



## PEC Astronomy Syllabus

---

### **1.1 The Planet Earth**

- a Describe the features of the Earth that distinguish it from other planets. Including its water surface and atmosphere.
- b Relate the blue sky to the preferential scattering of light in its atmosphere.
- c Demonstrate an understanding of the benefits of the Earth's atmosphere to mankind.
- d Describe some of the major causes of light pollution and demonstrate an understanding of why it is undesirable to astronomers.
- e Describe how Eratosthenes made the first accurate calculation of the circumference of the Earth.
- f Recall the shape (oblate spheroid/flattened sphere) and diameter (13,000 km) of the Earth.
- g Describe the evidence that the Earth is approximately spherical.
- h Recall the rotation period of the Earth (23 h 56 min) and the time to rotate through 1 degree (4 min).
- i Demonstrate an understanding of the terms: equator, tropics, latitude, longitude, pole, horizon, meridian and zenith.
- j Demonstrate an understanding of the drawbacks to astronomers of the Earth's atmosphere and relate these to the need for optical and infra-red observatories to be sited on high mountains or in space.

- k Describe the features of reflecting and refracting telescopes (detailed ray diagrams are not needed).
- l Demonstrate an understanding of why the world's largest telescopes are reflectors rather than refractors.
- m Demonstrate an understanding that the Earth's atmosphere is transparent to visible light, microwaves and some radio waves.
- n Interpret data on the effect of the Earth's atmosphere on infra-red, ultra-violet and x-rays.
- o Describe where infra-red, ultra-violet and x-ray observatories are sited and explain the reasons why.
- p Describe the nature and discovery of the an Allen Belts.

## **1.2 The Moon**

- a Identify the Moon's principal features, including the Sea of Tranquility, Ocean of Storms, Sea of Crisis, the craters Tycho, Copernicus and Kepler, and the Apennine mountain range (Latin names are acceptable).
- b Recall the Moon's diameter (3,500 km) and its approximate distance from Earth (380,000 km).
- c Recall that the Moon's rotational period and orbital period are both 27.3 days.
- d Demonstrate an understanding of why the far side of the Moon is not visible from Earth.
- e Describe how astronomers know the appearance of the Moon's far side and how it differs from the near side.
- f Distinguish between the lunar saes (maria) and highlands (terrae).
- g Demonstrate an understanding of the origin of lunar seas and craters.
- h Demonstrate an understanding that the relative number of craters in the seas and highlands implies different ages of these features.
- i Describe the nature of rilles and wrinkle ridges.
- j Relate the lack of atmosphere to the Moon's low gravity.
- k Describe the nature and purpose of the Apollo space programme and its experimental packages (ALSEPs).
- l Describe the likely origin of the Moon the giant impact hypothesis).
- m Describe the evidence that allowed astronomers to develop the giant impact hypothesis.

## **1.3 The Sun**

- a Demonstrate an understanding of how the Sun can be observed safely by amateur

astronomers.

- b Recall the Sun's diameter (1.4 million km) and its distance from Earth (150 million km).
- c Recall the temperature of the Sun's photosphere (5,800 K).
- d Describe the solar atmosphere (chromosphere and corona) and recall the approximate temperature of the corona (2 million K).
- e Describe the appearance and explain the nature of sunspots.
- f Recall that the Sun's rotation period varies from 25 days at the equator to 36 days at its poles.
- g Demonstrate an understanding of how astronomers use observations of sunspots to determine the Sun's rotation period.
- h Interpret data (for example a Butterfly Diagram) in order to describe the long-term latitude drift of sunspots, determine the length of the solar cycle and predict the year of the next solar maximum.
- i Demonstrate an understanding that the Sun's energy is generated by nuclear fusion reactions at its core, converting hydrogen into helium.
- j Describe how astronomers observe the Sun at different wavelengths.
- k Demonstrate an understanding of the appearance of the Sun at different wavelengths of the electromagnetic spectrum, including visible, H-alpha and x-ray.
- l Describe the structure and nature of the solar wind.

