Learning objectives of the subject

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.
<table>
<thead>
<tr>
<th>Study load</th>
<th>Hours large group:</th>
<th>Hours medium group:</th>
<th>Hours small group:</th>
<th>Guided activities:</th>
<th>Self study:</th>
<th>Total learning time:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>26h</td>
<td>0h</td>
<td>13h</td>
<td>0h</td>
<td>86h</td>
<td>125h</td>
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<tr>
<td></td>
<td>20.80%</td>
<td>0.00%</td>
<td>10.40%</td>
<td>0.00%</td>
<td>68.80%</td>
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### Content

1. **Introduction to space geodesy**

   Degree competences to which the content contributes:

1.1. **Space geodesy and GPS.**

   Degree competences to which the content contributes:

1.2. **Basic concepts and historical development**

   Degree competences to which the content contributes:

2. **Global positioning system**

   Degree competences to which the content contributes:

2.1. **Introduction.**

   Degree competences to which the content contributes:

2.2. **Space segment.**

   Degree competences to which the content contributes:

2.3. **Control segment.**

   Degree competences to which the content contributes:

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

   Degree competences to which the content contributes:

2.5. **GPS ephemeris and message structure**

   Degree competences to which the content contributes:
3. Orbital movement of a satellite

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<tr>
<th>Degree competences to which the content contributes:</th>
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3.1. Trajectory of a satellite in the Earth's gravitational field.

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<th>Degree competences to which the content contributes:</th>
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3.2. Elliptical movement of a satellite

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3.3. Orbital elements.

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3.4. Perturbed movement of a satellite.

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3.5. Orbit determination

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4. Fundamentals of physics

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<th>Degree competences to which the content contributes:</th>
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4.1. Topics of reference.

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<th>Degree competences to which the content contributes:</th>
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4.2. Weather.

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<th>Degree competences to which the content contributes:</th>
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</table>
### 4.3. Electromagnetic signal propagation

Degree competences to which the content contributes:

### 5. GPS observables and data processing

Degree competences to which the content contributes:

#### 5.1. Observables

Degree competences to which the content contributes:

#### 5.2. Parameter estimation.

Degree competences to which the content contributes:

#### 5.3. Data reprocessing.

Degree competences to which the content contributes:

#### 5.4. Least squares.

Degree competences to which the content contributes:

#### 5.5. The Kalman filter.

Degree competences to which the content contributes:

#### 5.6. Fast GPS methods.

Degree competences to which the content contributes:

#### 5.7. GPS navigation

Degree competences to which the content contributes:
### 6. Errors and corrections

Degree competences to which the content contributes:


Degree competences to which the content contributes:

#### 6.2. Apparent geometry of constellations.

Degree competences to which the content contributes:

#### 6.3. Orbits and clocks.

Degree competences to which the content contributes:

#### 6.4. Signal propagation.

Degree competences to which the content contributes:

#### 6.5. Reception systems.

Degree competences to which the content contributes:

#### 6.6. System integrity

Degree competences to which the content contributes:

### 7. Applications

Degree competences to which the content contributes:

#### 7.1. Ionosphere modelling.

Degree competences to which the content contributes:
7.2. Troposphere modelling

Degree competences to which the content contributes:

Planning of activities

**Answers in the Lab sessions.**

<table>
<thead>
<tr>
<th>Hours</th>
<th>40h</th>
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<tbody>
<tr>
<td>Laboratory classes</td>
<td>13h</td>
</tr>
<tr>
<td>Theory classes</td>
<td>27h</td>
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**Support materials:**

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

**Specific objectives:**

- Learning from Actual GNSS Data (LeGAD).

**Academic-ITT**

<table>
<thead>
<tr>
<th>Hours</th>
<th>5h</th>
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<tbody>
<tr>
<td>Guided activities</td>
<td>5h</td>
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</table>

**Description:**

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

**Support materials:**

- List of scientific and technical GNSS open problems.

**Specific objectives:**

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

Qualification system

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

Basic:


Complementary:


Others resources: