General Topics:

Orbital mechanics:
1. Discuss the two-body problem in orbital mechanics and its practical limitations.
2. Discuss the main types of orbital maneuvers used in mission design and their trade-offs.
3. Describe the methods used in interplanetary mission analysis and trajectory design.

Materials for Space:

4. What are the most important material properties required for reliable operation in the space environment?
5. How do advanced coatings improve the performance and durability of aerospace materials?
6. What are the main challenges in designing materials for long-duration space missions?
7. How can additive manufacturing influence the future development of materials and structures for space applications?

Robotics:

8. Discuss the main types of robotic systems used in space applications
9. What are the key challenges in designing robotic systems for space missions?
10. Explain the role of control theory in space robotics
11. Compare robotic systems used for planetary exploration with robotic systems used in orbit

Astrophysics:

12. Discuss the most important astronomical objects studied in modern astrophysics
13. What are the main methods of astronomical observation used in modern astronomy
14. Explain the importance of astronomical databases and scientific literature in astrophysical research.
15. Discuss the basic methods of astronomical data analysis and interpretation.

Upstream:

1. Spacecraft architecture and systems integration (EPS, OBC, TTC, ADCS, payload, interfaces, mass, power, data budgets, redundancy, verification flow).
2. Space systems engineering lifecycle (requirements flow-down, WBS, TRL, verification and validation, risk management).
3. Embedded electronics in spacecraft (radiation tolerance, fault tolerance, PCB design, redundancy, embedded software reliability, communication buses).
4. Spacecraft avionics and onboard computer systems (OBC architecture, telemetry and telecommand, data handling, command hierarchy, failure modes).
5. Spacecraft attitude dynamics and representation (rigid body dynamics, Euler equations, Euler angles, quaternions, angular velocity).
6. Attitude Determination and Control Systems (ADCS) in satellites (detumbling, stabilization modes, control loops).
7. ADCS sensors and actuators (star trackers, sun sensors, IMUs, gyroscopes, reaction wheels, magnetorquers, thrusters).
8. Orbital mechanics and satellite motion (Kepler’s laws, orbital elements, energy in orbit, trajectory basics).
9. Satellite orbit types and applications (LEO, MEO, GEO, SSO, polar orbits, communication, Earth observation).
10. Orbital maneuvers and mission planning (Hohmann transfer, rendezvous, station keeping, deorbiting).
11. Space propulsion systems (chemical vs electric vs nuclear, thrust, specific impulse, efficiency, applications, limitations).
12. Rocket equation and Δv budget.

13. Space payload design and integration (payload requirements, platform interfaces, power, data, thermal constraints, integration challenges).
14. ECSS standards and payload verification (ECSS procedures, worst-case analysis, vibration testing, thermal vacuum testing, qualification vs acceptance).
15. Space environment and spacecraft reliability (radiation, space debris, thermal cycling, atomic oxygen, redundancy, fault tolerance).

Biomedical:

1. Discuss physiological effects of microgravity on the human body.
2. Evaluate biological and medical risks associated with space radiation.
3. Analyze biomedical challenges of long-duration human space missions.
4. Discuss applications of biotechnology in space exploration and medicine.
5. Evaluate the use and limitations of medical devices in spaceflight conditions.
6. Discuss psychological and behavioral challenges during space missions.
7. Analyze mechanisms of human adaptation to the space environment.
8. Evaluate the role of telemedicine and remote healthcare in space missions.
9. Discuss the importance of astronaut nutrition and metabolism in spaceflight.
10. Analyze the role of bioastronautics in human space exploration.
11. Evaluate artificial gravity as a countermeasure against spaceflight hazards.
12. Discuss ethical aspects of human enhancement technologies in space exploration.
13. Analyze the integration of bioengineering approaches in space medicine and life-support systems.
14. Evaluate experimental and operational challenges in biomedical space research.
15. Discuss applications of biomedical solutions developed for human space exploration.

Downstream:

1. Fundamentals of satellite remote sensing - definition, scope, applications.
2. Electromagnetic radiation in remote sensing — spectral ranges and their significance.
3. Interaction of radiation with the atmosphere — absorption, scattering, atmospheric windows.
4. Interaction of radiation with the Earth’s surface — reflection, emission, transmission.
5. Resolution of satellite data — spatial, spectral, radiometric, and temporal resolution.
6. Passive and active sensors — differences, examples, advantages, and limitations.
7. Optical imaging in satellite remote sensing — operating principles and examples of missions.
8. SAR radar remote sensing — fundamentals, signal properties, applications.
9. Atmospheric correction of satellite data — basic approaches and applications.
10. Spectral indices in environmental analysis — NDVI, NDWI, NDBI, and others.
11. Classification of satellite imagery — supervised, unsupervised, and object-based classification.
12. Change analysis based on satellite data — change detection, time series.
13. Applications of remote sensing in vegetation and agriculture monitoring.
14. Applications of remote sensing in water, drought, and flood monitoring.
15. Limitations and sources of error in satellite remote sensing — clouds, atmosphere, geometry, mixed pixels, calibration.