#### **1.4 Earth-Moon-Sun Interactions**

- a Demonstrate an understanding that the Earth and Sun appear to be the same size when viewed from Earth.
- b Recall the period of the lunar phase cycle (29.5 days).
- c Demonstrate an understanding of lunar phases and deduce the lunar phase cycle from given data.
- d Use diagrams to explain why the lunar phase cycle is (29.5 days) longer than the orbit period of the Moon.
- e Describe the appearance of partial and total solar and lunar eclipses.
- f Describe, using diagrams, the mechanisms causing solar and lunar eclipses.
- g Demonstrate an understanding that the duration of total solar and lunar eclipses are different and that they do not occur every new and full Moon.
- h Describe the terms 'solar day' and 'sidereal day'.
- i Explain why a solar day is longer than a sidereal day.
- j Interpret simple shadow stick data to determine local noon and observer's

longitude.

- k Describe how a sundial can be used to determine time.
- l Interpret charts and diagrams showing the variation in daylight length during a year.
- m Demonstrate an understanding that there are seasonal variations in the rising and setting of the Sun.
- n Demonstrate an understanding of the terms 'apparent Sun' and 'mean Sun'.
- o Demonstrate an understanding of the term 'equation of time' (apparent solar time - mean solar time) and perform simple calculations.
- p Describe aurorae and recall from where on Earth they are most likely to be observed.
- q Explain how aurorae are caused.

## **2.1 Our Solar System**

- a Describe the location and nature of the main constituents of our Solar System, including planets, dwarf planets, asteroids, comets, centaurs and trans Neptune Objects (TNOs).
- b Recall the names of planets and dwarf planets in order of their mean distance from the Sun.
- c Demonstrate an understanding of the scale and size of our Solar System using scale models (for example balls of different sizes at appropriate spacing, model Solar Systems such as the Spaced Out project).
- d Recall that the ecliptic is the plane of the Earth's orbit around the Sun.
- e Demonstrate an understanding that one astronomical unit (AU) is the mean distance between the Earth and Sun.
- f Recall that planets move in elliptical orbits, slightly inclined to the ecliptic.
- g Demonstrate an understanding that the planets appear to move within the band called the zodiac.
- h Demonstrate an understanding of the direct and retrograde motion of planets on a star chart.
- i Demonstrate an understanding of the terms: perihelion, aphelion, greatest elongation, conjunction, opposition, transit and occultation.
- j Describe the main physical characteristics of the planets ( including surface features, atmosphere, temperature and composition).
- k Discuss how the atmosphere of Venus can be used to gain data on the danger of extreme global warming.
- l Describe how astronomers use space probes to gain data on the characteristics of planets and other bodies in the Solar System.

- m Demonstrate an understanding of some of the problems that would be encountered by a manned exploration of our Solar System.
- n Demonstrate an understanding that some planets have satellite systems with a variety of origins and structures (including Mars and Neptune).
- o Describe the appearance, physical nature and composition of planetary ring systems.

## **2.2 Comets and Meteors**

- a Describe cometary orbits and distinguish them from planetary orbits.
- b Describe the location and nature of the Kuiper Belt and Oort Cloud and show an appreciation of their association with comets.
- c Describe some of the evidence for the existence of the Oort Cloud.
- d Identify the nucleus, coma, dust and ion tails of comets.
- e Demonstrate an understanding that the tails of comets develop when relatively close to the Sun.
- f Demonstrate an understanding of the mechanisms for the development of cometary dust and ion tails.
- g Describe the nature and origin of meteoroids, meteorites and micrometeorites.
- h Demonstrate an understanding of meteors, fireballs and annual meteor showers.
- i Relate the occurrence of annual meteor showers to cometary orbits and account for their apparent divergence from a radiant point.
- j Describe the orbits of Potentially Hazardous Objects (PHOs).
- k Demonstrate an appreciation of the need to monitor the motion of PHOs.
- l Demonstrate an appreciation of the potential consequences of a collision between an impactor and the Earth.
- m Describe how astronomers gather evidence of impacts between bodies within the Solar System and consider their effects.

## **2.3 Solar System Discoveries**

- a Describe the contribution of Copernicus, Tycho and Kepler to our understanding of the Solar System.
- b Illustrate Kepler's second law of planetary motion with the aid of a diagram.
- c Demonstrate an understanding of Kepler's third law relating planetary distances to orbital periods and perform simple calculations using the formula  $T^2 = R^3$ .  
where T is in years and R is in AU.
- d Recall the main astronomical discoveries of Galileo related to the Solar System:

- i) phases and apparent size of Venus.
- ii) relief features of the Moon.
- iii) Principal satellites of Jupiter (Callisto, Europa, Ganymede and Io).

e Describe the discoveries of Ceres, Uranus, Neptune and Pluto and the techniques involved.

f Demonstrate an understanding that gravity is the force responsible for maintaining orbits and its inverse square law.

## **2.4 Exoplanets**

a Describe how astronomers obtain evidence for the existence of exoplanets (including astrometry, transit observations and use of Doppler-shifts).

b Discuss the difficulties associated with the detection of individual planets.

c Demonstrate an understanding that the presence of liquid water is probably an essential requirement for life.

d Describe the present theories about the origin of water on Earth.

e Describe methods used by astronomers to determine the origin of water on Earth (for example analysis of water on a comet by the Rosetta probe).

f Demonstrate an understanding of the individual factors contained in the Drake Equation and their implications for the existence of life elsewhere in our Galaxy.

g Demonstrate an understanding of the existence and significance of habitable zones/Goldilocks zones.

h Describe some of the methods that astronomers use to obtain evidence for life (past or present) elsewhere in our Solar System.

i Discuss the possible benefits and dangers of discovering extra-terrestrial life.

## **3.1 Constellations**

a Describe the appearance of stars, double stars, asterisms, constellations, open clusters, nebulae and globular clusters in the night sky.

b Demonstrate an understanding of how stars within a constellation are labelled according to brightness (using Greek a(alpha) to e (eta)).

c Demonstrate an awareness of how the official list of constellations became established and cultural differences in this list.

d Recognise and draw the Plough, Orion, Cygnus and Cassiopeia.

Demonstrate the use of 'pointers' and other techniques to find other celestial objects, including:

- e i) Arcturus and Polaris from the Plough.
  - ii) Sirius, Aldebaran and the Pleiades from Orion.
  - iii) Fomalhaut and the Andromeda Galaxy from the Great Square of Pegasus.
- f Demonstrate an understanding that some constellations are visible from a given

latitude throughout the year, but others are seasonal.

### **3.2 Observing the Night Sky**

- a Demonstrate an understanding of the terms 'right ascension' and 'declination'.
- b Recall the declination of Polaris (+90 degrees) and explain why Polaris appears fixed in the night sky.
- c Demonstrate an understanding that the elevation of Polaris above the northern horizon is equal to the latitude of the observer.
- d Describe what is meant by the terms 'circumpolar stars' and explain the connection between the apparent motion of stars and the Earth's rotation.
- e Demonstrate an understanding that a star will be circumpolar from a given latitude provided declination is  $90 - \text{latitude}$ .
- f Analyse and interpret long exposure photographs of star trails to determine the rotation period of the Earth.
- g Demonstrate the use of a planisphere, star chart or computer software in order to plan an observing session.
- h Demonstrate an understanding of the terms 'ecliptic' and 'zodiacal band' on a star chart.
- i Plan equipment needed for a naked-eye observation session (red torch, clipboard, pencil/rubber, warm clothes).
- j Demonstrate an awareness of naked-eye observing techniques (dark adapted eye, relaxed eye and averted vision).
- k Demonstrate an awareness of, and use in a qualitative way, the Messier Catalogue.
- l Explain the apparent east-west motion of the night sky.
- m Recall the stars cross the observer's meridian and culminate when they are due south.
- n Use star data and charts to determine the time at which a star will cross the meridian.

### **3.3 Physical Properties of Stars**

- a Demonstrate an understanding that stars in a constellation are not physically related but that stars in a cluster are associated gravitationally.
- b Distinguish between optical double stars and binary stars.
- c Demonstrate an understanding of the apparent magnitude scale and how it relates to observed brightness of stars.
- d Use the scale of apparent magnitude.
- e Describe the method of heliocentric parallax to determine distances to nearby

stars.

- f Recall the definition of one parsec (pc).
- g Recall the definition of absolute magnitude.
- h Demonstrate an understanding of the universe square law nature of the intensity of light.  
Demonstrate an understanding of, and perform simple calculations involving, apparent magnitude ( $m$ ), absolute magnitude ( $M$ ) and distance ( $d$  in parsecs) using this formula:  
$$M = m + 5 - 5 \log d$$
- i involving powers of 10 parsecs only (students are not required to calculate  $d$  using this equation only  $M$  and  $m$ ).
- j Identify a Cepheid variable star from its light curve and deduce its period.
- k Explain how Cepheid variables can be used to determine distance.
- l Identify a binary star from the light curve and deduce its period.
- m Explain the causes of variability in the light curve of a binary star.
- n Demonstrate an understanding of what information can be obtained from a spectrum, including chemical composition, temperature and radial velocity.
- o Demonstrate an understanding of how stars can be classified according to their spectral type.
- p Demonstrate an understanding that a star's colour is related to its temperature.
- q Sketch and recognise the main components of the Hertzsprung-Russell diagram (HR diagram).

### **3.4 Evolution of Stars**

Associate the stages of evolution of a star:

- i) with a solar mass.
- a ii) with a much greater mass.  
with the components of the HR diagram.
- b Demonstrate an understanding that emission nebulae, absorption nebulae and open clusters are associated with the birth of stars.
- c Demonstrate an understanding that planetary nebulae and supernovae are associated with the death of stars.
- d Describe the nature of neutron stars and black holes.
- e Describe how astronomers obtain evidence for the existence of neutron stars and black holes.

### **4.1 Our Galaxy - the Milky Way**

- a Describe the appearance of the Milky Way as seen with the naked eye and



binoculars or a small telescope.

b Demonstrate an understanding that the observed Milky Way forms the plane of our own Galaxy.

c Demonstrate an understanding of the size and shape of our Galaxy and the location of the Sun, dust, sites of star formation and globular clusters.

d Demonstrate an understanding of how astronomers use 21 cm radio waves rather than visible light to determine the rotation of our Galaxy.

## **4.2 Galaxies**

a Demonstrate an understanding of the appearance of spiral, barred spiral, elliptical and irregular galaxies.

b Draw Hubble's tuning fork diagram.

c Recall that the Milky Way is an Sb type galaxy.

d Use images of galaxies in order to classify them.

e Demonstrate an understanding that some galaxies emit large quantities of radiation in addition to visible light (for example, radio waves, x-rays).

f Demonstrate an understanding that an Active Galactic Nucleus (AGN) is powered by matter falling into a super massive black hole.

g Recall the types of active galaxies, including Seyfert galaxies, blazars, quasars.

h Demonstrate an understanding that astronomers use many regions of the electromagnetic spectrum to obtain evidence for the existence and properties of AGNs.

i Describe the Local Group of galaxies.

j Recall the names of some galaxies in the Local Group, including the Large and Small Magellanic Clouds, Andromeda Galaxy (M31) and the Triangulum Galaxy (M33).

k Demonstrate an understanding that galaxies are grouped in large clusters and superclusters.

## **4.3 Cosmology**

a

Recall the Doppler principle for radial velocities.

b

Demonstrate an understanding that light from distant galaxies is shifted to longer wavelengths (redshift).

c

Use the equation:

$$\lambda - \lambda_0 / \lambda_0 = v/c$$

to determine the radial velocity of a galaxy.

d

Demonstrate an understanding that for galaxies in the Local Group blueshift is possible.

e

Recall that quasars are distant galaxies with high redshifts.

f

Describe the discovery of quasars by astronomers.

g

Demonstrate an understanding of the relationship between distance and redshift of galaxies (Hubble's Law) and use the formula:

$v = H_0 d$

h

Describe how astronomers use the value of the Hubble Constant to determine the age of the Universe.

i

Demonstrate an understanding of the existence and significance of cosmic background (CMB) radiation.

j

Describe how CMB radiation was discovered.

k

Describe recent observations of CMB radiation, including the Wilkinson Microwave Anisotropy Probe (WMAP), and their significance to cosmologists.

l

Demonstrate an understanding of the possible nature and significance of dark matter.

m

Demonstrate an understanding of the significance of dark energy.

n

Demonstrate an understanding of the observational evidence for an expanding Universe.

o

Demonstrate an understanding of the past evolution of the Universe and the main arguments in favour of the Big Bang.

p

Demonstrate an awareness of the different evolutionary models of the Universe (past and future) and why cosmologists are unable to agree on a model.

---