Name: _____   Date: _____

Answer Key: Orbital Mechanics or Coffee Shop Physics? Senior Astronomy Challenge

Calculate orbital perturbations and barycentric motions that satellite engineers and astrophysicists use to maintain global GPS synchronization.

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1. The Milankovitch cycle known as 'precession' involves a 26,000-year wobble of Earth's axis. Which celestial mechanic is the primary driver of this specific cyclic variation?

Answer: B) Gravitational tugging by the Sun and Moon on Earth's equatorial bulge

> Because Earth is an oblate spheroid (fatter at the equator), the gravitational pull of the Sun and Moon exerts a torque that causes the rotational axis to trace a circle over a 26,000-year period.

2. In the Earth-Moon system, the center of mass around which both bodies actually orbit is located approximately 1,700 km below Earth's surface. This point is scientifically termed the _____.

Answer: C) Barycenter

> The barycenter is the common center of mass around which two or more bodies revolve; for the Earth-Moon system, it stays within Earth's radius due to Earth's superior mass.

3. True or False: According to Kepler's Second Law, Earth travels at a higher orbital velocity during the Western Hemisphere's winter (perihelion) than it does during the summer (aphelion).

Answer: A) True

> Kepler's Second Law states that a line connecting a planet to the Sun sweeps out equal areas in equal times, requiring the planet to move faster when it is closer to the Sun (perihelion), which currently occurs in early January.

4. Consider the Saros cycle. Why do solar eclipses not occur every month during the New Moon phase?

Answer: A) The Moon's orbit is inclined at roughly 5 degrees relative to the ecliptic plane

> Except when the Moon crosses the 'nodes' (the intersection of its orbital plane and Earth's orbital plane), its shadow usually passes above or below Earth.

5. When the Sun, Earth, and Moon form a 90-degree angle (Quadrature), the solar tide partially cancels the lunar tide, resulting in the lowest tidal range of the month. This is known as a _____ tide.

Answer: D) Neap

Neap tides occur during the first and third quarter moon phases when the gravitational forces of the Moon and Sun are perpendicular to each other.

6. The ANALEMMA is a figure-eight shape seen when photographing the Sun from the same spot at the same time for a year. Which two factors synthesize to create this shape?

Answer: A) Axial tilt and orbital eccentricity

The north-south component of the analemma is caused by axial tilt; the east-west 'wobble' is caused by Earth's varying orbital speed due to its elliptical (eccentric) orbit.

7. True or False: A 'Sidereal Day' is approximately 4 minutes longer than a 'Solar Day' because Earth must rotate further to realign with the Sun.

Answer: B) False

This is false; the Solar Day (24 hours) is longer than the Sidereal Day (23h 56m) because Earth moves in its orbit while rotating, requiring an extra ~1 degree of rotation to face the Sun again.

8. Beyond simple tides, gravitational interaction causes 'Tidal Acceleration.' What is the long-term measurable impact of this on the Earth-Moon system?

Answer: B) Earth's rotation speed slows down and the Moon recedes from Earth

Tidal friction transfers angular momentum from Earth's rotation to the Moon's orbit, causing Earth's day to lengthen and the Moon to move away at about 3.8 cm per year.

9. The 'Ecliptic' is the apparent path of the Sun across the celestial sphere. The point where the Sun crosses the celestial equator moving North is specifically termed the _____.

Answer: C) Vernal Equinox

The vernal (spring) equinox occurs when the Sun's path intersects the celestial equator, marking the start of spring in the Northern Hemisphere.

10. True or False: During a Total Solar Eclipse, the 'Baily's Beads' effect is caused by sunlight passing through the rugged topography of the lunar limb.

Answer: A) True

As the Moon covers the Sun, the uneven lunar surface (mountains and valleys) allows beads of sunlight to shine through in specific spots just before and after totality.