Sleepy Classes
Awakening Toppers

UPSC PRELIMS 24th MAY, 2026

LAST MINUTE REVISION NOTES

Science & Tech

PHYSICS OF SPACE

Last Minute Revision (Lmr)

Science & Technology

Physics of Space - Lecture 1

UPSC 2026

Part 1: The Universe and Big Bang Theory

1.1 Composition of Universe

- **Observable matter:** Only 5% of universe
- **Dark Matter:** 27% - invisible mass, interacts through gravity
- **Dark Energy:** 68% - mysterious force causing accelerated expansion

1.2 Key Contributors to Understanding Universe

Scientist	Period	Contribution
Georges Lemaître	1927-1931	Proposed expanding universe from 'primeval atom'
Edwin Hubble	1930s	Confirmed universe is expanding (Hubble's Law)
George Gamow	1948	Predicted CMB as leftover radiation from Big Bang
Penzias & Wilson	1965	Accidentally discovered CMB (Nobel Prize 1978)
Fred Hoyle	1948	Proposed Steady State Theory (later disproven); coined term 'Big Bang'

1.3 Redshift - Evidence for Expanding Universe

- **Doppler Redshift:** Light from objects moving away is stretched toward red end of spectrum
- **Cosmological Redshift:** Due to expansion of universe itself - space stretching
- **Gravitational Redshift:** Light escaping strong gravitational field (black hole) loses energy and shifts red
- Crucial evidence for Big Bang Theory

Part 2: Dark Matter and Dark Energy

2.1 Dark Matter

Properties:

- No charge - does not interact electromagnetically
- Does not emit light (hence 'dark')
- Possesses mass - interacts through gravity

Evidence for Dark Matter

Evidence	Observation
Galaxy Rotation Curves	Outer arms of galaxies rotate too fast – need invisible mass
Gravitational Lensing	Light bending is stronger than visible matter can account for
CMB Fluctuations	Density patterns need dark matter to explain structure formation

2.2 Dark Energy

- Makes up 68% of universe
- **Discovery:** Universe's expansion is accelerating (not slowing as expected)
- Not like matter or ordinary energy – pushes galaxies apart
- Nature remains mysterious

Part 3: Defining Space

3.1 What is Space?

- Begins about 100 km above Earth
- No appreciable air to breathe or scatter light
- Sky appears black – not enough oxygen molecules to make it blue
- Vacuum: Sound cannot travel – molecules not close enough
- Not completely empty – gas, dust, planets, stars, galaxies exist

3.2 Kármán Line

- Altitude: 100 km (62 miles) above mean sea level
- Boundary between Earth's atmosphere and outer space
- Established: 1960s by Fédération Aéronautique Internationale (FAI)
- Named after: Theodore von Kármán (Hungarian-American physicist)
- Note: *US Air Force/NASA sometimes use 80 km (50 miles)*

Why Aircraft Cannot Generate Lift Above Kármán Line

- **Air density:** 1/2,200,000 of Earth's surface density
- Too thin to support aerodynamic flight
- Would need orbital velocity to generate lift
- Jet engines cannot work – insufficient oxygen
- Experience 'free fall' – weightlessness despite 97% of Earth's gravity still present

Part 4: Life Cycle of Stars

4.1 Stellar Nursery

- Stars form in nebulae from collapsing clouds of interstellar gas and dust
- Gravity pulls material together

4.2 Low to Medium Mass Stars (up to 1.5× Sun's mass)

Sun-like Star	Stable phase with hydrostatic balance – fusion vs gravity
Red Giant	Outer layers expand, core shrinks: shell burning starts
Planetary Nebula	Outer layer ejected: star sheds outer shell
White Dwarf	Dense hot core left behind: nuclear fusion stops
Black Dwarf	Cold, dark remnant (theoretical – universe not old enough)

4.3 High Mass Stars (1.5–3× Sun's mass)

- Huge Star → Red Supergiant → Supernova → Neutron Star
- Rapid fusion – shorter lifespan
- Supernova: Massive explosion
- Neutron Star: Extremely dense remnant (sugar cube = mass of all humanity)

Types of Neutron Stars

- **Pulsar:** Fast rotating neutron star emitting beams of electromagnetic radiation
- **Magnetar:** Extremely powerful magnetic field: burst emission
- **Note:** *Every pulsar/magnetar is a neutron star, but not every neutron star is a pulsar/magnetar*

4.4 Giant Stars (over 3× Sun's mass)

- Giant Stars → Red Supergiant → Supernova → Black Hole
- Gravity so strong that even light cannot escape

Part 5: Hydrostatic Equilibrium and Stellar Physics

5.1 Hydrostatic Equilibrium

Force	Direction	Source	Effect
Gravity	Inward	Star's own mass	Tries to collapse the star
Pressure	Outward	Nuclear fusion in core	Pushes outward

