



## Course guides

# 230680 - GPS - GPS and Galileo Data Processing: From Fundamentals to High Accuracy Navigation

Last modified: 06/05/2019

**Unit in charge:** Barcelona School of Telecommunications Engineering  
**Teaching unit:** 749 - MAT - Department of Mathematics.

**Degree:** MASTER'S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Optional subject).  
MASTER'S DEGREE IN ELECTRONIC ENGINEERING (Syllabus 2013). (Optional subject).  
MASTER'S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Optional subject).

**Academic year:** 2019    **ECTS Credits:** 5.0    **Languages:** English

### LECTURER

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**Coordinating lecturer:** Hernandez Pajares, Manuel

**Others:**

### PRIOR SKILLS

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Basic knowledge on Physics and Mathematics.

### REQUIREMENTS

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Degree related with Global Navigation Satellite Systems (GNSS).

### TEACHING METHODOLOGY

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Learning based on recent international Global Navigation Satellite Systems (GNSS) research projects.

### LEARNING OBJECTIVES OF THE SUBJECT

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To introduce the fundamental concepts of satellite positioning under the guideline of recent international research projects. The material has been refined in recent international post-graduate schools in Germany, Argentina, Brazil and Pakistan. To provide experience in GPS data processing for precision applications. To study some applications of GPS to geodesy and other Earth sciences. Basic contents of the course are the following. GPS observables. Reference systems and time. Orbit determination. Absolute positioning. Differential positioning. Ionosphere and troposphere modelling.

### STUDY LOAD

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Type	Hours	Percentage
Hours large group	26,0	20.80
Hours small group	13,0	10.40
Self study	86,0	68.80

**Total learning time:** 125 h



## CONTENTS

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### 1. Introduction to space geodesy

#### 1.1. Space geodesy and GPS.

#### 1.2. Basic concepts and historical development

### 2. Global positioning system

#### 2.1. Introduction.

#### 2.2. Space segment.

#### 2.3. Control segment.

#### 2.4. Principles of signal structure and observation.

#### 2.5. GPS ephemeris and message structure

### 3. Orbital movement of a satellite

#### 3.1. Trajectory of a satellite in the Earth's gravitational field.

#### 3.2. Elliptical movement of a satellite

#### 3.3. Orbital elements.

#### 3.4. Perturbed movement of a satellite.



**3.5. Orbit determination**

**4. Fundamentals of physics**

**4.1. Topics of reference.**

**4.2. Weather.**

**4.3. Electromagnetic signal propagation**

**5. GPS observables and data processing**

**5.1. Observables**

**5.2. Parameter estimation.**

**5.3. Data reprocessing.**

**5.4. Least squares.**

**5.5. The Kalman filter.**

**5.6. Fast GPS methods.**

**5.7. GPS navigation**

**6. Errors and corections**

**6.1. Basic considerations: precision versus exactitude.**



6.2. Apparent geometry of constellations.

6.3. Orbits and clocks.

6.4. Signal propagation.

6.5. Reception systems.

6.6. System integrity

7. Applications

7.1. Ionosphere modelling.

7.2. Troposphere modelling

## ACTIVITIES

**Answers in the Lab sessions.**

**Specific objectives:**

Learning from Actual GNSS Data (LeGAD).

**Material:**

Book with scripts for laboratory sessions, software and questionnaires in the fundamental GNSS aspects. Slides with new teaching software for additional fundamental GNSS aspects.

**Full-or-part-time:** 40h

Theory classes: 27h

Laboratory classes: 13h



## Academic-ITT

### Description:

Design of a proposal following the model of the European Space Agency (ESA).

### Specific objectives:

(1) To become familiar with the procedure of application to European research projects. (2) To be aware about open scientific and technical problems associated with GNSS.

### Material:

List of scientific and technical GNSS open problems.

### Full-or-part-time: 5h

Guided activities: 5h

## GRADING SYSTEM

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- Laboratory assignments: 15%
- Academic Intended To Tender (ITT, ESA-like proposal): 30%
- Synthesis test: 55%

## BIBLIOGRAPHY

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### Basic:

- Hernández-Pajares, M.; Juan, J.M.; Sanz, J. GPS data processing: code and phase algorithms, techniques and recipes [on line]. Barcelona: Centre de Publicacions del Campus Nord, 2008 [Consultation: 01/10/2015]. Available on: [http://gage.upc.edu/sites/default/files/TEACHING\\_MATERIAL/GPS\\_BOOK/ENGLISH/PDGPS/BOOK\\_PDGPS\\_gAGE\\_NAV\\_08.pdf](http://gage.upc.edu/sites/default/files/TEACHING_MATERIAL/GPS_BOOK/ENGLISH/PDGPS/BOOK_PDGPS_gAGE_NAV_08.pdf). ISBN 8493223050.
- Hernández, M.; Juan, J.M.; Sanz, J. Tratamiento de datos GPS: prácticas de laboratorio [on line]. Barcelona: Edicions UPC, 1997 [Consultation: 04/03/2015]. Available on: <http://hdl.handle.net/2099.3/36420>. ISBN 8483012146.

### Complementary:

- Wells, D. Guide to GPS positioning. Fredericton: Canadian GPS Associates, 1986. ISBN 0920114733.
- Seeber, G. Satellite geodesy. 2nd compl. rev. and ext. ed. Berlin [etc.]: Walter de Gruyter, 2003. ISBN 3110175495.
- Hofmann-Wellenhof, B.; Lichtenegger, H.; Collins, J. Global positioning system: theory and practice. 5th rev. ed. Wien [etc.]: Springer-Verlag, 2001. ISBN 3211835342.

## RESOURCES

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### Other resources: