

ForumIAS

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Prelims Marathon

2nd week May, 2026

*HISTORY
ECONOMICS
POLITY
SCIENCE AND TECHNOLOGY
GEOGRAPHY AND ENVIRONMENT*

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Information and Communication Technology -IV

1. Consider the following statements:

1. Infrastructure as a Service (IaaS) provides only the software applications, while the client manages the underlying hardware and operating systems.
2. Platform as a Service (PaaS) allows developers to deploy applications without the complexity of buying and managing the underlying hardware and software layers.
3. Software as a Service (SaaS) requires the end-user to perform regular technical maintenance and server configurations.

Which of the statements given above is correct?

- (a) 1 only
- (b) 2 only
- (c) 3 only
- (d) None of the above

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** In IaaS, the provider manages the hardware; the client manages the OS and apps.
- **Statement 2 is correct:** PaaS provides a framework (like AWS Elastic Beanstalk) where developers focus on coding, not infrastructure.
- **Statement 3 is incorrect:** SaaS (like Gmail) is fully managed by the provider; users perform no maintenance.

2. Which of the following best describes the MeghRaj initiative?

- (a) A satellite-based weather forecasting system for the Indian subcontinent.
- (b) A set of discrete cloud computing environments spread across multiple locations following common protocols issued by the Government of India.
- (c) An indigenous software for the digital encryption of sensitive military communication.
- (d) A rural broadband connectivity project under BharatNet.

Correct Answer: (b)

Explanation:

MeghRaj is the Government of India's Cloud Computing initiative. It aims to accelerate the delivery of e-services while optimizing ICT spending by using a shared environment based on common standards.

3. Consider the following statements regarding Edge Computing:

1. It involves centralizing all data processing in distant mega-data centers to maximize computational power.
2. By processing data closer to the source, it reduces latency and improves response times for real-time applications.
3. It is primarily used for slow-moving data backups and has no relevance to Autonomous Vehicles or Virtual Reality.

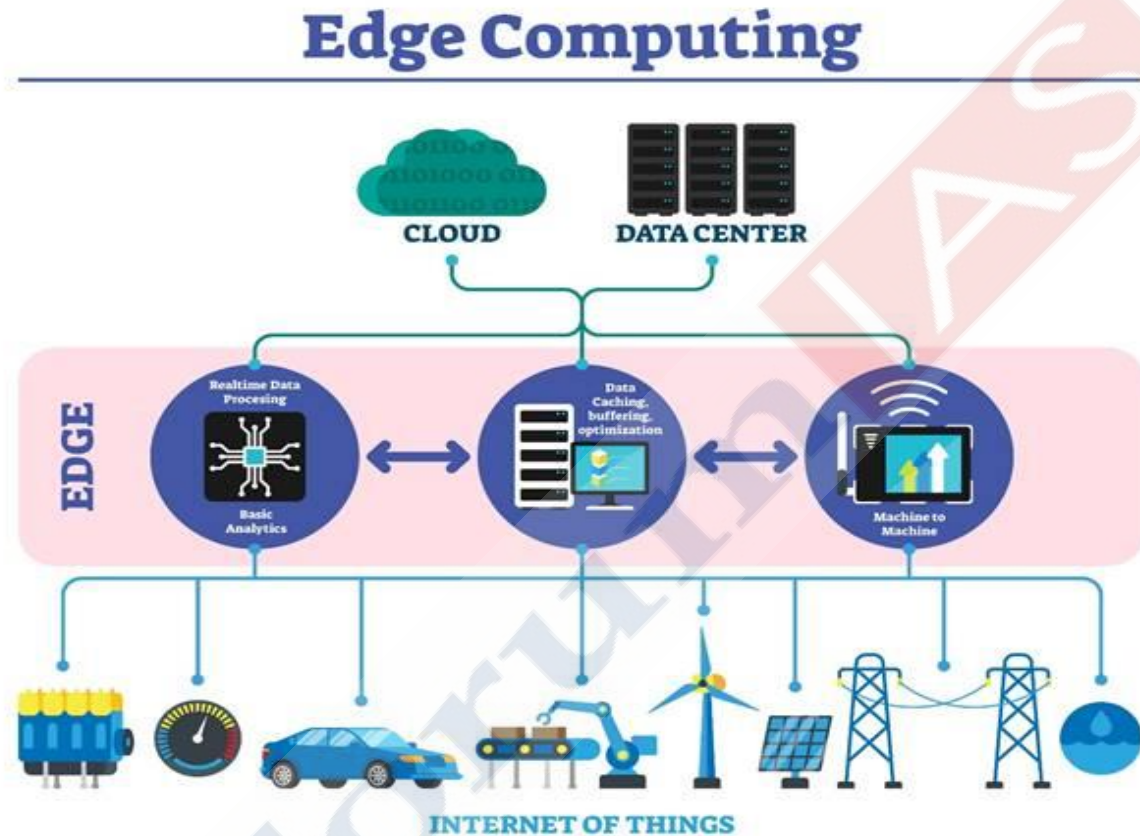
Which of the statements given above is correct?

- (a) 1 only
- (b) 2 only
- (c) 3 only
- (d) None of the above

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** Edge computing is decentralized.
- **Statement 2 is correct:** Lowering the physical distance data travels reduces the "lag" (latency).
- **Statement 3 is incorrect:** Autonomous vehicles and VR require near-instant processing, making Edge computing vital for them.



4. Consider the following statements:

1. As of late 2024, El Capitan has emerged as the world's fastest supercomputer, surpassing the Frontier system.
2. Frontier was the first supercomputer to officially reach the exascale barrier, attaining speeds over 1.1 exaFLOPS.
3. China currently leads the world with the highest number of supercomputers in the global top 10 list.

Which of the statements given above is/are incorrect?

- (a) 1 only
- (b) 2 only
- (c) 3 only
- (d) 1 and 2 only

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** El Capitan reached 1.742 exaFLOPS in Nov 2024. Frontier was the previous leader.

- **Statement 3 is incorrect:** The United States currently leads in terms of the number of supercomputers in the top 10, followed by nations like Japan and China.

5. Consider the following statements regarding Qubits:

1. A qubit is the fundamental unit of quantum information, capable of existing in a state of 0, 1, or both simultaneously.
2. The phenomenon of Superposition is what allows qubits to hold multiple states at once, unlike classical bits.
3. Because qubits use quantum mechanics, they are significantly slower than classical bits at performing simple arithmetic tasks.

Which of the statements given above is incorrect?

- (a) 1 only
- (b) 2 only
- (c) 3 only
- (d) None of the above

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** These describe the core principles of quantum computing.
- **Statement 3 is incorrect:** While quantum computers aren't necessarily better for every task, their unique logic allows them to solve specific complex problems (like drug discovery or cryptography) exponentially faster, not slower.

6. Consider the following statements:

1. Quantum Supremacy is achieved when a quantum computer performs a calculation that is practically impossible for any classical supercomputer to complete in a reasonable timeframe.
2. In 2019, Google's Sycamore processor demonstrated this by solving a problem in 200 seconds that would have taken a supercomputer thousands of years.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (c)

Explanation:

Both statements are correct. John Preskill coined the term, and Google's 53-qubit Sycamore provided the first major experimental proof of the concept.

7. Consider the following statements:

1. GPT is a type of large language model (LLM) designed specifically for hardware-level encryption of database servers.
2. GPT models are capable of generating human-quality text and translating languages by predicting the next sequence of data based on patterns.

Which of the statements given above is correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2

(d) Neither 1 nor 2

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** GPT is an AI application for language processing, not hardware encryption.
- **Statement 2 is correct:** It is Generative (creates new content) and Pre-trained (learned from massive datasets).

8. Consider the following statements regarding the AI Impact Summit 2026:

1. The summit adopted the New Delhi Declaration, which focuses on democratizing AI access for the Global South.
2. The framework of the declaration is built around the Seven Pillars (Chakras) including Secure AI and Human Capital Development.
3. The summit focused exclusively on the existential threats of AI, rejecting any discussion on deep-tech research investment.

Which of the statements given above is incorrect?

- (a) 1 only
- (b) 2 only
- (c) 3 only
- (d) 1 and 2 only

Correct Answer: (c)

Explanation:

- **Statement 1 and 2 are correct:** These reflect the outcomes of the Feb 2026 summit.
- **Statement 3 is incorrect:** The summit deliberately moved away from existential risk toward practical Deep-tech investment (mobilizing \$250 billion).

9. Consider the following statements:

1. Augmented Reality (AR) replaces the physical world entirely with a digital simulation, as seen in fully immersive gaming.
2. Virtual Reality (VR) creates a computer-generated environment that completely replaces the user's perception of the real world.
3. Mixed Reality (MR) allows digital and physical objects to coexist and interact in real-time, such as through Microsoft HoloLens.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** AR overlays info on the real world; it does not replace it.
- **Statement 2 is correct:** VR is fully immersive (e.g., Oculus).
- **Statement 3 is correct:** MR is the most advanced, where virtual objects know where real objects are and can interact with them.

10. Consider the following statements regarding the Metaverse:

1. It is a shared virtual space that combines elements of AR, VR, and social media into a single immersive digital realm.
2. The term was first introduced by Neal Stephenson in the 1992 science fiction novel Snowcrash.
3. It envisions the use of persistent virtual avatars to interact with other users and digital assets in a 3D cyberspace.

How many of the statements given above are correct?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

Correct Answer: (c)

Explanation:

All statements are correct. The Metaverse is seen as the next evolution of the internet, characterized by presence, interoperability, and immersion. Major tech firms are currently building the infrastructure to support this vision.

Universe and Space, Information and Communication Technology

1. Consider the following statements regarding Graphene:

1. It is a single-layer honeycomb lattice of carbon atoms, characterized by high electrical and thermal conductivity.
2. Due to its unique atomic structure, it is considered the most flexible and heavy material known to man, making it suitable for flexible electronics.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** Graphene is a 2D form of carbon where free-moving electrons allow for record-breaking conductivity.
- **Statement 2 is incorrect:** Graphene is exceptionally lightweight and flexible, not heavy. Its flexibility is exactly why it is a leading candidate for the next generation of flexible electronic screens and wearable devices.

2. With reference to display technologies, consider the following statements regarding AMOLED (Active-Matrix Organic Light-Emitting Diode):

1. Each individual pixel in an AMOLED display generates its own light and color, eliminating the need for a separate backlight.
2. The Active Matrix component utilizes thin-film transistors (TFTs) to control the current flowing to each pixel individually, allowing for faster refresh rates.
3. AMOLED displays consume significantly more battery power than traditional LCDs when displaying true black colors.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: A

Explanation:

- **Statement 1 is correct:** AMOLED is based on OLED (Organic Light-Emitting Diode) technology. Unlike LCDs (Liquid Crystal Displays) that require a large, always-on backlight, each sub-pixel in an AMOLED panel is self-emitting and produces its own light.
- **Statement 2 is correct:** The Active Matrix refers to the layer of Thin-Film Transistors (TFTs) behind the organic material. This matrix acts as a switch, directing electrical current to precise, individual pixels much faster than a passive matrix would, which enables smoother motion and higher refresh rates.
- **Statement 3 is incorrect:** When an AMOLED screen displays a dark or true black image, it does so by simply turning off the pixels. Because no electricity is flowing to those specific pixels, it actually conserves battery power, making it more energy-efficient for dark backgrounds compared to LCDs.

3. Consider the following statements regarding the working of LCDs:

1. The display relies on a backlight and a layer of liquid crystals that act as shutters to control light passage.
2. When a voltage is applied (On state), the liquid crystals untwist and prevent light from passing through the second polarizer, creating a dark pixel.
3. LCD pixels emit their own light through organic diodes, eliminating the need for external illumination sources.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 1 and 2 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statements 1 and 2 are correct:** These accurately describe the light-shutter mechanism using polarizers and liquid crystal molecules.
- **Statement 3 is incorrect:** LCDs are non-emissive. They cannot produce their own light and must rely on a backlight (typically LED).

4. Consider the following statements:

1. Dark Matter acts as an attractive gravitational force that helps hold galaxies together, whereas Dark Energy acts as a repulsive force that accelerates the expansion of the universe.
2. The mass-energy content of the universe is dominated by ordinary matter (atoms), with Dark Energy making up less than 5% of the total.
3. Neither Dark Matter nor Dark Energy interact with ordinary matter through the electromagnetic force, making them invisible to traditional telescopes.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 1 and 3 only

- (c) 2 and 3 only
(d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statement 1 is correct:** This describes the fundamental push-pull relationship in cosmology.
- **Statement 2 is incorrect:** Ordinary matter makes up only about 5%. Dark Energy (~68%) and Dark Matter (~27%) dominate the universe.
- **Statement 3 is correct:** They do not emit, absorb, or reflect light, which is why we can only detect them through their gravitational effects.

5. Match the following telescopes with their primary descriptions:

Telescope	Primary Description
A. Hubble	1. Primary infrared observatory studying the early universe.
B. James Webb (JWST)	2. India's collaboration for remote control studies in Devasthal.
C. Event Horizon (EHT)	3. First major space-based optical telescope (1990).
D. ARIES	4. Global radio telescope network that imaged a Black Hole.

Select the correct code:

- (a) A-3, B-1, C-4, D-2
(b) A-1, B-3, C-2, D-4
(c) A-3, B-4, C-1, D-2
(d) A-2, B-1, C-4, D-3

Correct Answer: (a)

Explanation:

- **Hubble (A-3):** Famous for visible/UV light observations.
- **JWST (B-1):** Specialized in deep infrared to see through dust clouds.
- **EHT (C-4):** Used Very Long Baseline Interferometry to image M87 and Sagittarius A.
- **ARIES (D-2):** Located in Uttarakhand, India, featuring the 3.6m Devasthal Optical Telescope.

6. Consider the following statements:

1. AstroSat is India's first dedicated multi-wavelength astronomy mission that observes the universe in X-ray, optical, and UV bands simultaneously.
2. The Thirty Meter Telescope (TMT) is a radio telescope project being built in Hawaii to detect faint signals from the early universe.
3. The SARAS telescope is an Indian radio telescope designed to detect signals from the "Cosmic Dawn" (the birth of the first stars).

Which of the statements given above are correct?

- (a) 1 and 2 only

- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** AstroSat's unique feature is its ability to observe different wavelengths at the same time.
- **Statement 2 is incorrect:** TMT is an Optical/Infrared telescope (using mirrors), not a radio telescope.
- **Statement 3 is correct:** SARAS (Shaped Antenna measurement of the background Radio Spectrum) is used to study the Epoch of Reionization.

7. Consider the following statements regarding Solar Eclipses:

1. During a Total Solar Eclipse, the Moon completely obscures the Sun, allowing only the solar corona to be visible to the naked eye.
2. An Annular Solar Eclipse occurs when the Moon is at its closest point to Earth (perigee), appearing larger than the Sun.
3. A Partial Solar Eclipse occurs when the Sun, Moon, and Earth are not perfectly aligned, obscuring only a portion of the solar disk.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (c)

Explanation:

- **Statement 1 is correct:** Totality provides the only safe time to look at the corona without filters.
- **Statement 2 is incorrect:** An Annular eclipse occurs when the Moon is at its farthest point (apogee). Because it looks smaller, it cannot cover the whole Sun, leaving a Ring of Fire.
- **Statement 3 is correct:** This is the most common form of eclipse observed globally.

8. Which of the following scientific processes is responsible for the reddish appearance of the Moon during a total lunar eclipse?

- (a) The Moon's volcanic activity reflecting red light back to Earth.
- (b) Rayleigh scattering in Earth's atmosphere, which filters out blue light and refracts longer red wavelengths onto the Moon.
- (c) The presence of high-energy solar flares that directly strike the lunar surface during an eclipse.
- (d) Gravitational lensing of sunlight by the Moon's mass.

Correct Answer: (b)

Explanation:

During a total lunar eclipse, Earth blocks direct sunlight. However, the Earth's atmosphere bends (refracts) sunlight. Just like at sunset, shorter blue wavelengths are scattered away, while longer red wavelengths pass through and hit the Moon, giving it a blood red color.

9. Consider the following statements regarding the Geotail:

1. It is a region formed by the interaction of the Earth's magnetic field and the solar wind, extending on the Sun-facing side of the planet.
2. The geotail is an extension of the magnetosphere that stretches far beyond the Moon's orbit.
3. Once every month, the Moon enters the geotail for approximately six days around the time of the full moon.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** The geotail is formed on the opposite side of the Sun (the night side). The Sun-facing side is compressed by the solar wind.
- **Statement 2 is correct:** It is a long, tail-like structure of the magnetic field.
- **Statement 3 is correct:** This is a significant event for lunar orbiters (like Chandrayaan) to study plasma and particles.

10. Consider the following statements regarding General Relativity:

1. Gravity is described not as a direct force between masses, but as a curvature in the fabric of spacetime caused by mass and energy.
2. The theory predicted the existence of Gravitational Waves, which are disturbances in spacetime that were first directly detected in 2015.
3. According to the Equivalence Principle, the effects of gravity are completely different from the effects of acceleration, making them easily distinguishable in a closed system.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** This is the core geometric interpretation of gravity.
- **Statement 2 is correct:** The LIGO observatory detected these waves coming from merging black holes in 2015.
- **Statement 3 is incorrect:** The Equivalence Principle states that gravity and acceleration are indistinguishable. An observer in a closed elevator cannot tell if they are being pulled by gravity or pushed by acceleration.

Universe and Space-II

1. With reference to the reclassification of celestial bodies by the International Astronomical Union (IAU), why is Pluto classified as a Dwarf Planet rather than a primary planet?

- (a) It does not possess enough mass to assume a nearly round shape.
- (b) It orbits a larger planet rather than circling the Sun directly.
- (c) It has not cleared the neighborhood of debris surrounding its orbit.
- (d) It is composed primarily of ice and dust rather than rocky or metallic minerals.

Correct Answer: (c)

Explanation:

According to the IAU, a planet must meet three criteria: it must orbit the Sun, be nearly round, and have cleared the neighborhood of its orbit. Pluto fails the third criteria as it shares its orbital path with other Kuiper Belt objects.

2. Consider the following statements:

- 1. The Asteroid Belt is a region of rocky and metallic remnants situated specifically between the orbits of Mars and Jupiter.
- 2. The Kuiper Belt is a disk of icy bodies and dwarf planets located just beyond the orbit of Neptune.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (c)

Explanation:

Both statements are factually correct. The Asteroid Belt contains rocky remnants, while the Kuiper Belt (containing Pluto and Eris) is composed of frozen volatiles such as methane, ammonia, and water ice.

3. Consider the following statements:

- 1. A Ploonet is a celestial body that was originally a moon but escaped its planet's gravity to orbit its host star directly.
- 2. The Goldilocks Zone refers to the region in a galaxy where the concentration of heavy metals is high enough to form terrestrial planets.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (a)

Explanation:

Statement 1 is correct. Statement 2 is incorrect; the Goldilocks Zone (Habitable Zone) is the region around a star where the temperature is just right for liquid water to exist on a planet's surface.

4. Which of the following statements best describes the Van Allen Radiation Belts?

- (a) They are rings of icy rocks and dust situated between Saturn and Uranus.
- (b) They are zones of energetic charged particles captured and held around Earth by its magnetic field.
- (c) They are regions of space where gravitational forces of the Earth and Sun perfectly balance.
- (d) They are man-made debris fields found exclusively in Low Earth Orbit.

Correct Answer: (b)

Explanation:

These belts are comprised of solar wind particles trapped by Earth's magnetosphere. They are most intense over the Equator and are responsible for the Aurora phenomena at the poles.

5. Consider the following statements regarding Space Debris:

1. The majority of space junk is concentrated in High Earth Orbit (HEO) to avoid atmospheric drag.
2. Kessler Syndrome refers to a runaway chain reaction where collisions between objects in orbit create more debris, leading to further collisions.
3. Space debris includes both defunct large satellites and tiny fragments like paint flecks.

How many of the statements given above are correct?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect;** most debris is found in Low Earth Orbit (LEO), below 2,000 km.
- **Statements 2 and 3 are correct** descriptions of the nature and cascading risks of space junk.

6. Match List I (Initiative) with List II (Organization/Origin):

List I (Initiative)	List II (Origin)
A. Project NETRA	1. European Space Agency (ESA)
B. Clean Space Initiative	2. Indian Space Research Organisation (ISRO)
C. IS40M	3. UN General Assembly (1958)
D. COPUOS	4. ISRO (Space Situational Awareness)

Select the correct code:

- (a) A-2, B-1, C-4, D-3
- (b) A-4, B-1, C-2, D-3
- (c) A-4, B-3, C-2, D-1
- (d) A-2, B-3, C-4, D-1

Correct Answer: (b)

Explanation:

Project NETRA is an early warning system in space to detect debris. Clean Space is by ESA. IS40M (ISRO System for Safe & Sustainable Operations Management) was launched in 2022. COPUOS is a UN committee.

7. Consider the following pairs regarding Satellite Orbits:

Orbit Type	Altitude Range	Primary Application
1. Low Earth Orbit (LEO)	160 – 2,000 km	International Space Station (ISS)
2. Medium Earth Orbit (MEO)	2,000 – 35,780 km	Global Positioning System (GPS)
3. High Earth Orbit (HEO)	> 35,786 km	Weather monitoring (Geosynchronous)

How many of the pairs given above are correctly matched?

- (a) Only one pair
- (b) Only two pairs
- (c) All three pairs
- (d) None of the pairs

Correct Answer: (c)

Explanation:

All three are correctly matched. LEO is for imaging and ISS; MEO is for navigation constellations like GPS/Galileo; HEO/GEO is for communication and weather monitoring.

8. Consider the following pairs:

Orbit Type	Description	Application
1. Polar Orbit	Passes over Earth's poles	Remote Sensing (Cartosat)
2. Sun-Synchronous Orbit	Passes over same point at same local time	Climate Change studies
3. Geosynchronous Orbit	Appears stationary above a fixed point	Weather Monitoring (INSAT)

How many of the pairs given above are correctly matched?

- (a) Only one pair
- (b) Only two pairs
- (c) All three pairs
- (d) None of the pairs

Correct Answer: (c)

Explanation:

All pairs are correct. Polar/SSO orbits are ideal for Earth observation because they cover the entire globe. Geosynchronous orbits are essential for constant monitoring of a specific geographic area.

9. Consider the following statements regarding Lagrange Points:

1. They are positions in space where the gravitational forces of two large bodies and the centrifugal force of a smaller object balance each other.
2. The L1 point is located behind the Earth (opposite the Sun) and is used by the James Webb Space Telescope.
3. The Aditya-L1 mission is stationed at the L1 point to allow an uninterrupted view of the Sun.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (c)

Explanation:

- **Statement 1 and Statement 3 is correct.**
- **Statement 2 is incorrect; L2** is behind the Earth (used by Webb), while **L1** is between the Earth and Sun.

10. With reference to space flight, what is a Halo Orbit?

- (a) A circular orbit exactly 1,000 km above the Earth's Equator.
- (b) A three-dimensional, periodic orbit around a Lagrange point.
- (c) An orbit that allows a satellite to stay in the Earth's shadow permanently.
- (d) The path taken by a moon when it is about to become a Ploonet.

Correct Answer: (b)

Explanation:

Halo orbits allow a spacecraft to hover around a Lagrange point (which is just a point in empty space) by following a 3D circular path where forces are balanced. This is commonly used for missions at L1 and L2.

Satellite and Rocket Technology

1. Consider the following table regarding satellite categories:

Type of Satellite	Primary Purpose	Representative Examples
1. Earth Observation (EOS)	Monitoring biosphere, oceans, and weather forecasting	Cartosat, Oceansat, EOS-04
2. Navigation Satellites	Providing PVT (Position, Velocity, and Timing) services	NavIC, GPS, Galileo

3. Communication Satellites	Telecommunication, broadcasting, and internet	GSAT-31, Starlink, OneWeb
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How many of the rows given above are correctly matched?

