# 230647 - ACWS - Advanced Communications for Wireless Systems

**Coordinating unit:** 230 - ETSETB - Barcelona School of Telecommunications Engineering  
**Teaching unit:** 739 - TSC - Department of Signal Theory and Communications  
**Academic year:** 2020  
**Degree:** MASTER’S DEGREE IN TELECOMMUNICATIONS ENGINEERING (Syllabus 2013). (Teaching unit Compulsory)  
MASTER’S DEGREE IN ADVANCED TELECOMMUNICATION TECHNOLOGIES (Syllabus 2019). (Teaching unit Optional)  
**ECTS credits:** 5  
**Teaching languages:** English

## Teaching staff

**Coordinator:** Vazquez Grau, Gregori  
**Others:** Riba Sagarra, Jaume  
Vazquez Grau, Gregori

## Requirements

Students are required to certify that they have previously followed courses on digital communications with similar technical contents than the master adaptation course ‘Digital Communications’ (http://infoteleco.upc.edu/documents/guia_docent/assignatures/all/ang/230600.pdf) or as for the undergraduate subjects ‘Introduction to Communications’ (https://www.upc.edu/content/grau/guiadocent/pdf/ing/230018) and ‘Advanced Digital Communications’ (http://infoteleco.upc.edu/documents/guia_docent/assignatures/all/ang/230051.pdf).

## Degree competences to which the subject contributes

### Specific:
1. Ability to apply information theory methods, adaptive modulation and channel coding, as well as advanced techniques of digital signal processing to communication and audiovisual systems.

### Transversal:
2. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.
3. FOREIGN LANGUAGE: Achieving a level of spoken and written proficiency in a foreign language, preferably English, that meets the needs of the profession and the labour market.

## Teaching methodology

- Lectures  
- Application classes  
- Individual work (distance)  
- Exercises  
- Mid-Term Exam  
- Final Exam

## Learning objectives of the subject

Learning objectives of the subject:

The aim of this course is to present advanced concepts on digital communication systems. The course is divided in two main sections, that is, the point-to-point communication theory and the extension to multiuser scenarios. From a definition and a measure of information, the course develops the theory associated to the important concept of channel
capacity. Impact of frequency-flat fading channels and frequency selective channels are analyzed. Performance degradations are mitigated through the use of transmission and reception diversity techniques. The extension of all the former concepts to a multiuser framework is done, providing a more rich and interesting context for current and future communication networks.

Learning results of the subject:
- To achieve a solid background on fundamental concepts of digital communications and information theory.
- Ability to understand the physical layers of modern advanced communication systems in point-to-point and multiuser networks.
- Ability to analyze, characterize and develop the physical layers of modern advanced communication systems in point-to-point and multiuser networks.

<table>
<thead>
<tr>
<th>Study load</th>
<th>Total learning time: 125h</th>
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<tbody>
<tr>
<td>Hours large group:</td>
<td>39h</td>
</tr>
<tr>
<td>Hours medium group:</td>
<td>0h</td>
</tr>
<tr>
<td>Hours small group:</td>
<td>0h</td>
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<tr>
<td>Guided activities:</td>
<td>0h</td>
</tr>
<tr>
<td>Self study:</td>
<td>86h</td>
</tr>
</tbody>
</table>

Total learning time: 125h
- Hours large group: 39h (31.20%)
- Hours medium group: 0h (0.00%)
- Hours small group: 0h (0.00%)
- Guided activities: 0h (0.00%)
- Self study: 86h (68.80%)
### Content

| 1. Introduction: A Definition of Information. | **Learning time:** 42h  
Theory classes: 12h  
Self study : 30h |
|---------------------------------------------|-------------------|
| **Description:**  
- Discrete memoryless sources and source entropy.  
- Discrete memoryless channels, mutual Information and channel capacity.  
- Continuous time-amplitude channels. The Gaussian channel.  
- Water-pouring and bit-loading approaches. |

| 2. Additive White Gaussian Channel (AWGN). | **Learning time:** 7h  
Theory classes: 3h  
Self study : 4h |
|-------------------------------------------|-------------------|
| **Description:**  
Signalling and optimal detection.  
Performance bounds and case studies. |

| 3. Frequency-Flat-Fading Channels: the wireless channel. | **Learning time:** 16h  
Theory classes: 6h  
Self study : 10h |
|----------------------------------------------------------|-------------------|
| **Description:**  
- Statistical Models.  
- Performance degradation and diversity schemes.  
- Use of the channel-state information.  
- Slow-fading: outage probability and outage capacity.  
- Fast-fading: ergodic capacity. |

| 4. Frequency-Selective Channels: the multipath channel. | **Learning time:** 20h  
Theory classes: 6h  
Self study : 14h |
|--------------------------------------------------------|-------------------|
| **Description:**  
- Bello’s channel model and channel transfer matrix.  
- SVD and optimal communication schemes.  
- OFDMA: Orthogonal Frequency Division Multiple Access.  
- Hybrid SVD on OFDMA solutions. |
5. Multiple-Access Channel.

Learning time: 40h
- Theory classes: 12h
- Self study: 28h

Description:
- Ahiswede-Liao multiple-access capacity region.
- Multiple-access schemes and capacity regions: TDMA, FDMA-OFDMA, CDMA.
- Multiuser detection.
- Uplink fading channel.
- Downlink fading channel.
- Multiuser diversity.

Planning of activities

EXERCISES

EXTENDED ANSWER TEST (MID TERM EXAMINATION)

EXTENDED ANSWER TEST (FINAL EXAMINATION)

Qualification system

Final examination: 40 %
Mid-Term examination: 60 %
Final Grade: The final grade is the maximum between the Final Exam mark and the weighted former mark.
Bibliography

Basic:


Complementary:


