Sample Exam Questions
Satellite Geodesy and Reference Systems (AE4-E01)

- Define a hierarchy of reference systems
- What is a reference system, what is a reference frame?
- On which physical structure (objects) may we base the definition of a Newton reference system? What are the corresponding kinematic and dynamic models?
- In what way differs a Newton system from a Galileo system from an Inertial system
- Describe the transformation ICRF ITRF. What are parameters, where do they come from, what changes quickly, what slowly.
- Was is precession, what is nutation? Describe the physical causes, the timescale and the magnitude of these two processes.
- What is a nutation series? From which processes can we derive the frequencies governing nutation?
- What is meant by GMST and GAST?
- What is UT? What kind of time does your watch show?
- What is the vernal equinox?
- How much differ solar day and sideral day, and why?
- What is an epoch?
- What is a year?
- What is a leap second?
- How is atomic time, TAI, realized?
- What is Julian daycount?
- How accurate do we need timekeeping for 1) description of a satellite orbit 2) transformation of terrestrial coordinates into a celestial frame 3) radaraltimetric range measurement at the 1cm level?
- The december 2004 earthquake/tsunami changed Earth's rotation axis measurably, as was reported in the media. What observation technique can be used to this end? Which parameters in our models are affected?
- How is the ITRS defined, and what is the role of Earth's mean rotation axis and the Greenwich meridian?
- What means ITRF2000 ?
- What exactly is geodetic latitude and longitude?
- Draw a figure with geodetic, geocentric, reduced latitude

- What is the deflection of the vertical, and how big can it be?
- Why do we use ellipsoids as a referency body, and not a sphere?
- Assume we have the zenith direction for a large number of stations globally distributed, measured by transportable zenith camera. How can we fit an ellipsoid to this? What happens when we use only stations in Europe?
- What to do if we want to compare geodetic coordinates (longitude, latitude, height) referring to two different national systems?
- How do we compute cartesian coordinates from geodetic ones, how do we solve the inverse operation?
- Why are there so many ellipsoids in use?
- What is an ellipsoid transfer?
- How do we compute visibility maps, for example for GPS satellites?
- How to tranform coordinates between a local astronomical system, a local ellipsoidal system, a global geocentric system, a (non-geocentric) conventional global system?
- Assume we want to compute the parameters of a similararity (Helmert) transformation, relating two global systems. For how many stations in both systems do we need coordinate triples?
- Define amplitude, phase and wavelenght in signal propagation
- Compute the divergence of a radio antenna, diameter 100 m, wavelength 10 cm
- What is refraction?
- What is the relation between refraction and signal delay
- What is the difference between group and phase velocity
- What is dispersion?
- Explain two different signal modulation techniques
- What causes signal delay with microwave and optical techniques? (at least 3 different phenomena)
- Why are there 2 frequencies in GPS, L1 and L2?
- What is a ionospheric-free combination in GPS?
- How do we model wet and dry tropospheric delay?
- (At least) five different natural objects in our solar system? How many of these objects exist in the solar system?
- How can we measure distance to a neighbouring solar system

- Draw a figure of the Earth, Moon, Sun configuration at March 23, September 21, in mid-summer, mid-winter, during a solar or lunar eclipse, during new moon, half-moon, full moon
- How can we measure distance to a close galaxy?
- Describe Kepler's laws.
- Which differential equation describes a bullet trajectory?
- Which differential equation describes a satellite's trajectory if the Earth is assumed to be a point mass?
- What kind of equation decribes the four possible solutions of Kepler's first law?
- Draw a Kepler ellipse and explain a, e, θ
- Mean distance to Sun is for Mars 1.5 AU, for Venus 0.7 AU. What can we say about the orbital periods of these two planets then?
- Why do planets move within a plane?
- Which Kepler elements are used to describe a satellite in inertial space?
- How does one solve the transcendental Kepler equation?
- Which steps are necessary for transforming 6 Kepler elements to state vector (position, velocity)?
- What is the vis-viva equation?
- How does perturbation due to J_2 affect a satellite orbit?
- Given the perturbation due to J_2, how do we design a sun-synchronous orbit?
- What kind of other perturbing forces does a satellite sense? How big is the effect for a GPS satellite after 24 hours?
- What might be the simplest way to determine C_{20} of the Titan moon
- How does a numerical orbit integrator work? How do we formulate the exact equations of motion for this method?
- What are the variational equations? Which parameters are typically estimated for precise orbit determinations?
- Why is precise orbit determination an iterative process?
- What is post-processing of data, and why is it relevant in all space-geodetic techniques?
- Why does a ionospheric-free combination increase the noise in the data?
- What is the approximate magnitude of vertical dry and wet tropospheric delay?
- What is a GPS navigation solution, how does the mathematical model look like?

- Why do we apply differencing in GPS? Why (under which conditions) is this a valid/successful procedure?
- What is the difference between a GPS code measurerement and a carrier phase measurement, which accuracy may be reached?
- What is plate tectonics? Can we measure this with GPS? How big is the effect, in cm/year?
- Why can we use GPS for measuring polar motion?
- What does a radar altimeter measure (raw data)? What are the three principal quantities that we can derive from the raw measurement? How big is the footprint of a radar altimeter?
- Three methods to determine the orbit of an altimetry satellite?
- Why do altimetry satellites often use repeating orbits? How do we obtain a repearing orbit?
- What is dynamic sea topography? How do we measure it with an altimeter?
- Physical processes that lead to sea level variations? Describe cause, temporal and spatial scales of these processes. Is it possible to measure these effects with an altimeter?
- Describe three other remote sensing techniques to study the ocean.
- What kind of mission are CHAMP, GRACE, GOCE? Draw a figure, point out the principles.

J. Kusche, E. Schrama, 21. Januar 2005