Name: _____ Form: _____

GCSE

Astronomy

Club

2.1 Planetary Systems

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-Neptunian Objects (TNOs)

Solar System Constituent	Location (type of orbit, mean distance from Sun, nearby objects)	Nature of constituent (Solid/Liquid/Gas, main materials, size, Interactions with other objects)
Inner Planets	Close together, but evenly spaced 58 million km → 228 million km from Sun Nearly circular orbits, but Mercury + Mars offset.	small + dense, few moons Rocky + terrestrial, mostly silicates + metals Radius of region < distance between orbits of Jupiter + Saturn
Outer Planets	778 million km → 4,497 million km from Sun (almost doubling at each step) Largely circular orbits. Also occupied by centaurs + comets	Gas giants, 99% of mass of bodies that orbit the Sun, many moons each, liquid heavy metal cores, often rings.
Dwarf Planets	Asteroid belt, Kuiper Belt, scattered disc. 2-3 AU, 39-48 AU, 68 AU More inclined + eccentric orbits	~~Minor planets/planetoids~~ A rounded, planetary-mass object orbiting the Sun, but not cleared its orbital neighbourhood Rock + ice, less massive than the moon
Asteroids	Mostly in a belt between Mars + Jupiter But can be found within Earth's orbit + beyond Jupiter Belt = 2-3.5 AU	Minor planets/planetoids - rocky + metallic objects upto 1km across. Likely leftover solar system formation material. Occasional impacts if knocked out of orbit.
Comets	Elongated elliptical orbits, ranging from <100 years → thousands of years Can interact with inner + outer solar system	Ice, dust + rock Nuclei, 10km across typically Record tail = 3.8 AU Occasional impacts if paths cross
Centaurs	Unstable orbits (likely interacted with outer planets), between Jupiter + Neptune Eccentric + changing orbits	Minor planets, similar to asteroids + comets Have dynamic lifetimes of a few million years, before impact or ejection Eg planetoids
Trans-Neptunian Objects (TNOs)	Orbit a minor planet that orbits the Sun outside Neptune (on average), eg. Pluto. Kuiper Belt - 30-55 AU - relatively stable orbits Scattered disk - up to 70 AU - elliptical + inclined orbits	Rock, ice, + organic surface material Can migrate + interact with other bodies 50 - 2400km diameter

b) Recall the names of planets and dwarf planets in order of their mean distance from the Sun

List the planets and dwarf planets in order of mean distance from the Sun, closest first:

Mercury, Venus, Earth, Mars, Ceres, Jupiter, Saturn, Uranus, Neptune, Pluto, Haumea, Makemake, Eris

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)

Draw a graph of Distance from the Sun (AU) vs Year length (Earth Years). eg. sydneyobservatory.com.au/wp-content/uploads/2011/01/Earth-distance-2011.jpg

Draw the planets next to each other to scale in size order. Indicate on the same scale the size of the Sun. spacedout.ukt.com/solar-system/index.asp homepages.wmich.edu/akonista/ss-images-planets...

d) Recall what the ecliptic is

The ecliptic is the apparent annual path of the Sun / projection of Earth's orbit onto the celestial sphere

e) Demonstrate an understanding of what one astronomical unit (AU) is.

1 AU = 149.6 million km. This is the mean distance between the Earth and Sun

f) Recall that planets move in elliptical orbits, slightly inclined to the ecliptic

Explain what is meant by an elliptical orbit, slightly inclined to the ecliptic: An elliptical orbit is an oval orbit. The shape is determined by eccentricity (circle = 0) with the Sun at one focus. An orbit inclined to the ecliptic does not lie in the same plane (and may have formed separate to the disc). 30-39 AU

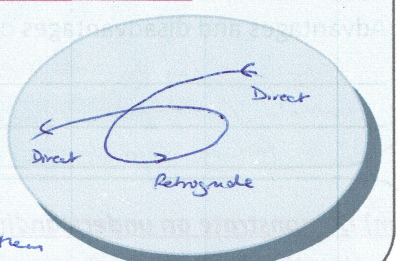
Explain how Pluto's orbit differs to that of the Planets: it is both more elliptical + more inclined, something bringing it closer to the Sun than Neptune 17°

g) Demonstrate an understanding that the planets appear to move within a band called the Zodiac

Explain what the Zodiac is, how far it extends and from which reference point: a circle of twelve 30° divisions of celestial longitude that are (latitudinally) centred upon the ecliptic (path of the Sun) over a year. The divisions correspond roughly to the 12 constellations known as signs. The Sun at vernal equinox is the origin of longitude.

h) Demonstrate an understanding of the direct and retrograde motion of planets on a star chart

Explain the cause of retrograde motion, including a description of the direct motion of planets. Draw both on this background of stars: All 8 planets orbit the Sun in the direction the sun is rotating (counterclockwise). Retrograde motion is the apparent motion of a planet in the opposite direction (as observed from the Earth), with respect to the background stars, for a time. Planets further from the Earth from the Sun move take longer to orbit and the Earth will overtake them - appears to slow down as retakes up, then stand still, then go backwards, then stand still, then move forwards again.



i) Demonstrate an understanding of the following terms:

Term	Explanation
Perihelion	When the Earth is at that point in its orbit that it is closest to the Sun
Aphelion	" " " " furthest from the Sun
Greatest elongation	Greatest apparent distance from the Sun in the sky (inferior planets) - angular separation
Conjunction	When 2 or more planets (usually viewed from Earth) appear (due to perspective) close to each other in the sky. (usually inferior planets)
Opposition	When a superior planet, Sun and Earth are in line (on the same side), on opposite sides of the sky
Transition	When one celestial body appears to move across the face of another eg. Venus passes between the Earth + Sun
Occultation	When one celestial object is hidden by another that passes between it and the observer. Eg. when a planet is on the opposite side of the Sun from the Earth

j) Describe the main physical characteristics of the planets

Planet	Surface features	Atmosphere	Min/Max/Mean temp	Composition
Mercury	Cratered + ridges	Virtually none, like the moon	90→700 K	70% metals, 30% silicates. Large core, heavy elements
Venus	Few craters, several volcanoes	Very dense, high pressure, CO_2 + sulphuric acid	740° K	Presumed to be similar to Earth (similar density)
Earth	70% water, active plate movement	Sustains life, contains weather. 78% N_2, 21% O_2 + rest.	287° K	Silicates, metals + rock. mantle + crust, core, oxidation = red
Mars	Mountains, canyons + craters, erosion	Very thin, mostly CO_2	−133 → 20° C. 140° K → 293° K	Earth and Mars are similar
Jupiter	Bands of coloured clouds incl GRS	Huge storms	143° K	Gas giant, 90% hydrogen, mostly liquid metallic hydrogen
Saturn	Bands of coloured clouds (less distinct)	Storms	143° K	Gas giant, mostly H + He, Sulk is liquid metallic hydrogen
Uranus	Largely featureless	Windy	73° K	Gas giant, mostly H + He, plus methane (blue color)
Neptune	Great dark spot	Huge storm systems	73° K	Similar to Uranus

k) Discuss how the atmosphere of Venus can be used to illustrate the danger of extreme global warming.

Early venus is suspected of having oceans. As the brightness of the Sun increased, the water vapour in the atmosphere increased, increasing the temperature and the evaporation rates, etc, to produce a dense & hot atmosphere. CO_2 is a greenhouse gas like H_2O so could lead to runaway/positive feedback effect

l) Describe how astronomers use space probes to gain data on the characteristics of planets and other bodies in the Solar System

Advantages and disadvantages of Orbiters: Allows longer term study of atmosphere and surface at larger scales. Play a role as communications/data relays. Cannot conduct direct experimentation. Can observe the planet as a whole. Could perform return.

Advantages and disadvantages of Landers: Can probe a planet's surface + atmosphere. Some carry rovers. Can perform direct experimentation. Limited to immediate area. Landings are precarious, and missions more complex generally.

Advantages and disadvantages of Rovers: Can examine more territory and can be directed to interesting features. Can position themselves to have a steady supply of solar power. Practice robotic remote control. Can observe at microscopic level & conduct physical experimentation. But, higher chance of failure (esp. landing), may end up in wrong place, and can only explore limited area.

m) Demonstrate an understanding of some of the problems that would be encountered by a manned exploration of our Solar System

Problems facing a manned mission to Mars (including explanations): A very technically demanding, energy intensive and very expensive process. Astronauts would need to be protected from the intense cold and the solar radiation. You would need to bring all the 'air', food and water you need with you, and clean the air as you go. The integrity of the capsules & space suits must be 100% maintained. Fuel for the journey, and return, would be needed, and stays on Mars would need to be very short or very long. The hope would be no one gets ill or injured on the journey (about 1yr one way). Bodies would need to cope with low gravity. Then there's the landing & re-entry...

n) Demonstrate an understanding that some planets have satellite systems with a variety of origins and structures (including Mars and Neptune)

Theory	Description	Planets with moons thought to have formed this way.
Fission	Satellite part of parent planet originally & separated.	
Capture	Satellite formed elsewhere & gravitationally captured	Neptune, Saturn, Mars
Condensation	Satellite & parent planet formed together from original nebula	Jupiter (Jovian), Neptune
Colliding planetessimals	Satellite formed from planet- and Sun-orbiting debris interacting.	
Ejected ring	Planet-planetesimal impact ejecting mass that forms a satellite.	Earth, Mars (Phobos)

Comparison of formation of Mars' and Neptune's moons:

Mars - likely captured main-belt asteroids, or possibly condensation (second generation) in the case of Phobos.
Neptune - all condensed apart from Triton, which was likely captured as its orbit is retrograde (retrieved) & is much larger than the other 13. Triton may have disrupted the original Neptunian satellite system.

o) Describe the appearance, physical nature and composition of planetary ring systems.

Appearance: Around Jupiter, Saturn, Uranus & Neptune. Only Saturn's rings known until c. 1970s. Light and dark bands with 'gaps' - light areas more dense & reflect more light. Other's rings more faint & still in bands.

Physical nature: formed from either the protoplanetary disk or moon debris. Could date from early solar system

Composition: About 95% dust & ice. Made of tiny particles: 10^{-7}m → several m. Ave. thickness = 20m.
Outer & inner rings separated (Cassini division).