CSIR UGC NET

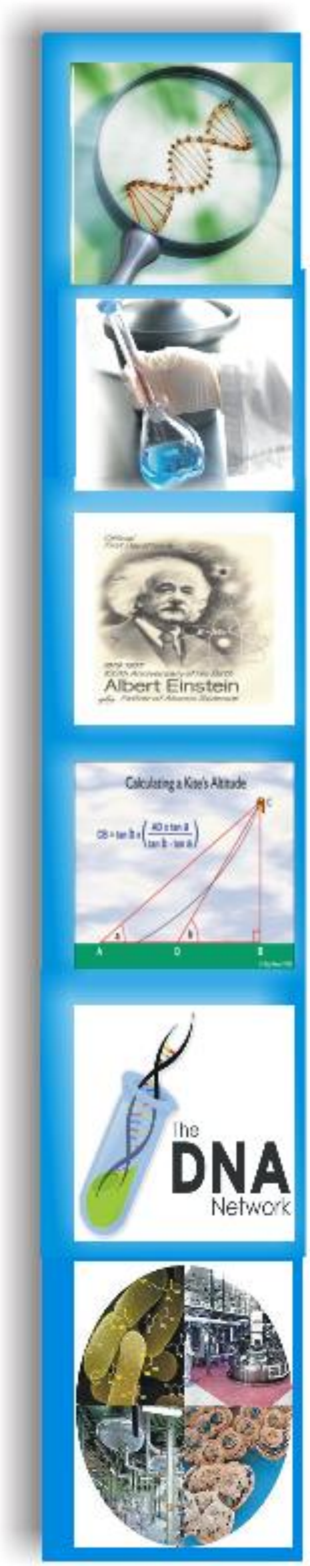
EARTH SCIENCE

SAMPLE THEORY

* THE SOLAR SYSTEM
* WEATHERING & EROSION

9001894070

www.vpmclasses.com



CSIR NET - EARTH SCIENCE

SAMPLE THEORY

- *THE SOLAR SYSTEM*
- *WEATHERING & EROSION*

VPM CLASSES

FOR IIT-JAM, JNU, GATE, NET, NIMCET AND OTHER ENTRANCE EXAMS

Web Site www.vpmclasses.com E-mail-vpmclasses@yahoo.com

THE SOLAR SYSTEM

- A Star may be defined as a huge, massive body of luminescent matter radiating enormous amount of energy every second.
- Each star holds around itself, under the influence of force of gravity, a variable number of relatively small sized, non-radiant bodies of matter, called Planets.
- The basic difference between a star and a planet is in their masses: a star is thousands times bigger than a planet. Because of such an enormous mass, very high temperatures are reached in the interior of a star that make it radiate energy.
- Sun is also a typical star. It has nine planets and revolving around it under gravitation. The Sun and the planets taken together make a solar system.
- Each galaxy is believed to contain billions of solar systems. Our solar system; the Sun in the center and nine planets revolving around it-is just an insignificant part of our galaxy, named by us for our convenience, as MILKY WAY.
- The nine plants revolving around the sun in order of their increasing distance from the sun have been named as Mercury, Venus, The Earth, Mars, Jupiter, Saturn, Uranus, Neptune and Pluto

Astronomical Unit- The recorded distance between the Earth and the Sun is approximately 149.6 million km which may vary as 149,597,890 km, 149,669,180 km, 150,00,000 km. This distance is commonly referred as ONE Astronomical Unit. It is very convenient to use this unit in describing the distance of other planets from the sun as follows:

Table 1. Planets and their Distances from the Sun

S.No.	Name	Distance (A.U*)	S.No	Name	Distance (A.U*)
1.	**Mercury**	0.39	6.	**Saturn**	9.54
2.	**Venus**	0.72	7.	**Uranus**	19.20
3.	**The Earth**	1.00	8.	**Neptune**	30.10
4.	**Mars**	1.52	9.	**Pluto**	38.0
5.	**Jupiter**	5.20			

