

DELFT UNIVERSITY OF TECHNOLOGY
FACULTY OF AEROSPACE ENGINEERING

Course : Avionics (ae4-393)

Date : August 29, 2003 from 9:00 until 12:00 hr

Remarks : Write your name, initials and student number on your work
Answer all questions in English or Dutch and mark all pages with
your name.

This examination consists of 6 questions. The number of points you can gain with each question is indicated below. Your grade will be equal to one plus the total number of points divided by ten.

READ THE QUESTIONS FIRST BEFORE ANSWERING THEM (some things might be asked twice, but in a different context).

1. (15 points) **AIR DATA AND AIR DATA SYSTEMS**

- (a) Describe, using a simple sketch, the manner in which the aircraft velocity is measured. Assume that there are no effects of air compressibility. (3 points)
- (b) What is the difference between the True Air Speed (TAS) and the Calibrated Air Speed (CAS)? (3 points)
- (c) What is *altimetry*? What is altimetry used for? (3 points)
- (d) Explain, using a simple sketch, the following altimetry codes: QNE, QNH, QFE. When or where are these codes used? (3 points)
- (e) Describe the two transition planes between QNE and QNH (i.e. QNE to QNH and QNH to QNE). (3 points)

2. (15 points) **THE EARTH MAGNETIC FIELD: COMPASSES**

- (a) What is a *magnetometer*? (1 point)
- (b) Describe in detail the working principle of the magnetometer. (7 points)
- (c) What are the advantages of the magnetometer with respect to a direct-reading magnetic compass? (1 point)
- (d) Describe, at the hand of Figure 1, *how* the magnetometer is combined with a directional gyro to constitute a *gyrosyn* compass (i.e. a *Magnetic Heading Reference System* (MHRS)). In other words, how does this combination work? (4 points)
- (e) In the MHRS, how do the magnetometer and the directional gyro compensate for each other's deficiencies? (2 points)

3. (15 points) **TERRESTRIAL RADIO NAVIGATION**

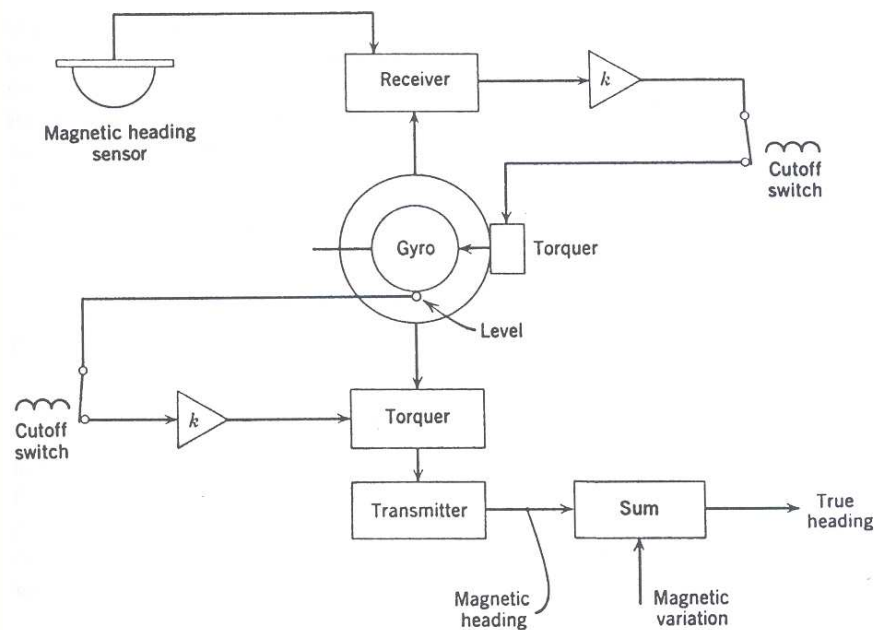


Figure 1: *The gyrosyn compass.*

- How do radio waves propagate on the Earth? Include in your answer the ground wave and sky wave propagation and the ways in which these two waves interfere. What are line-of-sight waves? (3 points)
- Describe the principle of the Automatic Direction Finder (ADF). What ground station is used in co-operation with the ADF? How is the ADF information presented to the pilot? (4 points)
- Describe the main working principle of a VHF Omni-directional Radio Range (VOR) beacon. How is the VOR information presented to the pilot? (6 points)
- In terms of aircraft navigation and guidance, what are the main differences between using an ADF and a VOR? (2 points)

4. (15 points) **SATELLITE RADIO NAVIGATION**

- Describe in detail the main working principle of the Global Positioning System (GPS). (5 points)
- How do we get an estimation of our position? (2 points)
- How do we get an estimation of our velocity? (2 points)
- Describe in detail the principle of Differential GPS (DGPS). (2 points)
- When the GPS navigation system is used as a *sole means* navigation system, e.g. in the context of the Global Navigation Satellite System (GNSS), it needs to be *augmented*.
 - Why does it need to be augmented? (1 point)
 - Describe the three main forms of augmenting GPS. (3 points)

5. (15 points) **COMMUNICATION, NAVIGATION, SURVEILLANCE**
- (a) What aircraft variables or states can be measured or obtained with the secondary surveillance radar (SSR)? (2 points)
 - (b) Describe the two modes (Mode A, Mode C) of an SSR. How many codes can be selected in Mode A? (3 points)
 - (c) Describe the interrogation/reply process of an SSR and an aircraft transponder. How does the transponder know what reply it should give? What do the interrogation signals look like? (4 points)
 - (d) Describe the phenomenon of *side-lobe interrogation*. How is this problem solved for the SSR? (4 points)
 - (e) The SSRs can be upgraded with Mode S. What is Mode S and what primary virtue does it have with respect to the 'old' system? (2 points)
6. (15 points) **AIR TRAFFIC CONTROL & MANAGEMENT**
- (a) What are the three Air Traffic Services which together form the Air Traffic Management (ATM) service? Describe the fundamental differences between them. (3 points)
 - (b) What are the CTR, the CTA, the UTA and the TMA? (3 points)
 - (c) Sketch how the controlled airspace is structured into different parts. Which part (or 'team') of the Air Traffic Control is responsible for which part of the controlled airspace? (4 points)
 - (d) What is a STAR? What is an SID? Why are they established? (3 points)
 - (e) Sketch and describe in general terms how an airplane, coming from an arbitrary airway, lands at an arbitrary runway of an airport. Which parts of the airspace structure are passed during this flight? At what moments is the responsibility of Air Traffic Control handed over between the different ATC teams? (2 points)