GCSE Astronomy Syllabus

1 The Planet Earth

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)

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

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

1.6 Understand the effects of the Earth's atmosphere on astronomical observations, including sky colour, skyglow (light pollution) and 'twinkling' (seeing)

2 The Lunar Disc

2.1 Know the shape of the Moon

2.2 Be able to use information about the mean diameter of the Moon (3500 km)

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

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

3 The Earth-Moon-Sun-System

3.1 Be able to use the relative sizes of the Earth, Moon and Sun

3.2 Be able to use the relative distances between the Earth, Moon and Sun

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

3.4 Be able to use information about the mean diameter of the Sun (1.4 × 106 km)

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'saxis

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

4 Time and the Earth-Moon-Sun Cycles

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)

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

4.7 Understand how to determine the time of local noon using shadows, including use of a shadow stick

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

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)

4.19 Be able to use shadow-stick data and the Equation of Time to determine longitude

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)

5 Solar System observation

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

5.4 Understand the observed motion of the planets takes place within a narrow Zodiacal Band

5.5 Understand the observed retrograde motion of planets

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

6 Celestial observation

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

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

6.8 Understand the use of the equatorial coordinate system (right ascension and declination)

6.9 Understand the use of the horizon coordinate system (altitude and azimuth)

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

6.11 Understand how the observer’s meridian defines local sidereal time and an object’s hour angle

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

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

6.15 Be able to use a star’s declination to determine whether the star will be circumpolar from an observer’s latitude

6.16 Understand the apparent motion of circumpolar stars, including upper transit (culmination) and lower transit

6.17 Be able to use information about rising and setting times of stars to predict their approximate position in the sky

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

7 Early models of the Solar System

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 × 108 km), light year (l.y.) and parsec (pc)

8 Planetary motion and gravity

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

8.5 Understand the terms ‘aphelion’ and ‘perihelion’ (solar orbits), ‘apogee’ and ‘perigee’ (Earth orbits) for an elliptical orbit

8.6 Be able to use Kepler’s third law in the form:
$\frac{T^2}{r^3}$ = a constant
where T is the orbital period of an orbiting body and r is the mean radius of its orbit

8.7 Understand that the constant in Kepler’s third law depends inversely on the mass of the central body

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)

9 Exploring the Moon

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

10 Solar astronomy

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

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

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

11 Exploring the Solar System

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

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 × 108 km), light year (l.y.) and parsec (pc)

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

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 (diverging) mirrors can be used to collect and focus light fromastronomical 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

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

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

11.23 Be able to use the formula for the magnification of a telescope:

$$\text{magnification} = \frac{f_o}{f_e}$$

where fo is the focal length of the objective element and fe is the focal length of the eyepiece

11.24 Understand the importance of Galileo's early telescopic observations in establishing a heliocentric (Sun-centred) model of the Solar System

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

12 Formation of planetary systems

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 lifeforms 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

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

13 Exploring starlight

13.1 Understand the astronomical magnitude scale and how apparent magnitude relates to the brightness of stars as viewed from Earth

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

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

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')

13.11 Understand the term parsec (pc)

13.12 Be able to determine astronomical distances using heliocentric parallax

13.13 Understand how to use a Hertzsprung-Russell diagram to determine distances to stars

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

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

13.19 Be able to use star trail photographs to determine the length of the sidereal day

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 a 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

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

13.26 Understand how multiple radio telescopes can operate as an aperture synthesis system (array)

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

14 Stellar evolution

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

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

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

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 giant
d white dwarf
e supernova
f neutron star
g black hole14.11 Understand how astronomers study and

14.11 Understand how astronomers study and gather evidence for the existence of black holes

15 Our place in the Galaxy

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

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

16 Cosmology

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, λ0 is the emitted wavelength, v is the radial velocity of the source, c is the speed of light

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, Ho is the Hubble constant and d is the distance of the galaxy from Earth.

16.6 Understand the estimation of the age and size of the Universe using the value of the Hubble constant

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

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