- (a) Only one
- (b) Only two
- (c) All three
- (d) None

Correct Answer: (c)

Explanation:

All three rows are correctly matched.

- EOS satellites focus on remote sensing and environmental monitoring.
- Navigation satellites provide geospatial positioning.
- Communication satellites are placed primarily in Geostationary orbits for continuous coverage of telecommunications.

2. Consider the following statements regarding the Navigation with Indian Constellation (NavIC):

1. It is an independent regional system designed to provide positioning services over India and a region extending approximately 1,500 km beyond its borders.
2. The second-generation NVS series satellites are designed to augment the constellation by adding the L1 band signal and utilizing indigenous atomic clocks.
3. The Standard Positioning Service (SPS) is an encrypted signal reserved exclusively for military and authorized government agencies.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** It provides regional coverage including the Indian landmass and its surroundings.
- **Statement 2 is correct:** NVS-01 (launched in 2023) featured the first indigenous rubidium atomic clock.
- **Statement 3 is incorrect:** SPS is for civilian users. The Restricted Service (RS) is the encrypted one meant for authorized/military users.

3. Match the following organizations with their correct descriptions:

1. **IN-SPACe:** Nodal agency to promote and authorize private sector participation in space activities.
2. **NSIL:** The commercial arm of ISRO responsible for production of launch vehicles through industry consortiums.
3. **Antrix:** Founded in 1992 to commercialize ISRO's space products and technology transfer.
4. **ISRO:** The primary R&D body under the Department of Space (DOS).

How many of the above are correctly matched?

- (a) Only one
- (b) Only two

- (c) Only three
(d) All four

Correct Answer: (d)

Explanation: All are correctly described.

- IN-SPACe acts as a single-window regulator for private entities.
- NSIL (New Space India Limited) is the newer commercial arm focused on industry-building.
- Antrix has traditionally handled international commercial launches and tech transfers.

4. Consider the following table regarding India's launch vehicles:

Launch Vehicle	Stages & Payload (GTO)	Primary Orbits & Features
1. SSLV	3 Stages (Solid-Solid-Liquid)	Low Earth Orbit (500 kg)
2. PSLV	4 Stages (Solid-Liquid-Solid-Liquid)	Sun-Synchronous Polar Orbits
3. GSLV Mk-II	3 Stages (Solid-Liquid-Cryogenic)	Geostationary Transfer Orbit (2,250 kg)
4. LVM3 (Mk-III)	3 Stages (Solid-Liquid-Cryogenic)	Heavy lifting (4 tons to GTO)

How many of the pairs given above are correctly matched?

- (a) Only one
(b) Only two
(c) Only three
(d) All four

Correct Answer: (d)

Explanation: All pairs are correct. Note the stage configuration:

- **PSLV** uses an alternating S-L-S-L pattern.
- **LVM3** (Launch Vehicle Mark 3) is India's heaviest lifter, crucial for the Gaganyaan (Human Spaceflight) and Chandrayaan missions.

5. Consider the following statements regarding rocket propulsion:

1. ISRO utilizes Unsymmetrical Di-Methyl Hydrazine (UDMH) as fuel combined with Nitrogen Tetroxide as an oxidizer, a combination often termed a dirty combo due to its toxicity.
2. In a liquid propellant system, the fuel and oxidizer are stored separately and mixed only in the combustion chamber to produce thrust.
3. A cryogenic propellant uses gases like Hydrogen and Oxygen that have been liquefied at extremely high temperatures and high pressures.

Which of the statements given above are correct?

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only

(d) 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statement 1 & 2 are correct:** These describe hypergolic and liquid propulsion mechanics.
- **Statement 3 is incorrect:** Cryogenic propellants are stored at extremely low (sub-zero) temperatures (Hydrogen at -253°C and Oxygen at -183°C), not high temperatures.

6. Consider the following statements regarding Cryogenic Engines:

1. They offer higher efficiency and provide greater thrust for every kilogram of propellant burned compared to solid or earth-storable liquid stages.
2. The engine uses liquid hydrogen as the fuel and liquid oxygen as the oxidizer, both maintained at cryogenic temperatures.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (c)

Explanation: Cryogenic engines are technically complex but highly efficient, making them essential for upper stages of heavy-lift rockets (like LVM3 and GSLV) to carry large payloads into deep space or high orbits.

7. With reference to speed classifications in aeronautics, which of the following is correctly matched?

- (a) Subsonic: Speed exactly at Mach 1.0
- (b) Supersonic: Mach 1.2 to 5
- (c) Hypersonic: Mach 0.8 to 1.2
- (d) High-hypersonic: Speed less than Mach 0.8

Correct Answer: (b)

Explanation:

- **Subsonic:** < 0.8
- **Transonic:** $0.8 - 1.2$
- **Supersonic:** $1.2 - 5$
- **Hypersonic:** $5 - 10$
- **High-hypersonic:** $10 - 25$

8. Consider the following statements regarding air-breathing engines:

1. A Ramjet engine uses the vehicle's forward motion to compress incoming air for combustion without a rotating compressor, but it cannot operate at zero velocity.
2. A Scramjet (Supersonic Combustion Ramjet) is designed to operate at hypersonic speeds where the airflow through the engine remains supersonic.
3. A Dual Mode Ramjet (DMRJ) is a specialized engine that can operate in both subsonic and supersonic combustion modes across a range of Mach 4 to 8.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) 3 only

(d) 1, 2 and 3

Correct Answer: (d)

Explanation: All three are correct. These engines are air-breathing because they take oxygen from the atmosphere rather than carrying it on board, significantly reducing the rocket's weight.

9. Consider the following statements:

1. CMS-01 and GSAT-11 are part of India's communication satellite fleet, designed for high-throughput broadband and connectivity services.
2. GSAT-7A, nicknamed Angry Bird, is a dedicated communication satellite primarily serving the connectivity needs of the Indian Air Force.
3. OCEANSAT-3 and RISAT-2 are Earth Observation Satellites used for oceanography, weather forecasting, and radar imaging respectively.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (d)

Explanation:

All statements are correct. RISAT (Radar Imaging Satellite) is particularly useful because it can see through clouds and at night, making it vital for disaster management and surveillance.

