class Qualification Principles[1] and our ambition to put the student at the heart of everything we do.

We have developed and designed this qualification by:

- reviewing other curricula and qualifications to ensure that it is comparable with those taken in high-performing jurisdictions overseas
- consulting with key stakeholders on content and assessment, including learned bodies, subject associations, higher-education academics, teachers and employers to ensure this qualification is suitable for a UK context
- reviewing the legacy qualification and building on its positive attributes.

This qualification has also been developed to meet criteria stipulated by Ofqual in their documents *GCSE (9 to 1) Qualification Level Conditions and Requirements* and *GCSE Subject Level Conditions and Requirements for Astronomy*, published in March 2016.

[1] Pearson's World Class Qualification Principles ensure that our qualifications are:

- **demanding**, through internationally benchmarked standards, encouraging deep learning and measuring higher-order skills
- **rigorous**, through setting and maintaining standards over time, developing reliable and valid assessment tasks and processes, and generating confidence in end users of the knowledge, skills and competencies of certified students
- **inclusive**, through conceptualising learning as continuous, recognising that students develop at different rates and have different learning needs, and focusing on progression
- **empowering**, through promoting the development of transferable skills, see *Appendix 7*.

From Pearson's Expert Panel for World Class Qualifications

" The reform of the qualifications system in England is a profoundly important change to the education system. Teachers need to know that the new qualifications will assist them in helping their learners make progress in their lives.

When these changes were first proposed we were approached by Pearson to join an 'Expert Panel' that would advise them on the development of the new qualifications.

We were chosen, either because of our expertise in the UK education system, or because of our experience in reforming qualifications in other systems around the world as diverse as Singapore, Hong Kong, Australia and a number of countries across Europe.

We have guided Pearson through what we judge to be a rigorous qualification development process that has included:

- establishing External Subject Advisory Groups, drawing on independent subject-specific expertise to challenge and validate our qualifications
- subjecting the final qualifications to scrutiny against the DfE content and Ofqual accreditation criteria in advance of submission.

Importantly, we have worked to ensure that the content and learning is future oriented. The design has been guided by what is called an 'Efficacy Framework', meaning learner outcomes have been at the heart of this development throughout.

We understand that ultimately it is excellent teaching that is the key factor to a learner's success in education. As a result of our work as a panel we are confident that we have supported the development of qualifications that are outstanding for their coherence, thoroughness and attention to detail and can be regarded as representing world-class best practice. "

Sir Michael Barber (Chair)

Chief Education Advisor, Pearson plc

Professor Lee Sing Kong

Director, National Institute of Education, Singapore

Bahram Bekhradnia

President, Higher Education Policy Institute

Professor Jonathan Osborne

Stanford University

Dame Sally Coates

Principal, Burlington Danes Academy

Professor Dr Ursula Renold

Federal Institute of Technology, Switzerland

Professor Robin Coningham

Pro-Vice Chancellor, University of Durham

Professor Bob Schwartz

Harvard Graduate School of Education

Dr Peter Hill

Former Chief Executive ACARA

Appendix 7: Transferable skills

The need for transferable skills

In recent years, higher education institutions and employers have consistently flagged the need for students to develop a range of transferable skills to enable them to respond with confidence to the demands of undergraduate study and the world of work.

The Organisation for Economic Co-operation and Development (OECD) defines skills, or competencies, as 'the bundle of knowledge, attributes and capacities that can be learned and that enable individuals to successfully and consistently perform an activity or task and can be built upon and extended through learning.' [1]

To support the design of our qualifications, the Pearson Research Team selected and evaluated seven global 21st-century skills frameworks. Following on from this process, we identified the National Research Council's (NRC) framework as the most evidence-based and robust skills framework. We adapted the framework slightly to include the Program for International Student Assessment (PISA) ICT Literacy and Collaborative Problem Solving (CPS) Skills.

The adapted National Research Council's framework of skills involves:[2]

Cognitive skills

- **Non-routine problem solving** – expert thinking, metacognition, creativity.
- **Systems thinking** – decision making and reasoning.
- **Critical thinking** – definitions of critical thinking are broad and usually involve general cognitive skills such as analysing, synthesising and reasoning skills.
- **ICT literacy** – access, manage, integrate, evaluate, construct and communicate.[3]

Interpersonal skills

- **Communication** – active listening, oral communication, written communication, assertive communication and non-verbal communication.
- **Relationship-building skills** – teamwork, trust, intercultural sensitivity, service orientation, self-presentation, social influence, conflict resolution and negotiation.
- **Collaborative problem solving** – establishing and maintaining shared understanding, taking appropriate action, establishing and maintaining team organisation.

Intrapersonal skills

- **Adaptability** – ability and willingness to cope with the uncertain, handling work stress, adapting to different personalities, communication styles and cultures, and physical adaptability to various indoor and outdoor work environments.
- **Self-management and self-development** – ability to work remotely in virtual teams, work autonomously, be self-motivating and self-monitoring, willing and able to acquire new information and skills related to work.

Transferable skills enable young people to face the demands of further and higher education, as well as the demands of the workplace, and are important in the teaching and learning of this qualification. We will provide teaching and learning materials, developed with stakeholders, to support our qualifications.

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[1] OECD – *Better Skills, Better Jobs, Better Lives* (OECD Publishing, 2012)

[2] Koenig J A, National Research Council – *Assessing 21st Century Skills: Summary of a Workshop* (National Academies Press, 2011)

[3] PISA – *The PISA Framework for Assessment of ICT Literacy* (2011)

Appendix 8: Codes

Type of code	Use of code	Code
Discount codes	Every qualification eligible for performance tables is assigned a discount code indicating the subject area to which it belongs. Discount codes are published by DfE in the RAISEonline library (www.raiseonline.org)	RE1
Regulated Qualifications Framework (RQF) codes	Each qualification title is allocated an Ofqual Regulated Qualifications Framework (RQF) code. The RQF code is known as a Qualification Number (QN). This is the code that features in the DfE Section 96 and on the LARA as being eligible for 16–18 and 19+ funding, and is to be used for all qualification funding purposes. The QN will appear on students' final certification documentation.	The QN for this qualification is: 603/0244/6
Subject codes	The subject code is used by centres to enter students for a qualification. Centres will need to use the entry codes only when claiming students' qualifications.	GCSE – 1AS0
Paper codes	These codes are provided for reference purposes. Students do not need to be entered for individual papers.	Paper 1: 1AS0/01 Paper 2: 1AS0/02

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