	Age	Location	Distance	Diameter	Mass	Orbital Periods	Features
UN	About 4.5 billion years	At the center of our solar system.	149,600, 000 km.	1,390,000 km.	1.99 x 1030 kg.		The Sun, an ordinary star, contains more than 99.8% of the total mass of our solar system.
URY	About the same age as the Sun.	Solar System.	58,340,0 00 km.	4880 Km.	3.30 x1023 kg.	0.24 Earth years (88 Earth days).	Temperature variations on Mercury are the most extreme in the solar system ranking from –170º C to 430º C.
S	About the same age as the Sun.	Solar System.	108,200, 000 km.	12,100 km.	4.869 x 1024 kg.	0.616 Earth years (225 Earth days).	Thick clouds containing sulfuric acid hide the rocky surface.
H	About the same age as the Sun.	Solar System.	149,600, 000 km.	12,760 km.	5.972 x 1024 kg.	1 year (365 days)	Earth is the only planet to have liquid water on its surface.
;	About the same age as the Sun.	Solar System.	227,900, 000 km.	6794 km.	6.4219 x 1023 kg.	1.88 Earth years (687 Earth days).	Known as the Red Planet, Mars has a very thin atmosphere.
ER	About the same age as the Sun.	Solar System.	778,300, 000 km.	143,000 km.	1.900 x 1027 kg.	11.86 Earth years (4330 Earth days).	Ganymede is the largest moon in our solar system (larger than even the planet Mercury).
RN	About the same age as the Sun.	Solar System.	1,429,00 0,000 km	120,500 km.	5.69 x 1026 kg.	29.46 Earth years (10,750 Earth days).	Saturn´s most distinctive feature is the thousand of rings that orbit the planet.
IUS	About the same age as the Sun.	Solar System.	2,871,00 0,000 km	51,120 km.	8.683 x 1025 kg.	84 Earth years (30,660 Earth days).	The blue-green color of the planet is due to methane in the atmosphere.
UNE	About the same age as the Sun.	Solar System.	4,504,00 0,000 km	49,530 km.	1.0247 x 1026 kg.	164.8 Earth years (60,150 Earth days).	Neptuno is smaller in diameter than Uranus, but larger in mass.
O	About the same age as the Sun.	Solar System.	5,914,00 0,000 km	2340 km.	1.27 x 1022 kg.	247.7 Earth years (90,410 Earth days).	Pluto was the smallest planet until August 2006, when the International Astronomical Union reclassified it as a dwarf planet.
N	About the same age as Earth.	Solar System.	384,400 km.	3476 km.	7.35 x 1022 kg.	27 Earth days.	The Moon has no atmosphere or magnetic field.

*A.U. = Astronomical Unit = 14,96,42000 km, taken approximately as 150 million kms.

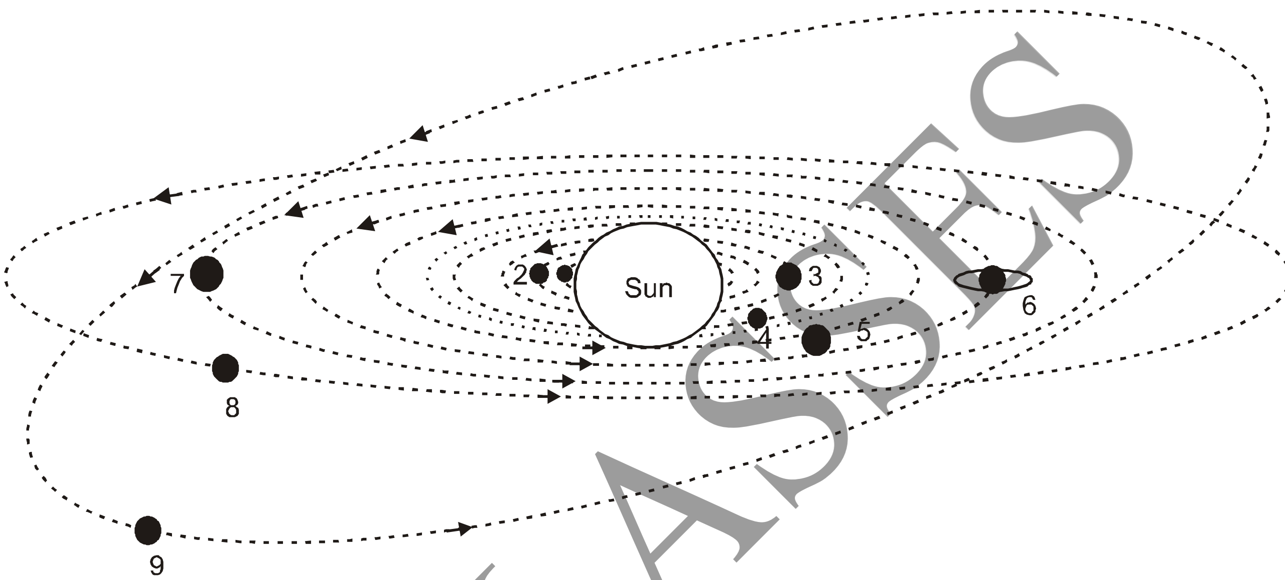


Fig. 1. The Solar System in Space (Diagrammatic - Not to scale)

1-Mercury, 2-Venus, 3-Earth, 4-Mars, 5-Jupiter, 6-Saturn, 7-Uranus, 8-Neptune, 9-Pluto

- All the nine planets, including the Earth, revolve around the Sun along regular, stable and nearly circular paths called orbits that lie almost in the same plane (except that of Pluto).
- The Earth makes its orbital motion around the Sun at a speed of 29.76 km/s and completes one revolution in 365.25 days or one year. For the other eight planets, the speeds of revolution and the days they take to complete one revolution are different.

- All the nine planets also rotate around their own axes in a perpetual manner while revolving around the Sun. The period of rotation around their axes also varies from planet to planet.
- The Earth has a period of rotation of 23 hours 56 minutes and 4 seconds.
- The planet Venus takes the longest time to complete one rotation: 88 days and the planet Jupiter takes the shortest time: 9 hours 50 minutes.

Planetary Orbits and Solar Spin

Two-body motion

The description of planetary orbits:

- Planets move in elliptical orbits with the Sun at one focus.
- The line joining a planet to the Sun sweeps out equal areas in equal times.
- The square of the orbital period is proportional to the cube of the average distance from the Sun (semi-major axis).
- Kepler formulated these laws based on observations mainly of the planet Mars and he did not appreciate the dynamical aspects of planetary motion.
- This fundamental problem was solved by Isaac Newton (1642–1727) who analysed mathematically the motion of two gravitating bodies moving under an inverse square law of attraction. Kepler's laws are perfectly consistent with this solution.
- The equation of motion for the two-body problem can be written

$$\ddot{r} = -\mu \frac{r}{|r|^3}$$

in which r is the position of one body relative to the other and $\mu = G(m_1 + m_2)$, G being the gravitational constant and m_1 ; m_2 the masses involved.

- It may be shown that r = |r| satisfies the equation of an ellipse given by

$$r = \frac{p}{1 + e\cos\theta}, \; p = a(1 - e^2),$$

where a is the semi-major axis of the ellipse of eccentricity e, and p is the semi latus rectum.

- Other distances of interest in a heliocentric orbit are the perihelion and aphelion distances, q and Q respectively, corresponding to the closest and furthest distances from the Sun.
- Another description of the ellipse is

$$r = a(1 - e \cos E);$$

where E, satisfies Kepler's equation

$$E - e\sin E = nt, \; n = \sqrt{\frac{\mu}{a^3}}$$

The quantities E, and n are termed eccentric anomaly, true anomaly and mean angular motion respectively. The mean angular motion is the average angular speed in the orbit.

Solar system orbits

- The Solar System contains many bodies, not just two, but with the Sun being 1000 times more massive than Jupiter, the most massive planet, the motion of each planet is largely governed by the solar mass.

- The assumption of elliptical motion for each planet–Sun pair is useful and fairly accurate. Thus the equations of motion for the planets relative to the Sun may be written

$$\ddot{r}_i = -\mu_i \frac{r_i}{|r_i|^3} + F_i,\ i = 1, 2, ..., 9,$$

$$\ddot{r}_i = -\mu_i \frac{r_i}{|r_i|^3} + F_i,\ i = 1, 2, ..., 9,$$

in which the vectors F_i have small magnitudes and contain the perturbing effects on planet i of all the other planets and satellites and μ_i = (M +m_i).

- The symbol indicates quantities pertaining to the Sun. These perturbations cause the elliptic elements of the planetary orbits to vary but, as far as can be determined, only in a periodic fashion.
- As an example, the eccentricity of the Earth's orbit, currently 0.0167, varies in the range 0 to 0.06. At one extreme the distance of the Sun will vary by 12% during each year; this has important implications for the terrestrial climate.
- The present-day elliptic elements (a, e, i) of the nine planets are shown in table.

Angular momentum distribution

- A cosmogonically significant feature of the Solar System concerns the distribution of angular momentum within it.
- The Sun spins about an axis inclined at 6 º to the vector representing the angular momentum for the whole of the system. The period of its

outer layers varies from 25.4 days at the equator to 36 days near the poles.

- Internally the Sun appears to spin as a solid body with a period near 27 days. The spin angular momentum of the Sun has magnitude

$$H_\odot = \alpha_\odot M_\odot R_\odot^2 \omega_\odot = 2.5\alpha_\odot \times 10^{42}\ \mathrm{kg\ m^2\ s^{-1}},$$

where $M_\odot$, $R_\odot$ and $\omega_\odot$ are the solar mass, radius and angular speed and $\alpha_\odot$ is the moment-of-inertia factor.

- With a central density about 100 times the mean density $\alpha_\odot$ is about 0.055; for a uniform sphere α is 0.4 and becomes less as the central condensation in the body increases.

The Saturnian System

- With 18 members identified so far Saturn has the most heavily populated satellite system. Only Titan, slightly larger than Mercury, matches the Galileans but four others—Tethys, Dione, Rhea and Iapetus—have diameters greater than 1000 km.
- The system has a number of striking commensurabilities with both Enceladus–Dione and Mimas–Tethys having mean motions in the ratio 2:1. In addition the 4:3 ratios for Titan–Hyperion ensures that this pair have conjunctions near the aposaturnium (furthest orbital point from Saturn) of Hyperion.
- The smallest separation of these two bodies is thus about 400 000 km rather than the 100 000 km implied by a simple consideration of the sizes of the two orbits.

- Spacecraft discoveries of smaller satellites show a number of 1:1 commensurabilities which are really examples of special solutions in the restricted three body problem.
- It is well known that general solutions of the gravitational problem of n ($\geq$ 3) bodies do not exist. However, Lagrange (1736–1813) showed that special configurations of three bodies do satisfy the equations of motion.
- These involve collinear and equilateral triangular arrangements of the bodies, as illustrated in figure 2, in which two of the bodies are placed at the points A and B and the third (C) can occupy one of the five points, L1 to L5, known as the Lagrange points.
- The whole system must rotate about the centre of mass. Generally, these solutions are unstable and any small displacement will rapidly destroy the symmetry. Since no three-body system can properly be isolated from the perturbing effects of other bodies, this suggests that the Lagrange solutions cannot be achieved in practice.
- In certain restricted conditions the triangular solutions are stable; they require the third body, C, to be of negligible mass and for the ratio of the masses of A and B to exceed 25. In such cases small displacements of body C from L_4 and L_5 do not become unbounded and, of course, A and B execute two-body motion.
- The conditions are satisfied by Saturn–Tethys–Calypso, Saturn–Tethys–Telesto and also by Saturn–Dione–Dione B. Effectively Calypso and Telesto move in the same orbit as Tethys (hence the 1:1

commensurability) but maintain a position on average 60º in front and 60º behind Tethys in its orbit.]

Saturn has a single very large satellite, Titan, which is very little below

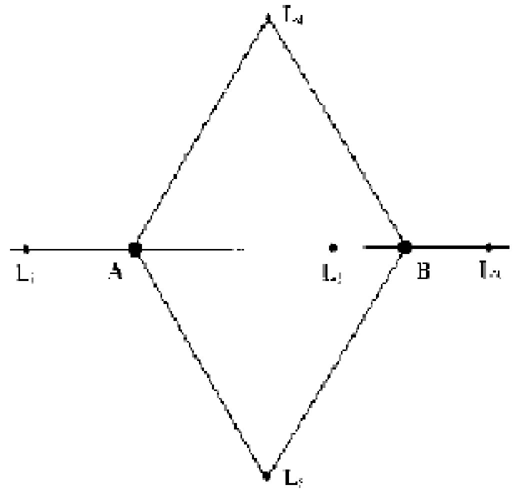


Fig 2. The Lagrange solutions for the three-body problem.

WEATHERING & EROSION

- Weathering is the process of decay and disintegration of rocks under the influence of certain physical and chemical agencies of the atmosphere.
- Erosion is the process of removal of the decayed and disintegrated rock fragments which have been produced by weathering.
- The agents of erosion are wind, running water and moving ice.
- Denudation is the sum total of the processes of weathering and erosion operating for a geological (long) time in a certain region.
- The decayed and disintegrated product remains generally at or near the parent rock body because the weathering agencies do not involve

themselves in the removal of the end products to any significant distances.

