

# Mobile Communications Systems

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# General Objectives

- The course provides knowledge in the area of terrestrial mobile communication systems, namely mobile cellular ones.
- Besides the general basic aspects of these systems, focus is given on radio network aspects of GSM (2G), *UMTS* (3G), LTE (4G) and NR (5G).



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# Operational Objectives

- The student having success in the course is supposed to have a good general knowledge of mobile communication systems and should be capable of designing a radio network, in terms of coverage, capacity, traffic, and interference.

# Programme

- The topics dealt with are:
  - Statistical Distributions in Telecommunications
  - Propagation Models
  - Antennas for Bases and Mobiles
  - Radio Channel Characterisation
  - Cellular Networks
  - Radio Interface
  - Private Mobile Radio Systems
  - Mobility and Traffic
  - Cellular Design.

# Study Elements

- Study elements are:
  - Copy of lecture Power Point files, to be used as a study guide, available at FENIX;
  - Chapters of books, to be used for effective study, available at AEIST's *Secção de Folhas*;
  - Problems collection, available at FENIX;
  - Exams of previous years, available at FENIX.

# Assessment

- Evaluation is done via 3 components:
  - 50% - Exam
  - 30% - Problems in Classes
  - 20% - Research Paper
- All components are compulsory.
- Grades above 17 require an oral defence.

# Exam (1)

- The Exam:
  - can be done with supporting bibliography, which can only be books and course notes;
  - has a minimum grade of 8;
  - has no oral component.

## Exam (2)

- Hints for a successful exam:
  - Read all questions carefully, before starting replying to them.
  - Reply to the questions directly.
  - Since you carry bibliography to the exam, don't waste time copying expressions, but rather mention the page from where it was taken.
  - Always explain your assumptions.
  - Be critical with the numbers you obtain and analyse them. If it is the case, put a comment on the value, and get back to it if you have time.





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# Problems in Classes (1)

- Problems in Classes:
  - are intended to be solved and discussed by students;
  - are intended to involve students in the application of concepts;
  - are performed by teams of 3 students (the same as for the Research Paper).

## Problems in Classes (2)

- For each class, there will be for each problem:
  - a “Solver”: solving the problem at home and presenting it at the class;
  - an “Examiner”: identifying problems in exams that are similar to the problem and discussing its solution.
  - a “Challenger”: solving the same problem at home and challenging the “Solver” and the “Examiner”.
- There will be a rotation of roles between classes among teams.



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## Problems in Classes (3)

- The working material is:
  - pencil & paper (or electronic equivalent),
  - lectures (\*.ppt files),
  - list of problems,
  - pocket calculator, or equivalent,
  - will to work.

# Research Paper

- The Research Paper :
  - is performed by teams of 3 students;
  - is devoted to applications in mobile and wireless communication systems;
  - does not require a written report;
  - is to be presented before the class by the end of the quarter;
  - has no minimum grade;
  - is being presented in the next class (Practice), where teams will be formed.

# Final Grade (1)

- The final grade,  $G_F$ , will be evaluated as follows:

$$G_F = 0.5 G_{Ex} + 0.3 G_{PC} + 0.2 G_{RP}$$

where

- $G_{Ex}$  - grade of Exam
- $G_{PC}$  - grade of Problems in Classes
- $G_{RP}$  - grade of Research Paper

## Final Grade (2)

- The Exam grade,  $G_{Ex}$ :
  - will be evaluated as follows

$$G_{Ex} = \max \{ G_{Ex-R}, G_{Ex-S} \}$$

where

- $G_{Ex-R}$ : grade in Regular date
- $G_{Ex-S}$ : grade in Supplementary date
- is an individual evaluation component.

## Final Grade (3)

- The Problems in Classes grade,  $G_{PC}$ :
  - will be evaluated as follows:

$$G_{PC} = 0.5 G_{PC-S} + 0.3 G_{PC-C} + 0.2 G_{PC-E}$$

where

- $G_{Ex}$  - grade in Solver
- $G_{PC}$  - grade in Challenger
- $G_{RP}$  - grade in Examiner
- is a team evaluation component.

## Final Grade (3)

- The Research Paper grade,  $G_{RP}$ :
  - will be evaluated as follows:

$$G_{RP} = 0.7 G_{RP-C} + 0.3 G_{RP-P}$$

where

- $G_{RP-C}$  - grade in content
- $G_{RP-P}$  - grade in presentation
- is a team evaluation component.





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## What is Expected from You?

- You're supposed to dedicate 9h per week to the course, besides the classes.
- You'll be trained to be an engineer,
  - not a medicine doctor in an emergency room – you don't need to know things by heart!
  - not an electrician – you'll have to develop the capacity to analyse things, and be critical!
  - requiring a perspective similar to an athlete – continuous training!
  - in a way similar to riding a bike – you need to try, and make errors, in the learning process.