5.2 Chandrasekhar Limit

- Limit: 1.4 times mass of Sun
- No white dwarf can be more massive than this limit
- Any degenerate object more massive must collapse into neutron star or black hole
- Named after: Subrahmanyan Chandrasekhar (1931)
- Nobel Prize: 1983 for work on stellar structure and evolution

Part 6: Black Holes

6.1 Definition and Formation

- Place where gravity is so strong that even light cannot escape
- **Reason:** Matter squeezed into tiny space when star dies

- Invisible – cannot be seen directly

6.2 Types of Black Holes

Type	Mass Range	Formation	Evidence
Primordial	Atom to planet-sized	After Big Bang	Not much evidence
Stellar	5–100 solar masses	Collapse of massive star	Indirect evidence
Intermediate	100–100,000 solar masses	Unknown	Limited evidence
Supermassive	Million+ solar masses	Galaxy centers	Sagittarius A*, M87

6.3 Key Terms Related to Black Holes

Singularity	Point with infinite density and zero volume
Event Horizon	Point of no return – boundary beyond which escape is impossible
Ergosphere	Region outside event horizon: space-time dragged: escape possible
Accretion Disk	Spinning disk of gas/dust spiraling into black hole: emits X-rays
Hawking Radiation	Black holes can slowly emit radiation and eventually evaporate
Eddington Limit	Maximum rate at which black hole can feed: radiation pressure balances gravity

6.4 How to Detect Black Holes

- **X-rays:** From matter spiraling into accretion disk
- **Gravitational Waves:** From black hole mergers
- **Orbital Motion:** Stars orbiting Milky Way's central black hole (Sagittarius A*)

First Image of Black Hole

- **Date:** April 10, 2019
- **Telescope:** Event Horizon Telescope (EHT) – global network of radio telescopes
- **Black Hole:** M87* in galaxy Messier 87

Part 7: The Sun

7.1 Basic Facts

- **Age:** 4.5 billion years
- **Composition:** Hot glowing ball of Hydrogen and Helium
- Largest object in solar system
- Located at center of solar system

7.2 Layers of the Sun

Layer	Temperature	Key Features
Photosphere	6,500K (bottom) to 4,000K (top)	Deepest layer we can observe: sunspots appear here
Chromosphere	4,000K (bottom) to 8,000K (top)	Above photosphere: gets HOTTER away from Sun
Transition Region	8,000K to 500,000K	Very narrow layer (100 km): rapid temperature rise
Corona	500,000K or more	Outermost layer: visible during total solar eclipse: no upper limit

7.3 Solar Phenomena

Sunspots

- Dark areas on photosphere (up to 50,000 km diameter)
- Appear dark because cooler than surroundings (~6,500°F)
- **Cause:** Strong magnetic fields prevent heat from reaching surface

Solar Flares

- Sudden explosion of energy when magnetic field lines tangle/reorganize
- Release massive amounts of radiation
- **Effects:** Disrupt satellites, radio transmission: damage power grid transformers

Coronal Mass Ejection (CME)

- Huge bubbles of radiation and particles from Sun's corona
- Explode into space at high speed
- Sometimes accompany solar flares

Solar Wind

- Stream of charged particles (electrons, protons) flowing from Sun
- **Speed:** Up to 900 km/s
- **Temperature:** 1 million degrees Celsius
- Made of plasma (ionized atoms)

Aurora

- Natural light display in high latitude regions (Arctic/Antarctic)
- **Cause:** Charged particles from solar wind enter atmosphere → interact with gases → emit light
- Occur along magnetic field lines of Earth
- **Other planets:** Jupiter, Saturn, Uranus, Neptune also have auroras: Mars has discrete auroras

Part 8: Solar System Objects

8.1 Planets – IAU Definition (2006)

- Must orbit a fully-fledged star
- Must have enough gravity to pull itself into spherical shape
- Must have cleared neighborhood around its orbit
- Pluto: *Demoted to dwarf planet in 2006 (failed 3rd criterion)*

8.2 Dwarf Planets

- Celestial body in direct orbit of Sun
- Massive enough for spherical shape
- **Has NOT cleared neighboring region**

- **IAU recognizes 5**: Ceres, Pluto, Eris, Haumea, Makemake
- **Plutoids**: All dwarf planets except Ceres

8.3 Asteroids

- Small rocky objects leftover from solar system formation
- **Size**: Small to 600 miles (Ceres)
- **Location**: Mostly between Mars and Jupiter (Asteroid Belt)

Types of Asteroids

- **C-type (Carbonaceous)**: 75%: mostly water, hardly any metal
- **S-type (Silicate)**: 17%: Fe, Nickel, Mg: little water but brighter
- **M-type (Metal)**: Platinum: large amount on Earth came from this type

