

DELFT UNIVERSITY OF TECHNOLOGY
FACULTY OF AEROSPACE ENGINEERING

Course : Avionics I (ae4-393)
Date : January 16, 2003 14:00 to 17:00 hour

- Note
- 1 Put your name and all your initials on each sheet.
 - 2 Answer all questions.
 - 3 Provide your answers in English or Dutch.

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) **INERTIAL SENSORS: OPTICAL GYROSCOPES**

- (a) What are the main advantages of optical gyroscopes over their mechanical counterparts? (2 points)
- (b) In strapdown inertial navigation systems only optical gyroscopes are used. Why can't mechanical gyroscopes be used in this particular system, i.e. what particular property of optical gyroscopes makes them superior in this case? (2 points)
- (c) How many optical gyroscopes are used in strapdown inertial navigation systems? What do they measure? (2 points)
- (d) Describe, at the hand of a sketch, the way in which a Ring Laser Gyro (RLG) operates. What are the basic principles? (7 points)
- (e) What is the 'lock-in' effect and what is done to overcome it? (2 points)

2. (15 points) **THE NAVIGATION EQUATIONS**

- (a) Two categories exist of navigation systems, namely *Positioning systems* and *Dead Reckoning systems*.
 - i. Give a definition of both categories, clearly indicating the main difference between them. (3 points)
 - ii. Give one typical example of a navigation system for each category. (2 points)
 - iii. Discuss the advantages and disadvantages of dead reckoning navigation systems with respect to positioning navigation systems. (2 point)
- (b) Any navigation system is subject to making errors. When considering the

Global Positioning System (GPS), the GDOP measure is an important benchmark.

- i. What does the acronym GDOP stand for? (1 point)
- ii. When using GPS, what navigation system errors contribute to the GDOP? (2 points)
- iii. Can a GPS receiver use the GDOP measure to increase its *accuracy*? Briefly explain your answer. (2 points)
- iv. Can a GPS receiver use the GDOP measure to increase its *integrity*? Briefly explain your answer. (2 points)
- v. Suppose a GPS receiver is indeed capable of using GDOP to increase its integrity. How is this capability called? (1 point)

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

In this question we consider the DME radio beacon.

- (a) What does the acronym DME stand for? (1 point)
- (b) How does the DME system work? In your answer, include:
 - i. a description of the ground equipment and the airborne equipment (if any),
 - ii. the basic working principle of the DME,
 - iii. the DME signal characteristics,
 - iv. the different modes in which the DME can work,
 - v. the characteristics of the DME in terms of accuracy, integrity, availability, capacity and autonomy.

(8 points)

- (c) Explain *in detail* how the aircraft equipment can distinguish between replies of the DME station for other aircraft and the replies of the DME station to the owncraft. (4 points)
- (d) An aircraft is flying directly above the DME beacon, at an altitude of 31000 feet. What is the DME reading (expressed in Nautical Miles)? (1 ft = 0.3048 m, 1 NM = 1852 m). (1 point)
- (e) What elements have to be added to a DME station to create a TACAN station? (1 point)

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

- (a) Describe in detail the main working principle of the Global Positioning System (GPS). (5 points)
- (b) How do we get an estimation of our position? (2 points)
- (c) How do we get an estimation of our velocity? (2 points)

- (d) Describe in detail the principle of Differential GPS (DGPS). (2 points)
- (e) 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*.
 - i. Why does it need to be augmented? (1 point)
 - ii. Describe the three main forms of augmenting GPS. (3 points)

5. (15 points) **LANDING GUIDANCE SYSTEMS**

- (a) ICAO has defined three categories of visibility for landing aircraft. Describe in detail how these categories are defined. (3 points)
- (b) In low-visibility conditions, *how* does a pilot decide to continue or abort the landing? In other words, on which knowledge or information does a pilot base his or her decision? (2 points)
- (c) Describe, using a sketch, the main components of the Microwave Landing System (MLS). (3 points)
- (d) How does an MLS receiver determine its position relative to the runway? In other words, how does this system work? Explain your answer. (6 points)
- (e) What are the main advantages of MLS over its predecessor, the Instrument Landing System (ILS)? (1 point)

6. (15 points) **AIR TRAFFIC CONTROL & MANAGEMENT**

Since 1995, all aircraft with more than 30 passenger seats operating in the United States airspace are required to be equipped with an ACAS.

- (a) What does the acronym ACAS stand for? (1 point)
- (b) How does an ACAS work? What is the main reason why the ACAS needs to be installed in aircraft? (8 points)
- (c) What information does an ACAS provide to the pilot? (3 points)
- (d) What is the main problem with current ACAS systems? (2 points)
- (e) What is the name of the most-widely used ACAS system? (1 point)