10. Consider the following statements regarding the Shukrayaan-1 mission:

1. It is India's first planned orbiter mission to Venus, intended to study the planet's surface, geological features, and atmosphere.
2. The mission aims to explore signs of active volcanism and seismic activity to understand the climate evolution of Venus.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (c)

Explanation:

Shukrayaan-1 will use the GSLV Mk II to carry a payload of approximately 2,500 kg to Venus. Its goal is to investigate why Venus, similar in size to Earth, evolved into a high-pressure hell-scape with a runaway greenhouse effect.

ISRO Missions

1. Consider the following statements regarding the LUPEX mission:

1. It is a joint collaborative mission between the Indian Space Research Organisation (ISRO) and the National Aeronautics and Space Administration (NASA).
2. The primary objective is to investigate the quantity and quality of water ice in the Moon's permanently shadowed polar regions.
3. In this collaboration, ISRO is responsible for developing the lander, while the Japan Aerospace Exploration Agency (JAXA) is providing the rover.

Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect:** LUPEX is a collaboration between ISRO and JAXA (Japan), not NASA.
- **Statements 2 and 3 are correct.** The mission will use a Japanese launch vehicle and rover, and an Indian lander.

2. Consider the following statements regarding India's Gaganyaan mission:

1. The mission intends to orbit a crew of three Indian astronauts at an altitude of 300-400 km in Low Earth Orbit (LEO) for a period of 5-7 days.
2. The powerful GSLV Mk III (LVM-3) rocket has been designated as the launch vehicle for this human spaceflight program.
3. The mission consists of a total of five planned flights, all of which will be crewed to ensure maximum data collection.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: (a)

Explanation:

- **Statement 1 and 2 are correct:** The program intends to send a crew of three Indian astronauts (designated as Gaganyatris) to an altitude of 400 km in LEO. While initial plans suggested 5-7 days, recent updates indicate a mission duration of 3 days before a safe splashdown in the Indian Ocean. Launch Vehicle: The LVM-3 (Launch Vehicle Mark-3), formerly known as GSLV Mk III, is the designated heavy-lift launcher, re-configured as a human-rated vehicle (HLVM3) to ensure safety.
- **Statement 3 is incorrect:** The mission consists of three planned flights: two uncrewed missions to test systems and safety, followed by one crewed mission.

3. Consider the following statements regarding the testing phase of Gaganyaan:

1. The Pad Abort Test (PAT) is specifically designed to test the parachute and deceleration mechanisms during the final descent.
2. The first uncrewed mission of the Gaganyaan program is successfully completed and was targeted for the year 2022.
3. The Water Survival Test Facility (WSTF) involves recovery trials of the crew module in sea conditions with the assistance of the Indian Navy.

Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 3 only
- (c) 1 and 3 only
- (d) None of the above

Correct Answer: (b)

Explanation:

- **Statement 1 is incorrect;** PAT evaluates the safety of the crew module in case of an emergency on the launch pad (Integrated Air Drop Test handles parachutes).
- **Statement 2 is incorrect;** the first uncrewed mission is targeted for late 2024/2025. Statement 3 is correct.

4. Consider the following statements regarding the GEMINI (Gagan Enabled Mariner's Instrument for Navigation and Information) device:

1. It is a portable satellite receiver developed by ISRO to provide communication in blackout zones where cellular connectivity is unavailable.
2. The device is primarily designed for disaster management, offering a coverage range of up to 300 nautical miles from the coast.
3. GEMINI operates by connecting directly to international GPS satellites rather than Indian regional satellites.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Developed by ISRO to provide emergency communication and information to fishermen in deep sea, particularly in areas (blackout zones) where cellular networks are unavailable. Coverage Range: It offers a coverage range of up to 300 nautical miles from the coast, providing critical updates during severe weather and natural disasters.
- **Statement 3 is incorrect:** GEMINI utilizes India's own GAGAN satellite system (augmented by GSAT satellites) to transmit emergency alerts and information to mariners.

5. Consider the following statements regarding GAGAN:

1. It is a Satellite-Based Augmentation System (SBAS) developed jointly by ISRO and the Airports Authority of India (AAI) primarily for the civil aviation sector.
2. GAGAN functions by augmenting GPS signals to provide higher accuracy, integrity, and availability required for aircraft landing.
3. The system currently supports high-speed, two-way voice communication, allowing pilots to make emergency calls directly through the GAGAN interface.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: (a)

Explanation:

Statements 1 and 2 are correct: GAGAN (GPS-Aided GEO Augmented Navigation) is an Indian Satellite-Based Augmentation System (SBAS) jointly developed by the Indian Space Research Organisation (ISRO) and the

Airports Authority of India (AAI). It enhances GPS signal accuracy, integrity, and availability for civil aviation, enabling precision approaches (LPV-1) for safer landings over Indian airspace.

Statement 3 is incorrect; a current limitation of GAGAN is that it only supports one-way communication (positioning and alerts), not voice calls.

6. With reference to the Mission Shakti conducted by India, consider the following statements:

1. It was a joint anti-satellite (ASAT) missile test conducted by DRDO and ISRO to destroy a satellite in Geostationary Earth Orbit (GEO).
2. With this test, India became the fourth country in the world to possess this anti-satellite capability.
3. The mission used a modified interceptor missile, PDV Mark-II, that utilized a hit-to-kill technology.

Which of the statements given above is/are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: B

Explanation:

- **Statement 1 is incorrect:** Mission Shakti was carried out by the Defence Research and Development Organisation (DRDO) (not a joint mission with ISRO) and targeted a satellite in Low Earth Orbit (LEO) (around 300 km), not Geostationary Orbit.
- **Statement 2 is correct:** India joined the USA, Russia, and China as the fourth country to achieve this capability.
- **Statement 3 is correct:** The test used a modified Prithvi Defence Vehicle (PDV) Mark-II to strike the satellite directly using kinetic energy ('hit-to-kill'), rather than an explosive warhead, to minimize long-term debris.

7. Consider the following statements regarding XPoSAt:

1. It is India's first dedicated polarimetry mission to study the dynamics of bright astronomical X-ray sources in extreme conditions.
2. The POLIX payload is designed to measure the degree and angle of polarization of X-rays in the medium energy range of 8-30 keV.
3. The XSPECT payload provides high-resolution spectroscopic data and timing in the soft X-ray energy band (0.8-15 keV).

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2, and 3

Correct Answer: (d)

Explanation:

All statements are correct. XPoSAt was launched via PSLV-C58 and is only the world's second mission of its kind (after NASA's IXPE) to study X-ray polarization.

8. Consider the following statements regarding the NASA-ISRO Synthetic Aperture Radar (NISAR) mission:

1. NISAR is a joint Earth-observation mission designed to monitor global environmental changes including ice-sheet collapse and ecosystem disturbances.
2. The L-band Synthetic Aperture Radar (L-SAR), provided by ISRO, is specialized for detecting surface-level features like crop health and wetlands.
3. NASA provides the S-band Synthetic Aperture Radar (S-SAR), which is capable of penetrating dense forest canopies and soil to study biomass.

Which of the statements given above is/are incorrect?

- (a) 1 only
- (b) 1 and 2 only
- (c) 2 and 3 only
- (d) 1, 2, and 3

Correct Answer: (c)

Explanation:

Statement 1 is correct. NISAR (NASA-ISRO Synthetic Aperture Radar) is a joint earth-observation mission launched on July 30, 2025, from India, designed to monitor global environmental changes with high-resolution radar. Using dual-band SAR, it monitors ice-sheet collapse, ecosystem disturbances, and natural hazards like earthquakes and volcanic eruptions, providing data to help with climate change studies.

Statements 2 and 3 are incorrect: The roles are swapped: NASA provides the L-band (long wavelength, high penetration for biomass/ice) and ISRO provides the S-band (shorter wavelength, for surface features/agriculture).

9. Consider the following pairs regarding Space Observatories:

Telescope Name	Wavelength Range	Primary Purpose
1. Hubble (HST)	Visible and Ultraviolet	Imaging distant galaxies and nebulae
2. Compton (CGRO)	Gamma Rays	Studying high-energy celestial phenomena
3. Chandra (CXO)	X-rays	Observing hot, high-energy objects
4. Spitzer (SST)	Infrared	Observing cool, dusty objects and exoplanets

How many of the pairs given above are correctly matched?

- (a) Only one pair
- (b) Only two pairs
- (c) Only three pairs
- (d) All four pairs

Correct Answer: (d)

Explanation:

All four pairs are correctly matched. Each telescope is part of NASA's Great Observatories program, each viewing the universe through a different part of the electromagnetic spectrum.

10. Consider the following statements regarding NASA's Parker Solar Probe:

1. It is the first spacecraft to touch the Sun by flying through the solar corona, the Sun's outer atmosphere.
2. The mission's primary goal is to study the mechanisms that cool the solar surface and prevent the acceleration of solar winds.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (a)

Explanation:

Statement 1 is correct. Statement 2 is incorrect; the goal is to understand why the corona is much hotter than the surface and what accelerates the solar wind (not prevent it).

Space Missions

1. Consider the following statements:

1. The LVM3-M6 mission represents a commercial collaboration between NewSpace India Limited (NSIL) and a US-based private company to deploy the Bluebird Block-2 satellite.
2. The Bluebird Block-2 satellite is designed to establish a Low Earth Orbit (LEO) constellation to provide direct-to-mobile 4G and 5G telecommunication services.
3. At 6,100 kg, the Bluebird Block-2 payload stands as the heaviest satellite payload ever launched by ISRO's LVM3 vehicle.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (d)

Explanation:

- **Statement 1 is correct:** NSIL, incorporated in 2019 as the commercial arm of ISRO under the Department of Space, facilitated this mission for AST SpaceMobile, USA.
- **Statement 2 is correct:** It features a massive 223 m² phased array to facilitate direct cellular connectivity without ground tower dependence.
- **Statement 3 is correct:** It broke previous records, marking the maximum payload threshold successfully carried by the LVM3 to Low Earth Orbit.

2. Consider the following statements regarding the Dust Experiment (DEX):

1. It is India's maiden indigenous scientific instrument engineered to capture and analyze high-speed interplanetary dust particles.
2. The payload was deployed into space utilizing the PSLV Orbital Experimental Module (POEM) platform during the PSLV-C58 mission.
3. The instrument was conceptualized and developed by the Indian Institute of Astrophysics (IIA), Bengaluru.

Which of the statements given above is/are correct?

- (a) 1 and 2 only

- (b) 2 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** DEX tracks cosmic dust fragments from comets and asteroids using the cost-effective POEM platform, which repurposes the spent fourth stage of the PSLV rocket.
- **Statement 3 is incorrect:** DEX was developed by the Physical Research Laboratory (PRL), Ahmedabad, not the IIA.

3. Consider the following statements regarding the Voyager 1 mission:

1. Launched primarily to conduct flybys of Jupiter and Saturn, Voyager 1 became the first human-made object to cross the heliosphere into interstellar space.
2. It is currently traveling at a distance that makes it the first spacecraft to be more than one light-year away from Earth.
3. The heliosphere it crossed represents the boundary where interstellar plasma influences become stronger than the solar wind from our Sun.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 1 and 3 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statements 1 and 3 are correct:** Voyager 1 (launched in 1977) officially crossed the heliopause into interstellar space in 2012, charting regions outside our solar wind's protective bubble.
- **Statement 2 is incorrect:** It is approaching a distance of one light-day (the distance light travels in 24 hours, roughly 16 billion miles), not a light-year. One light-year is vastly further (approx. 5.88 trillion miles).

4. Consider the following statements:

1. NASA's OSIRIS-REx is the first space mission from the United States designed to collect and return pristine surface samples from an asteroid.
2. Chemical analysis of the sample returned from Asteroid Bennu confirmed the presence of organic building blocks, including amino acids and all five nucleobases of DNA and RNA.
3. Following its successful capsule drop-off, the primary spacecraft was decommissioned and deliberately crashed into Earth's atmosphere.

Which of the statements given above are correct?

- (a) 1 and 2 only
- (b) 2 and 3 only
- (c) 1 and 3 only
- (d) 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** The sample analysis from Bennu indicates a rich, early solar system molecular inventory that could have delivered prebiotic materials to early Earth.
- **Statement 3 is incorrect:** The spacecraft was not destroyed; it was granted an extended mission, renamed OSIRIS-APEX, and is currently en route to study the asteroid Apophis in 2029.

5. Consider the following statements regarding the defense agreement signed between India and France:

1. The joint production agreement centers on the SIGMA 30N Navigation System and the CM3-MR Direct Firing Sight to augment artillery units.
2. The integrated system allows autonomous artillery positioning and targeting completely independent of external GPS or satellite architectures.
3. The tracking and direct-fire modules are designed exclusively for heavy towed guns and cannot be cross-integrated with mobile air defense or anti-drone weapon systems.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 1 and 2 only
- (c) 2 and 3 only
- (d) 1, 2 and 3

Correct Answer: (b)

Explanation:

- **Statements 1 and 2 are correct:** The SIGMA 30N ensures precise navigation and targeting alignment even in heavily jammed Electronic Warfare (EW) environments where satellite navigation signals are lost.
- **Statement 3 is incorrect:** The system is explicitly valued for its versatility; it can easily integrate with diverse hardware systems, including radars, heavy artillery, and tactical mobile anti-drone assets.

6. Consider the following statements regarding NASA's Lucy Mission:

1. The mission is designed to explore Jupiter's Trojan asteroids, which are trapped in gravity wells ahead of and behind the giant planet.
2. To reach its distant targets, Lucy relies entirely on a high-powered, continuous nuclear propulsion engine without utilizing planetary gravity assists.

Which of the statements given above is/are correct?

- (a) 1 only
- (b) 2 only
- (c) Both 1 and 2
- (d) Neither 1 nor 2

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The Trojan asteroids are considered "fossils" or remnants of our early solar system's planetary formation.
- **Statement 2 is incorrect:** Lucy utilizes multiple Earth gravity assists (slingshot effects) to alter and accelerate its trajectory through space to match orbits with the Trojan clusters.

7. Consider the following statements regarding planetary defense technologies:

1. The DART mission successfully demonstrated the "kinetic impactor" method by intentionally colliding a spacecraft into the moonlet Dimorphos to alter its orbital path.

- The spacecraft's primary target was a single, isolated rogue comet heading directly toward the inner solar system.

Which of the statements given above is/are correct?

- 1 only
- 2 only
- Both 1 and 2
- Neither 1 nor 2

Correct Answer: (a)

Explanation:

- **Statement 1 is correct:** The mission in September 2022 successfully proved that humans could shift the orbital trajectory of a celestial body via kinetic momentum transfer.
- **Statement 2 is incorrect:** The target was not an isolated comet; it was a safe binary asteroid system comprising a larger body (Didymos) orbited by its smaller moonlet (Dimorphos).

8. Consider the following statements regarding the Artemis lunar exploration architecture:

- Artemis I served as an uncrewed system flight test integrating the heavy-lift Space Launch System (SLS) rocket with the Orion spacecraft capsule.
- Artemis II is slated to be the first crewed lunar flyby trajectory since the conclusion of the Apollo era, utilizing a free-return trajectory path.
- The Artemis Accords constitute a legally binding international treaty that carries strict judicial penalties under United Nations oversight for non-compliance.

Which of the statements given above are correct?

- 1 and 2 only
- 2 and 3 only
- 1 and 3 only
- 1, 2 and 3

Correct Answer: (a)

Explanation:

- **Statements 1 and 2 are correct:** Artemis I verified basic systems safety, while Artemis II will send a diverse four-person crew around the Moon without landing.
- **Statement 3 is incorrect:** The Artemis Accords are a set of non-legally binding political principles and guidelines for civil space cooperation, based loosely on the Outer Space Treaty, but they are not a UN-enforced judicial treaty.

9. Consider the following statements regarding India's domestic space station initiative:

- The Bharatiya Antariksh Station (BAS) is planned to occupy a Low Earth Orbit at an operational altitude of approximately 400 to 450 km.
- The entire space station assembly will feature a modular layout consisting of five blocks, with the target of launching the first Base Module by 2028.

Which of the statements given above is/are correct?

- 1 only
- 2 only
- Both 1 and 2
- Neither 1 nor 2

Correct Answer: (c)

Explanation: Both statements are correct. The BAS project will build India's footprint in long-duration microgravity research. The multi-phased module approach allows ISRO to scale up infrastructure systematically, aiming for full operational status by 2035.

10. Consider the following statements regarding Atomic Clocks:

1. They measure time by monitoring the resonant frequency of atoms transitioning between discrete energy states.
2. The International System of Units (SI) definition of the second is based on the resonant frequency of Caesium-133 atoms.
3. Unlike standard atomic clocks that use microwaves, optical atomic clocks operate at higher frequencies using lasers, enabling greater precision.

- (a) 1 and 2 only
(b) 2 and 3 only
(c) 1 and 3 only
(d) 1, 2 and 3

Correct Answer: (d)

Explanations:

- **Statement 1 is correct:** Unlike pendulum clocks that rely on mechanical swings or quartz clocks that use the vibration of a crystal, atomic clocks exploit quantum-mechanical properties. They track the precise resonant frequencies of atoms when they transition between different energy states.
- **Statement 2 is correct:** The global standard for timekeeping is defined by Caesium-133 atomic clocks. One second is officially defined as the duration of exactly $(9,192,631,770)$ cycles of radiation corresponding to the transition between two hyperfine levels of the ground state of the Caesium-133 atom.
- **Statement 3 is correct:** Optical atomic clocks are the next-generation timekeepers. While traditional atomic clocks (like those used in the Indian NavIC or global GPS satellites) operate in the microwave range of the electromagnetic spectrum, optical clocks use lasers to measure atomic vibrations in the visible or ultraviolet ranges. This allows them to count more cycles per second, making them thousands of times more precise.