- Examples: Rocks exposed to frost action at higher attitudes in cold and humid climates disintegrate into small sized fragments that remain strewn over the slopes. Similarly, rocks exposed to heating temperatures of the Sun in deserts gradually disintegrate into smaller pieces that remain lying on or close to the parent rock.

Weathering and erosion are complimentary processes, the agents of the erosion are -

Wind:

Aeolian topography is created by the geological action of wind, which can conveniently be divided into the following three stages-

- Erosion
- Transportation
- Deposition

(i) Erosion

Deflation - Deflation is the process of removal of loose soil or rock particles, along the course of the blowing wind. This process operates well in dry regions with little or no rainfall which forms blow outs (Shallow depression), oasis (a deep depression intersect the water table), slacks (a type of depression).

Abrasion - Abrasion is the sand blast action of wind with sand against the rocks. The loose particles that are blown away by the wind serve as tools of destruction and whey they move on some rock surface; they bring about a scraping of the surface.

Ventifacts and driekenters - These are pebbles faceted by the erosional power (abrasive effects) of the wind blown sand.

Ventifacts with one smooth surface is called Einkanters, with two smooth abraded falls is called Dreikanter, when three abraded falls are left, it is called zueeikanter.

Mushroom rocks or Zeugens - It is a tabular mass of more resistant rock resisting under cut pillars of softer material.

They are very often elongated in the direction of the prevailing wind.

Yardang - Elongated, grooved or furrowed topographic form produced by wind abrasion, which is elongated in the direction of the prevailing winds and is usually strongly under cut.

Fig 3

Hamada - Due to deflection and abrasion when the loose particles are swept away, only the hard particles or mantle are left behind which is known as Hamada.

Attrition - It is the grinding action when the wind born particles often collide with one another on transit. Such natural collision brings about a further grinding of the particles. Due to attrition, rounded desert sand grains are formed, which are called MILLET - SEED SANDS.

(ii) Transportation

Four processes of transportation are -

Traction - Here particles are removed through rolling and reeping.

Salfation - Here, the particles which are too heavy to remain in suspension and lighter to be transported are transported through a series of bounces.

Suspension - dust, clay, silt, cloud, smoke, etc. move with the wind quickly but settle very slowly, remain suspended in the air.

(iii) Deposition -

Sand hill - Rounds of sand whose surface is irregular is called sand hill.

Sand dune - When the mound is in the form of a round hillock or ridge with a crest, it is called a sand dune. In structure, a dune has a gentle slope towards the wind ward side and a steep - face towards the ward side. The shape of a dune is controlled by the amount of sand supply, wind - velocity, constancy of wind direction, and amount and distribution of vegetative cover.

Geological Work of Water

This phenomenon, which is associated with the geological action of river is usually known as the fluvial cycle of erosion, or the normal cycle of erosion.

Water -

The erosion caused by the running water is of two types -

(i) Mechanical erosion

Hydraulic action - Forces inherent in the flow of running water, can do a great deal of erosion of the bank and the bed rock. It is mostly due to surface relief.

Abrasion / corrosion - Wearing away of the bank and bed rock by the rubbing of the carried away materials by the running water.

Attrition - Materials during their transit often collide among themselves and in turn get themselves teared. This is the process through which big boulders are gradually reduced in size and finally reach the size - grane of sand and silt.

Cavitation - This is because of the presence of the air bubbles which create a whirl action at the time of penetration of water through the existing pores and fissures and the small sand particles along with the air bubbles play a major rock in widening the cavities.

Factors which help mechanical Erosion:

- Hydraulic gradient
- Climate determines precipitation and finally volume and velocity of water.
- Nature of bed rock, whether it is soft or hard, whether the layering or joining of the bed rock are parallel to the flow of the water or are perpendicular to the same, whether the bed rocks are igneous, metamorphic or sedimentary.
- Hardness of the transported materials

(ii) Chemical erosion -

- It is also known as solution or corrosion, during which process the materials get dissolved in the water of the river and are transported in solution.
- Dissolving action of water due to the presence of carbon dioxide.
- Solubility of the river bed.