SESA3041 and SESA6079
Problem sheet 2: Space Debris Guidelines and Standards

1.
(a) The requred propellant mass is 311.3408 kg
(b) The requred propellant mass is 155.0243 kg

2.
UN Space Debris Mitigation Guidelines are a high-level (non-quantitative) representation of the IADC Space Debris Mitigation Guidelines. The first five guidelines are focused on the prevention of debris in the short-term, whereas the final two guidelines aim to prevent the generation of debris in the long-term (and are focused on post-mission disposal):

1. Limit debris released during normal operations
2. Minimize the potential for break-ups during operational phases
3. Limit the probability of accidental collision in orbit
4. Avoid intentional destruction and other harmful activities
5. Minimize potential for post-mission break-ups resulting from stored energy
6. Limit the long-term presence of spacecraft and launch vehicle orbital stages in the low Earth orbit (LEO) region after the end of their mission
7. Limit the long-term interference of spacecraft and launch vehicle orbital stages with the geosynchronous (GEO) region after the end of their mission

The IADC also recommends that spacecraft whose on-ground casualty risk is higher than 1 in 10000 should perform a controlled de-orbit. This guideline can be interpreted in terms of the mass of the spacecraft: large spacecraft typically should perform a controlled de-orbit. Impacts on spacecraft systems (numbers represent corresponding guidelines from above):

1. Relates to mission-related debris, e.g. lens covers, which can be tethered to the spacecraft. Avoid use of explosive bolts.
2. Relates to risks from energy sources used during the mission (e.g. batteries, propellant, gyros) and requires redundancy, good fault tolerance and recovery. Also relates to protection from debris impact (e.g. shielding)
3. Best way to avoid collisions on-orbit is through use of collision avoidance manoeuvre, which nominally requires a propulsion system.
4. Avoid anti-satellite tests!
5. Requires passivation of spacecraft at end-of-life – passivation systems need to be reliable, as they need to function at the end of the mission. Vent excess propellant (or use to perform post-mission disposal), short-circuit batteries, etc.

And 7. Requires a way to de-orbit or re-orbit the spacecraft. Typically achieved through use of a propulsion system (chemical or electric) but can also be achieved through use of deployable structure (e.g. drag sail, solar sail)

3.

(i) a. Sentinel 1A: 0.041168 km/s and 42.3325 kg
Alphasat: 0.013738 km/s and 14.96306 kg

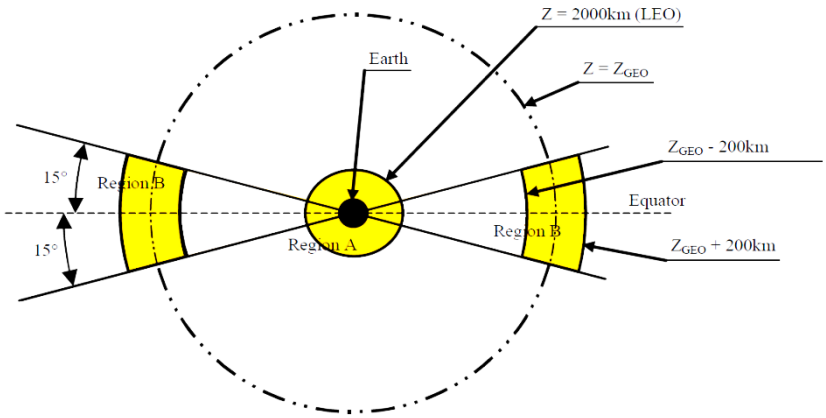
b. Sentinel 1A: 0.173538 km/s and 172.9406 kg
Alphasat: 1.485694 km/s and 1296.253 kg

(ii) remediation (removal) or just-in-time collision avoidance / net-based retrieval, robotic arm, harpoon

4.

(a) 9.07484 km/s
(b) 0.00512604

5.



Segment of spherical shell between $Z = Z_{GEO}$-200 km and $Z = Z_{GEO}$+200 km, and -15° ≤ latitude ≤ +15°, where Z_{GEO} = 35786 km

6.

Perigee: 42404.8 km / Apogee: 42659.99 km