NASA DART Mission

- **Full Name**: Double Asteroid Redirection Test
- **Target**: Asteroid Dimorphos
- **Purpose**: Test planetary defense by altering asteroid orbit
- **Companion**: LICIACube (Light Italian CubeSat for Imaging of Asteroids)

8.4 Comets

- Dust, ice, rock leftover from solar system formation
- **Origin**: Oort Cloud (stirred by stars) or Kuiper Belt (stirred by planets)
- **Features**: Nucleus, Coma (cloud around nucleus), Ion tail, Dust tail
- Tails point away from Sun due to solar wind and radiation

8.5 Meteoroids, Meteors, Meteorites

- **Meteoroids**: Small pieces of asteroid broken off
- **Meteors**: Streak of light when meteoroid enters atmosphere ('shooting star')
- **Meteorites**: Meteoroid rocks that survive trip through atmosphere and land on Earth

Part 9: Kuiper Belt and Oort Cloud

9.1 Asteroid Belt

- **Location**: Between orbits of Mars and Jupiter
- **Origin**: Leftover material that didn't form planet
- **Total mass**: Less than the Moon
- **Jupiter's gravity**: Prevented material from coalescing into planet

9.2 Kuiper Belt

- **Location**: Beyond eight major planets
- **Inner edge**: At Neptune's orbit (~30 AU from Sun)
- **Outer edge**: Nearly 1,000 AU (some orbits go further)
- **Size**: 20× wider and 20-200× more massive than Asteroid Belt
- **Contents**: Rock, ice, comets, dwarf planets (Pluto, Eris, Makemake, Haumea)

Cold vs Hot Classical Objects

- **Cold Classical KBOs**: Orbits never come close to Neptune – unperturbed
- **Hot Classical KBOs**: Had interactions with Neptune – elliptical, tilted orbits
- **Note**: *'Cold' and 'hot' refer to orbits, not temperature*

9.3 Oort Cloud

- **Shape**: Giant spherical shell surrounding solar system
- Unlike planets/Kuiper Belt (flat disk), Oort Cloud is 3D sphere

- **Composition:** Icy pieces of space debris (mountain-sized or larger)
- **Population:** Billions or trillions of objects
- **Source:** Most comets originate from Oort Cloud

Part 10: Special Topics

10.1 Lagrange Points

- Positions where gravitational pull of two large masses equals centripetal force
- Objects sent there tend to stay put
- **Five special points:** L1, L2, L3, L4, L5

Point	Stability	Significance/Use
L1	Unstable	Uninterrupted view of Sun: Solar and Heliospheric Observatory
L2	Unstable	Ideal for astronomy: can keep Sun/Earth/Moon behind: JWST location
L3	Unstable	Hidden behind Sun at all times: unlikely to find use
L4, L5	Stable	Form equilateral triangles: called Trojans (Jupiter has asteroids here)

10.2 Microgravity

- **Definition:** Condition where gravity seems very small (NOT zero gravity)
- Astronauts can float in spacecraft
- **Gravity at ISS:** 90% of Earth's surface gravity still present
- **Why float?** In free fall – continuous falling around Earth

Significance

- Learn effects on people and equipment
- Keep astronauts safe on other planets
- **Effects:** Fire burns differently, crystals grow better

Impact on Human Body

- Heart weakens (doesn't pump against gravity)
- Low red blood cells
- Immunodeficiency
- Cardiac problems

10.3 Gravitational Waves (LIGO)

- **Definition:** Ripples in space-time caused by violent cosmic events
- **Predicted by:** Albert Einstein
- **Travel at:** Speed of light
- **Sources:** Colliding black holes, neutron stars, supernovae

LIGO – Laser Interferometer Gravitational-Wave Observatory

- **First detection:** 2015 (two LIGOs in USA)
- **Current locations:** USA (Hanford, Livingston), Italy (Virgo), Japan (Kagra)
- **LIGO-India:** Hingoli district, Maharashtra (~450 km east of Mumbai)
- **Expected operational:** 2030

*** END OF LMR ***

Best of Luck for UPSC 2026!

Sleepy Classes
Awakening Toppers

UPSC PRELIMS 24th MAY, 2026

DAILY PRACTICE WORKBOOK

Science & Tech

PHYSICS IN SPACE

Daily Practice Workbook (DPW)

Science & Technology

Physics of Space - Lecture 1

UPSC 2026

Section A: Fill In the Blanks

(10 Questions × 1 Mark = 10 Marks)

1. Observable matter constitutes only _____ of the universe.
2. The Belgian priest and physicist who proposed the 'primeval atom' theory was _____.
3. The Cosmic Microwave Background (CMB) was accidentally discovered in 1965 by _____.
4. The Kármán Line, which marks the boundary between Earth's atmosphere and outer space, is located at an altitude of _____.
5. The Chandrasekhar Limit states that no white dwarf can be more massive than about _____ times the mass of the Sun.
6. The point of no return around a black hole, beyond which escape is impossible, is called the _____.
7. The outermost layer of the Sun's atmosphere, visible during total solar eclipse, is the _____.
8. The first-ever image of a black hole was released on April 10, 2019, showing the black hole _____ in the galaxy Messier 87.
9. The region of the Solar System beyond Neptune that contains dwarf planets like Pluto is called the _____.
10. LIGO-India, which will detect gravitational waves, is scheduled to be located in _____ district of Maharashtra.