## Prize and Contest

- There will be a prize (books) for the best student in the course, to be delivered at the next year's edition of the *Seminar on Mobile Communications*.
- In parallel, there is a contest within the students, for the best idea of an application:
  - It can be based on the research paper.
  - It has to be an original idea.
  - You need to deliver a 2 pages description, by Mar. 1<sup>st</sup>.
  - The prize (books) will be delivered at this year's edition of the *Seminar on Mobile Coms*.

## Relevant Dates

- 2024/03/25 – Delivery of research papers
  - 2024/04/02 – Presentation of research papers
  - 2024/04/09 – Exam R
  - 2024/07/05 – Exam S
  - 2024/07/18 – Exam E
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- During classes, student support is provided at the end of the classes (but a meeting can be scheduled upon request). A schedule will be announced for the examinations period.



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# General Schedule

Week	Begins	Ends	Monday	Tuesday	Wednesday	Thursday	Friday
1	Feb-12	Feb-16				L01, P01	
2	Feb-19	Feb-23	L02, P02			L03, P03	
3	Feb-26	Mar-01	L04, P04			L05, P05	
4	Mar-04	Mar-08	L06, P06			L07, P07	
5	Mar-11	Mar-15	L08, P08			L09, P09	Visit Altice
6	Mar-18	Mar-22	L10, P10			L11, P11	Seminar
7	Mar-25	Mar-29	L12, P12 Paper Delivery				
	Apr-01	Apr-05		Paper Presentation		Sup	Sup
	Apr-08	Apr-12	Sup	Ex R			
	Jun-24	Jun-28					
	Jul-01	Jul-05		Sup	Sup	Sup	Ex S
	Jul-08	Jul-12					
	Jul-15	Jul-19	Sup	Sup	Sup	Ex E	
	Jul-22	Jul-26					

## Study Visits and Seminar

- A study visit to a company with activity in the area of the course will be organised, aiming at providing the students contact with the “real world”, by the end of the quarter.
- At the end of the quarter, the *29<sup>th</sup> Seminar on Mobile Communications* will be organised, where people from industry will give a talk to the students.

# Classes

- The course is structured into the following classes:
  - Lectures, 2h00
    - Monday: 13h00/15h00 (Ea3)
    - and
    - Thursday: 08h00/10h00 (Q4.2)
  - Problems, 1h30
    - Monday: 15h00/16h30 (E1)
    - and
    - Thursday: 10h00/11h30 (Q4.2)



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# Replacement Classes and Study Visits

- If there is the need to hold some replacement classes, they can be on:
  - ?? : ??h00/??h00
- The study visit will be held on:
  - ??: morning/afternoon

# Should you go the Classes? (1)

- One ChatGPT answer (2023-Feb-08):




What is the relationship between frequency and wavelength



The relationship between frequency and wavelength is given by the equation:

```
makefile
```

 Copy code

$$v = c\lambda$$

where:

- $v$  is the frequency of the wave (measured in Hertz)
- $c$  is the speed of light (approximately 299,792,458 meters per second in a vacuum)
- $\lambda$  is the wavelength of the wave (measured in meters)



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## Should you go the Classes? (2)

- Another ChatGPT answer (2023-Feb-08):



what is the relationship between halfpower and null beamwidths



Half-power beamwidth (HPBW) and null beamwidth are two parameters that describe the radiation pattern of an antenna. They are related to the directivity of the antenna, which is a measure of its ability to concentrate its radio frequency (RF) energy in a specific direction.

So, the relationship between HPBW and null beamwidth is that, in general, a narrower HPBW will correspond to a wider null beamwidth, and vice versa. This is because as the directivity of an antenna increases, and its HPBW becomes narrower, its radiation pattern will also have deeper and wider nulls in other directions. The exact relationship between HPBW and null beamwidth will depend on the specific design of the antenna and its operating frequency.

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- One more ChatGPT answer (2023-Feb-08):



How to calculate the blocking probability for data in 5G?



Blocking probability is a measure of the likelihood that a new data request in a network will be blocked due to a lack of available resources. In 5G, blocking probability can be calculated using the following formula:

Blocking probability = (Blocked requests) / (Total requests)

To calculate this, you will need to know the number of requests that have been blocked and the total number of requests made. These values can be obtained through network measurements or simulation.

The blocked requests refer to the data requests that cannot be satisfied due to a lack of available resources, such as network bandwidth or server capacity. The total requests refer to the total number of data requests made during a specific time period.

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# Teaching staff

- The teaching staff is composed of:
  - Lectures classes – Prof. Luis M. Correia
  - Problems classes – Prof. Luis M. Correia

# Information

- All information concerning the course will be given and constantly updated via FENIX, <https://fenix.tecnico.ulisboa.pt/disciplinas/SCM3/2023-2024/2-semester>
- Students should update their data (namely the email) in the data base.