NORGES TEKNISK-
NATURVITENSKAPELIGE UNIVERSITET
Institutt for elektronikk og telekommunikasjon

Contact during the exam:
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EXAM IN COURSE
TTT4234 SPACE TECHNOLOGY I

Monday December 13, 2010
Time: 0900 - 1300

English version

Permitted material: Calculator, of a make according to a list approved by NTNU. Printed material: formula sheet attached to the exam.

Answers should be short and concise.

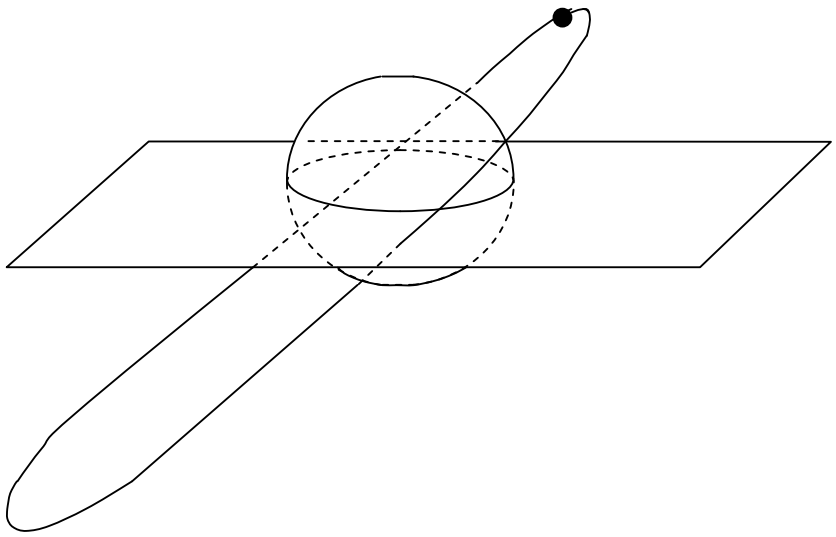
The results will be announced at the latest January 13th, 2011

Exercise 1: Orbital elemets

1a) Give the parameters describing an ellipsoid.

1b) Which orbit types (conic sections) will different values of the parameter e, eccentricity, give?

1c) Based on the figure below, give the six orbital parameters describing a satellite orbit. Start by defining the geocentric coordinate system with the z-axis along the earth's rotation axis.



1d) Which of the orbital parameters are time varying?

1e) Give the values of the six orbital parameters for a geostationary orbit.

1f) Give a description of a Molniya orbit, and the advantages of such an orbit when compared to 1) a circular polar orbit and 2) a geostationary orbit.

1g) What is a transfer orbit for geostationary orbit?

Exercise 2: Earth observation.

2a) What are the atmospheric windows, and which wavelengths are let through?

2b) The size of the smallest object a sensor can detect, is called the resolution. The expression for the resolution is given by the formula $R = 2.44\,\lambda H/D$. Explain what the different parameters are.

2c) Earth observation from satellites through the different atmospheric window runs into different problems. What are they?

2d) Explain how the resolution can be improved by means of synthetic aperture. Give an example by choosing typical values for λ, H and D.

2e) What is a chirp signal and why is it employed in earth observation?

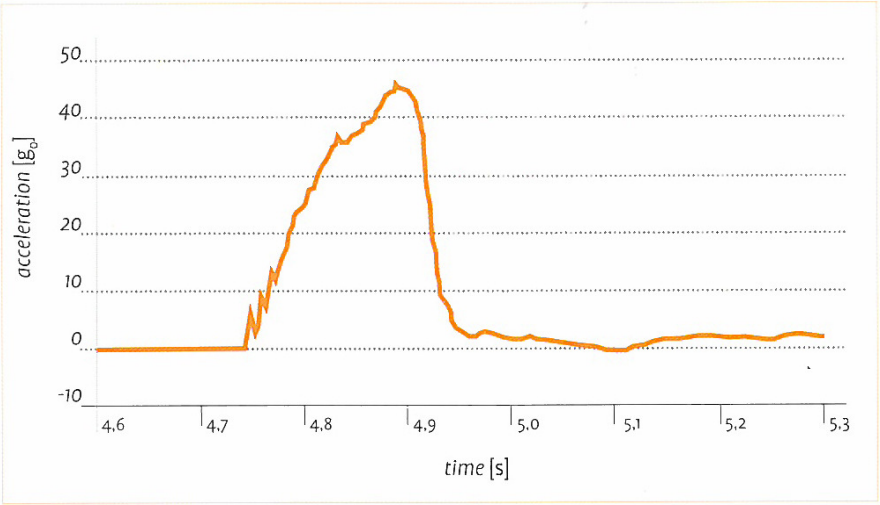
2f) Why is it so important to know as precisely as possible the position of a satellite used for earth observation, and how can it be derived? What is the order of magnitude for the obtainable resolution of today's satellite systems for earth observation?

Exercise 3: Free fall experiments in drop tower

In the Bremen drop tower – discussed in the lectures and the compendium - the drop tube itself has a height of 122 m. Assuming frictionless falling, one can calculate the time in 'free fall' (weightlessness).

The 'catapult facility' added in 2004 makes it possible to launch the experimental capsule upwards in the tube to reach the maximum height and then drop. A servohydraulic system controls the piston velocity at the launch and the specifications tell that after 'only a quarter of a second' the experimental capsule achieves its lift off speed of 175 km/h. This means a g-force at launch of the capsule that is rather high. But this roughly doubles the time in free fall.

The figure below gives the g-profile when the capsule is landing in the deceleration phase. The braking unit nowadays consists of polystyrene pellets!



3a) Calculate the time in weightlessness with and without the catapult system. If you have a solidifying experiment in the experimental capsule requiring minimum 8 seconds of free fall, what system do you have to use?

3b) Give an estimate of the g-force applied to the capsule during the first quarter of a second of a catapult launch.

3c) Disturbing gravitational forces will always influence a free fall experiment, this is called noise. What are, roughly, the noise levels in the free fall phase itself, compared e.g. with a rocket?

Exercise 4: Description. Choose one of the two topics below.

4a) Thermal control.
Why do we need thermal control in a satellite, and what are the different methods used to obtain thermal control?

4b) Space transportation
In order to reach high enough velocity a launch vehicle is often 'staged', i.e. comprises two or more stages.

Describe:

- the basic idea behind staging
- advantages and disadvantages with staging,
- why it is impossible with our present technology to reach the so-called "first and second cosmic speed, respectively" using a single stage launch vehicle.