Section B: True Or False

(5 Questions × 2 Marks = 10 Marks)

11. Dark matter does not emit or absorb light but can be detected through its gravitational effects on visible matter.
12. Giant stars live much longer than dwarf stars because they have slower rates of nuclear reactions.
13. The corona of the Sun is cooler than the photosphere despite being farther from the Sun's core.
14. Every neutron star is a pulsar, emitting beams of electromagnetic radiation.
15. Pluto was demoted from planet status to dwarf planet in 2006 because it failed to clear the neighborhood around its orbit.

Section C: Match The Following

(5 Questions × 1 Mark = 5 Marks)

Match the scientists in Column A with their contributions in Column B:

Column A (Scientists)	Column B (Contributions)
16. Edwin Hubble	A. Proposed Chandrasekhar Limit for white dwarfs
17. Subrahmanyan Chandrasekhar	B. Accidentally discovered CMB in 1965
18. Penzias & Wilson	C. Coined the term 'Big Bang' (mockingly)
19. Fred Hoyle	D. Confirmed universe is expanding (Hubble's Law)
20. Theodore von Kármán	E. Calculated boundary between atmosphere and space

Section D: Multiple Choice Questions

(5 Questions × 1 Mark = 5 Marks)

21. Consider the following statements regarding Dark Matter:

1. It is made up of particles that do not have a charge
2. Dark matter possesses no mass unlike normal matter
3. They interact only through electromagnetic interactions

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

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22. Which of the following statements is/are correct regarding the Geomagnetic Storm?

1. Geomagnetic storm occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth
2. The impact of solar storm is more at lower latitude than higher latitude
3. Solar flares impact Earth only when they occur on the side of the sun facing Earth

Select the correct answer using the code given below:

A. 1 and 3 only
B. 1 only
C. 2 and 3 only
D. 1, 2 and 3

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23. Consider the following pairs:

Objects in space	Description
1. Cepheids	Stars which brighten and dim periodically
2. Nebula	Giant clouds of dust and gas in space
3. Pulsars	Neutron stars formed when massive stars collapse

How many of the above pairs are correctly matched?

A. Only one pair

B. Only two pairs
C. All three pairs
D. None

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24. Consider the following statements:

Statement-I: There is a black hole behind every quasar, but not every black hole is a quasar.

Statement-II: Quasars are found in galaxies that have supermassive black holes which power these bright discs.

Which one of the following is correct in respect of the above statements?

A. Both Statement-I and Statement-II are correct and Statement-II explains Statement-I
B. Both Statement-I and Statement-II are correct, but Statement-II does not explain Statement-I
C. Statement-I is correct, but Statement-II is incorrect
D. Statement-I is incorrect, but Statement-II is correct

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25. With reference to asteroids and comets, consider the following statements:

1. Asteroids are small rocky planetoids, while comets are formed of frozen gases held together by rocky and metallic material
2. Asteroids are found mostly between the orbits of Jupiter and Mars, while comets originate mostly from the Oort Cloud and Kuiper Belt
3. Comets show a perceptible glowing tail when near the Sun, while asteroids do not

Which of the statements given above is/are correct?

A. 1 and 2 only
B. 1 and 3 only
C. 2 and 3 only
D. 1, 2 and 3

Answer Key with Explanations

Section A: Fill In the Blanks - Answers

1. Answer: 5%

Explanation: Observable matter constitutes only 5% of the universe. The remaining 95% consists of dark matter (27%) and dark energy (68%). This composition was revealed through various astronomical observations including the study of cosmic microwave background radiation and galaxy rotation curves.

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2. Answer: Georges Lemaître

Explanation: Georges Lemaître, a Belgian priest and physicist, proposed the idea of an expanding universe between 1927-1931. He suggested that the universe began from an extremely dense and hot initial state, which he called the 'primeval atom' or 'cosmic egg.' This theory later became known as the Big Bang Theory. Lemaître also fought against religious interference in science during his career.

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3. Answer: Penzias and Wilson (or Arno Penzias and Robert Wilson)

Explanation: Arno Penzias and Robert Wilson accidentally discovered the Cosmic Microwave Background (CMB) in 1965 while working with a radio antenna. This faint background noise turned out to be thermal radiation from the Big Bang, stretched into microwave wavelengths due to cosmic expansion. This discovery provided strong, direct evidence for the Big Bang theory and dealt a huge blow to the Steady State theory. They were awarded the Nobel Prize in Physics in 1978 for this discovery.

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4. Answer: 100 kilometers (or 62 miles)

Explanation: The Kármán Line is the boundary between Earth's atmosphere and outer space, located at an altitude of 100 kilometers (62 miles) above mean sea level. It was established in the 1960s by the Fédération Aéronautique Internationale (FAI) and named after Theodore von Kármán, a Hungarian-American physicist. At this altitude, the air is too thin to support traditional aerodynamic flight. Note that the U.S. Air Force and NASA sometimes define the boundary at 80 km (50 miles).

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5. Answer: 1.4

Explanation: The Chandrasekhar Limit states that no white dwarf can be more massive than about 1.4 times the mass of the Sun. Any degenerate object more massive than this limit must inevitably collapse into a neutron star or black hole. This limit was proposed by Nobel laureate Subrahmanyan Chandrasekhar in 1931, and he was awarded the Nobel Prize in Physics in 1983 for his work on the physical processes involved in the structure and evolution of stars.

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6. Answer: Event Horizon

Explanation: The Event Horizon is the 'point of no return' around a black hole. Once something crosses this boundary, it cannot escape the black hole's gravity, not even light. The Event Horizon marks the boundary where

the escape velocity equals the speed of light. This is different from the Ergosphere, which is outside the event horizon and from which escape is still possible.

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7. Answer: Corona

Explanation: The Corona is the outermost layer of the Sun's atmosphere. It reaches extremely high temperatures of 500,000 K or more, yet it is very dim because it is about 10 million times less dense than the Sun's surface. The corona cannot be seen with the naked eye except during a total solar eclipse or with the use of a coronagraph. Paradoxically, the corona is much hotter than the photosphere (the visible surface of the Sun), which is one of the great mysteries of solar physics.

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8. Answer: M87* (or M87-star)

Explanation: The first-ever image of a black hole was released on April 10, 2019, showing the supermassive black hole M87* at the center of the galaxy Messier 87. This historic image was captured by the Event Horizon Telescope (EHT), a global network of radio telescopes. The radio waves emitted by hot gas spiraling into the black hole were collected and combined to create this groundbreaking image. M87* is located approximately 55 million light-years from Earth and has a mass equivalent to 6.5 billion times that of our Sun.

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9. Answer: Kuiper Belt

Explanation: The Kuiper Belt is a region of the Solar System that exists beyond the eight major planets. Its inner edge begins at the orbit of Neptune, at about 30 AU from the Sun, and the outer edge extends to nearly 1,000 AU. It is similar to the asteroid belt but much larger (20 times as wide and 20-200 times as massive). The Kuiper Belt contains bits of rock and ice, comets, and dwarf planets. Besides Pluto, other dwarf planets in the Kuiper Belt include Eris, Makemake, and Haumea, collectively known as Plutoids.

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10. Answer: Hingoli

Explanation: LIGO-India (Laser Interferometer Gravitational-Wave Observatory) is scheduled to be located in Hingoli district of Maharashtra, about 450 km east of Mumbai. LIGO-India will be the fifth, and possibly the final, node of the planned global gravitational wave detection network. It is scheduled to begin its scientific runs from 2030. The other operational gravitational wave observatories are located in the United States (Hanford and Livingston), Italy (Virgo), and Japan (Kagra).

Section B: True Or False - Answers

11. Answer: TRUE

Explanation: This statement is correct. Dark matter does not emit or absorb light, which is why it is called 'dark.' However, its presence can be detected through its gravitational effects on visible matter. Three main pieces of evidence support the existence of dark matter: (1) Galaxy rotation curves show that stars orbit too fast at the edges of galaxies, suggesting invisible mass, (2) Gravitational lensing effects are stronger than visible matter can account for, and (3) Fluctuations in the Cosmic Microwave Background show density patterns that can only be explained by dark matter.

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12. Answer: FALSE

Explanation: This statement is incorrect. Giant stars actually live much SHORTER lives than dwarf stars, not longer. Giant stars have GREATER rates of nuclear reactions compared to dwarf stars, which causes them to burn through their fuel much faster. While our Sun (a medium-sized star) will live for about 10 billion years, a giant star might only last a few million years. This was directly tested in UPSC 2024 Prelims where Statement-I claimed giant stars live longer (which was incorrect) and Statement-II correctly stated that giant stars have greater rates of nuclear reactions.

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13. Answer: FALSE

Explanation: This statement is incorrect. The corona of the Sun is actually HOTTER than the photosphere, not cooler. The photosphere has a temperature between 6,500K at the bottom and 4,000K at the top. In contrast, the corona reaches temperatures of 500,000 K or more. This creates a paradox: as you move away from the Sun's core, the temperature should decrease, but in the outer layers (chromosphere and corona) it actually increases. This phenomenon is still not fully understood by scientists, though NASA's IRIS mission discovered 'heat bombs' that may partially explain it.

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14. Answer: FALSE

Explanation: This statement is incorrect. While every pulsar and magnetar IS a neutron star, NOT every neutron star is a pulsar or magnetar. Pulsars are fast-rotating neutron stars that emit beams of electromagnetic radiation from their magnetic poles. Magnetars are neutron stars with extremely powerful magnetic fields that produce burst emissions. The relationship is one-directional: all pulsars/magnetars are neutron stars, but many neutron stars are neither pulsars nor magnetars. This is an important distinction for UPSC Prelims.

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15. Answer: TRUE

Explanation: This statement is correct. In 2006, the International Astronomical Union (IAU) established three criteria for an object to be classified as a planet: (1) It must orbit a fully-fledged star, (2) It must have enough gravity to pull itself into a spherical shape, and (3) It must have cleared the neighborhood around its orbit. Pluto satisfied the first two criteria but failed the third criterion. Therefore, it was

reclassified as a dwarf planet. This last criterion is the key difference between planets and dwarf planets. The IAU currently recognizes five named dwarf planets: Ceres, Pluto, Eris, Haumea, and Makemake.

Section C: Match The Following - Answers

16. Answer: D (Edwin Hubble → Confirmed universe is expanding)

Explanation: Edwin Hubble, in the 1930s, confirmed that the universe is expanding through his observations of distant galaxies. Hubble's Law states that galaxies are moving away from us at speeds proportional to their distance. This provided crucial evidence supporting the Big Bang theory and contradicting the Steady State theory.

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17. Answer: A (Subrahmanyan Chandrasekhar → Proposed Chandrasekhar Limit)

Explanation: Subrahmanyan Chandrasekhar first proposed the Chandrasekhar Limit in 1931. This limit (1.4 times the mass of the Sun) determines the maximum mass of a white dwarf star. He was awarded the Nobel Prize in Physics in 1983 for his work on the physical processes involved in the structure and evolution of stars.

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18. Answer: B (Penzias & Wilson → Accidentally discovered CMB)

Explanation: Arno Penzias and Robert Wilson accidentally discovered the Cosmic Microwave Background (CMB) in 1965. They were awarded the Nobel Prize in Physics in 1978 for this discovery, which provided strong evidence for the Big Bang theory.

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19. Answer: C (Fred Hoyle → Coined the term 'Big Bang')

Explanation: Fred Hoyle, who actually supported the Steady State Theory, coined the term 'Big Bang' in 1948 during a BBC radio broadcast. Ironically, he used the term mockingly to describe the competing theory he didn't believe in. Despite his opposition, the name stuck, and the Big Bang theory eventually prevailed over the Steady State theory.

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20. Answer: E (Theodore von Kármán → Calculated boundary between atmosphere and space)

Explanation: Theodore von Kármán, a Hungarian-American physicist and engineer, calculated that at around 100 km altitude, the air is too thin to support traditional aerodynamic flight. An aircraft would need to travel faster than orbital velocity to generate lift at this altitude. The Kármán Line at 100 km is named in his honor and is recognized by the FAI as the boundary between Earth's atmosphere and outer space.

Section D: Multiple Choice Questions - Answers

21. Answer: A (1 only)

Explanation: Statement 1 is correct: Dark matter is made up of particles that do not have a charge. Statement 2 is incorrect: Dark matter DOES possess mass and interacts through gravity - this is how we detect it. If it had no mass, we wouldn't be able to observe its gravitational effects on galaxies. Statement 3 is incorrect: Dark matter does NOT interact through electromagnetic interactions - it only interacts through gravity. This is why it's invisible to telescopes that detect electromagnetic radiation.

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22. Answer: A (1 and 3 only)

Explanation: Statement 1 is correct: A geomagnetic storm is a major disturbance of Earth's magnetosphere that occurs when there is a very efficient exchange of energy from the solar wind into the space environment surrounding Earth. Statement 2 is incorrect: The impact of solar storms is GREATER at higher latitudes (near poles) than at lower latitudes (near equator). This is because Earth's magnetic field lines converge at the poles, channeling charged particles there, which is why auroras are predominantly seen in high-latitude regions. Statement 3 is correct: Solar flares impact Earth only when they occur on the side of the Sun facing Earth, as the radiation and charged particles travel in a relatively straight line from the Sun.\

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23. Answer: C (All three pairs)

Explanation: This question was directly asked in UPSC 2023 Prelims. All three pairs are correctly matched: Pair 1 - Cepheids are indeed stars which brighten and dim periodically (they are variable stars used as 'standard candles' to measure cosmic distances). Pair 2 - Nebula are giant clouds of dust and gas in space where stars are born. Pair 3 - Pulsars are neutron stars that are formed when massive stars run out of fuel and collapse. The confusion in the original question was that the descriptions were swapped between Cepheids and Nebula, but in this version, all pairs are correctly matched.

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24. Answer: A (Both statements correct, Statement-II explains Statement-I)

Explanation: Both statements are correct and Statement-II explains Statement-I. Statement-I is correct: There is indeed a black hole behind every quasar (quasars are powered by supermassive black holes), but not every black hole is a quasar. A quasar requires specific conditions - an actively feeding supermassive black hole with surrounding material falling in and emitting intense radiation. Statement-II is correct and explains why: Quasars are only found in galaxies that have supermassive black holes which power these bright accretion discs. Only about 10% of black holes are quasars because most black holes are not actively feeding at the high rates necessary to produce quasar-level luminosity.

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25. Answer: D (1, 2 and 3)

Explanation: This question was asked in UPSC 2011 Prelims. All three statements are correct: Statement 1 is correct - Asteroids are

small rocky planetoids, while comets are formed of frozen gases (ice), dust, and rock held together. Statement 2 is correct - Asteroids are found mostly between the orbits of Jupiter and Mars (in the Asteroid Belt), while comets originate mostly from the Oort Cloud (far beyond the planets) and the Kuiper Belt (beyond Neptune). The original 2011 question incorrectly stated comets are found between Venus and Mercury, which was wrong. Statement 3 is correct - Comets develop glowing tails (both dust tail and ion tail) when they approach the Sun due to solar radiation and solar wind, while asteroids do not show such tails.

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UPSC PRELIMS 2026

DAILY TARGET CHECKLIST

Science & Tech

PHYSICS IN SPACE

"Innovation distinguishes between a leader and a follower."
— Steve Jobs

Sleepy Classes Ias

UPSC Prelims 2026 | Science & Technology

Daily Target Sheet

Lecture 1: Physics Of Space

Date: _____	Study Start: _____	Study End: _____

"The cosmos is within us. We are made of star-stuff.
We are a way for the universe to know itself." — Carl Sagan
Today, YOU learn the universe. Make it count!

Today's Study Checklist — Physics of Space

PART A: Universe & Origin Theories	
☐	Big Bang Theory — Lemaitre's hypothesis, primeval atom / cosmic egg
☐	Steady State Theory — Fred Hoyle; no beginning or end; BBC coined 'Big Bang'
☐	Evidence for Big Bang — Redshift, Hubble's Law, CMB, Nucleosynthesis
☐	Cosmic Microwave Background (CMB) — Penzias & Wilson (1965); Nobel 1978
☐	Composition of Universe — 5% observable, 27% dark matter, 68% dark energy

PART B: Redshift & Dark Matter / Dark Energy	
☐	Redshift types — Doppler, Cosmological, Gravitational
☐	Dark Energy — accelerating expansion; repulsive force; ~68% universe
☐	Dark Matter — no charge, no light, has mass; ~27% universe
☐	Evidence for Dark Matter — Galaxy Rotation Curves, Gravitational Lensing, CMB

PART C: What is Space & Karman Line	
☐	Space begins ~100 km above Earth (Karman Line) — defined by FAI in 1960s
☐	Karman Line — named after Theodore von Karman (Hungarian-American); US/NASA use 80 km
☐	Space properties — vacuum, no sound, no appreciable air

PART D: Life Cycle of Stars	
☐	Low/medium mass stars (≤1.5x Sun) — Sun-like → Red Giant → Planetary Nebula → White Dwarf → Black Dwarf
☐	High mass stars (1.5–3x Sun) — Huge Star → Red Supergiant → Supernova → Neutron Star
☐	Giant stars (>3x Sun) — Red Supergiant → Supernova → Black Hole
☐	Hydrostatic Equilibrium — Gravity (inward) vs. Radiation Pressure (outward)

☐	Chandrasekhar Limit — max mass of white dwarf = 1.4 solar masses (Nobel 1983, proposed 1931)
☐	Pulsar vs. Magnetar — both are neutron stars; pulsar emits EM beams; magnetar has extreme magnetic field

PART E: Black Holes	
☐	Types of Black Holes — Primordial (post Big Bang), Stellar (5–100x Sun), Intermediate (100–100,000x Sun), Supermassive
☐	Key Black Hole terms — Singularity, Event Horizon, Ergosphere, Accretion Disk, Schwarzschild Radius
☐	Hawking Radiation — black holes slowly emit radiation and can evaporate
☐	Eddington Limit — max accretion rate; crossing it = super-Eddington accretion
☐	First BH image — April 10, 2019; EHT; M87* in galaxy Messier 87
☐	LIGO — detects gravitational waves; US (Hanford & Livingston); Italy (Virgo); Japan (KAGRA); LIGO-India (Hingoli, Maharashtra, 2030)
☐	GW231123 — recent massive BH merger detected by LIGO-Virgo-KAGRA
☐	White Holes — theoretical time-reversal of black holes; nothing can enter
☐	Wormholes — theoretical Einstein-Rosen bridges connecting two spacetime points

PART F: Quasars	
☐	Quasars — luminous objects in faraway galaxies; emit jets at radio frequencies; powered by supermassive BHs
☐	90% of quasars do NOT emit strong radio waves
☐	Not every BH is a quasar; not every galaxy hosts a quasar

PART G: The Sun	
☐	Sun's layers (inner): Core, Radiative Zone, Convective Zone
☐	Sun's layers (outer/atmosphere): Photosphere (6500K−4000K) → Chromosphere (4000K–8000K) → Transition Region → Corona (500,000K+)
☐	Corona — 10 million times less dense than surface; visible only during solar eclipse or via coronagraph
☐	Solar Wind — plasma stream (electrons + protons) at up to 900 km/s; 1 million°C
☐	Sunspots — dark, cool magnetic areas on photosphere; up to 50,000 km diameter
☐	Solar Flares — sudden energy explosions from sunspot area; disrupt satellite/radio; cause geomagnetic storms
☐	Coronal Mass Ejection (CME) — huge bubbles of radiation from corona; accompany solar flares
☐	Aurora — natural light display at high latitudes; caused by charged particles + Earth's magnetic field

PART H: Planets, Dwarf Planets & Asteroids

☐	Planet criteria (IAU 2006) — orbits a star, spherical by gravity, cleared neighborhood
☐	Pluto demoted — failed third criterion; Dwarf planets: Ceres, Pluto, Eris, Haumea, Makemake
☐	Plutoids — all dwarf planets EXCEPT Ceres
☐	Asteroid types — C-type (75%, carbonaceous), S-type (17%, silicate), M-type (metal, platinum)
☐	DART Mission — NASA; crashed into Dimorphos; carried LICIACube CubeSat
☐	Asteroid sample return — Hayabusa (JAXA, Itokawa, 2003–2010), Hayabusa-2 (Ryugu, C-type, 2014–2020), OSIRIS-Rex (NASA, Bennu, C-type, 2016–2023)
☐	PHAs (Potentially Hazardous Asteroids) — MOID ≤0.05 AU and magnitude H ≤22.0

PART I: Comets, Asteroid Belt, Kuiper Belt & Oort Cloud	
☐	Comets — dust, ice, rock; develop coma and two tails (ion + dust) near Sun
☐	Asteroid Belt — between Mars & Jupiter; total mass < Moon; shepherded by Jupiter
☐	Kuiper Belt — beyond Neptune; starts ~30 AU; 20x wider than asteroid belt
☐	Oort Cloud — spherical shell; source of most long-period comets; extends to ~100,000 AU

PART J: Lagrange Points, Microgravity & Gravitational Waves	
☐	Lagrange Points — 5 gravitational equilibrium points (L1–L5); L4 & L5 stable; L1/L2/L3 unstable
☐	L1: Solar observatory (SOHO); L2: Ideal for astronomy (JWST); L4/L5: Trojan asteroids
☐	Gravitational Waves — 'ripples' in spacetime; predicted by Einstein; strongest from BH/neutron star mergers
☐	Microgravity — condition of near-weightlessness; astronauts float due to free fall, not absence of gravity
☐	HERD — Human Eccentric Rotator Device; University of Colorado; artificial gravity research

Practice Questions Tracker

Question Type	Total Questions	My Score
Fill in the Blanks (1 mark each)	10	_____ / 10
True / False (1 mark each)	5	_____ / 5
Match the Following (1 mark each)	5	_____ / 5
MCQs (2 marks each)	5	_____ / 10

TOTAL	25 Qs	_____ / 30

Quick Recall: Fill In the Blanks (Self-Test)

1. The universe is ____% dark energy, ____% dark matter, and ____% observable matter.
2. The Karman Line is at ____ km above Earth and was established by _____.
3. The Chandrasekhar Limit is ____ solar masses and applies to _____.
4. The first image of a black hole was released on _____ and the BH is named _____.
5. LIGO-India will be located in _____ district of _____ and starts runs from _____.
6. The Penzias-Wilson discovery of CMB earned them the Nobel Prize in Physics in _____.
7. A _____ is a fast-rotating neutron star that emits beams of electromagnetic radiation.
8. The Oort Cloud is shaped like a _____ while the Kuiper Belt is a _____.