

Lecture 1

2025/2026

# Microwave Devices and Circuits for Radiocommunications

# 2025/2026

- 2C/1L, **MDCR**
- Attendance at minimum 7 sessions (course or laboratory)
- Lectures- **associate professor Radu Damian**
  - Tuesday 16-18, ~~Online~~, P8
  - E – 50% final grade
  - problems + (2p atten. lect.) + (3 tests) + (bonus activity)
    - first test L1: 24.02.2026 (t2 and t3 not announced, lecture)
    - 3att.=+0.5p
  - all materials/equipments authorized

# 2025/2026

- Laboratory – **associate professor Radu Damian**
  - Monday 14-16, II.13 / (even weeks)
  - L – 25% final grade
    - ADS, 4 sessions
    - Attendance + **personal results**
  - P – 25% final grade
    - ADS, 3 sessions (-1? 24.02.2026)
    - personal homework

# Materials

■ <https://rf-opto.etti.tuiasi.ro>

The screenshot shows a web browser window with the URL [https://rf-opto.etti.tuiasi.ro/microwave\\_cd.php?chg\\_lang=0](https://rf-opto.etti.tuiasi.ro/microwave_cd.php?chg_lang=0). The page features a dark blue navigation bar with links for Main, Courses, Master, Staff, Research, Students, and Admin. Below this is a secondary navigation bar with links for Microwave CD, Optical Communications, Optoelectronics, Internet, Antennas, Practica, Networks, and Educational software. The main content area is titled "Microwave Devices and Circuits for Radiocommunications (English)" and includes the following information:

- Course: MDCR (2017-2018)**
- Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian
- Code:** EDOS412T
- Discipline Type:** DOS; Alternative, Specialty
- Credits:** 4
- Enrollment Year:** 4, Sem. 7

**Activities**

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:  
**Laboratory:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

**Evaluation**

Type: **Examen**

**A:** 50%, (Test/Colloquium)  
**B:** 25%, (Seminary/Laboratory/Project Activity)  
**D:** 25%, (Homework/Specialty papers)

**Grades**

[Aggregate Results](#)

**Attendance**

[Course](#)  
[Laboratory](#)

**Lists**

[Bonus-uri acumulate \(final\)](#)  
[Studenti care nu pot intra in examen](#)

**Materials**

**Course Slides**

[MDCR Lecture 1](#) (pdf, 5.43 MB, en, [📄](#))  
[MDCR Lecture 2](#) (pdf, 3.67 MB, en, [📄](#))  
[MDCR Lecture 3](#) (pdf, 4.76 MB, en, [📄](#))  
[MDCR Lecture 4](#) (pdf, 5.58 MB, en, [📄](#))

On the right side of the screenshot, there is a dark blue banner for "RF-OPTO" with a globe icon and the text "ETTI". Below the banner, there are language selection options: "English" (with a UK flag icon) and "Romana" (with a Romanian flag icon). The "English" option is circled in red. Below the banner is another navigation bar with links for Main, Courses, Master, Staff, and Research. Below that is a third navigation bar with links for Grades, Student List, Exams, and Photos. The main content area on the right is titled "Online Exams" and includes the text "In order to participate at online exams you must get ready following" and a numbered list starting with "1. On the main menu, choose the language you are comfortable with".

# Materials

- RF-OPTO
  - <https://rf-opto.etti.tuiasi.ro>
- **David Pozar, “Microwave Engineering”,**  
Wiley; 4th edition , 2011
  - 1 exam problem ← Pozar
- Photos
  - sent by email/**online exam**
  - used at lectures/laboratory

# Photos



## Date:

<b>Grupa</b>	5304 (2015/2016)
<b>Specializarea</b>	Tehnologii si sisteme de telecomunicatii
<b>Marca</b>	5184

[Trimite email acestui student](#) | [Adauga acest student la lista \(0\)](#)

## Detalii curente

<b>Finantare</b>	Buget
<b>Bursa</b>	Fara Bursa

## Observatii



## Date:

<b>Grupa</b>	5304 (2015/2016)
<b>Specializarea</b>	Tehnologii si sisteme de telecomunicatii
<b>Marca</b>	5184

[Acceseaza ca acest student](#)

## Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Pondere	Obs.
<b>TW</b>			<b>Tehnologii Web</b>			
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Calendar Tehnologii Web 2013/2014	10	7.55	
	B	17/01/2014	Laborator Tehnologii Web 2013/2014	9	-	
	D	17/01/2014	Tema Tehnologii Web 2013/2014	9	-	



## Date:

<b>Grupa</b>	5304 (2015/2016)
<b>Specializarea</b>	Tehnologii si sisteme de telecomunicatii
<b>Marca</b>	5244

[Trimite email acestui student](#) | [Adauga acest student la lista \(0\)](#)

## Detalii curente

<b>Finantare</b>	Buget
<b>Bursa</b>	Bursa de Studii

## Observatii

# Photos

Nr. Student	Student	Prezent	Nr. Student	Student	Prezent	Nr. Student	Student	Prezent
1	ANGHELUS IONUT-MARIUS	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	2	ANTIGHIN FLORIN-RAZVAN	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	3	ANTONICA BIANCA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:
4	APOSTOL PAVEL-MANUEL	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	5	BALASCA VALIAN-PETRU	<input checked="" type="checkbox"/> Puncte: 0 Nota: 0 Obs:	6	BOSTAN ANDREI-PETRICIA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:
7	BOTEZAT EMANUEL	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	8	BUTUNOI GEORGE-MADALIN	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	9	CHILEA SALUCA-MARIA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:
10	CHERITOIU ECATERINA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:	11	COJOC MARIUS	<input checked="" type="checkbox"/> Puncte: 0 Nota: 0 Obs:	12	COJOCARIU AURA-FLORINA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:

Nr. Student	Student	Prezent
2	ANTIGHIN FLORIN-RAZVAN	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:

# Adrese email

- Sefii de grupa
  - lista cu adrese de email **utilizate** de toti studentii
    - poate fi @student.etti.tuiasi.ro (@gmail ~~@yahoo~~ etc.)
  - **rdamian@etti.tuiasi.ro**

# Online – Registration no.

- access to **online exams** requires the **password** received by email

The password is communicated during the lectures. It is necessary to

**Password**

**Registration no.**

**Name of the student**

**Proposed email 1**

**Proposed email 2**

**Write the code below**

 **RF-OPTO** 

English | Romana |

[Main](#) [Courses](#) [Master](#) [Staff](#) [Research](#) [Students](#)

[Login](#) [Tutoring](#)

**Login**

Use the Registration no. and your email or the password received by email

**Registration no.**

**Email/Password**

**Write the code below**

# Online

- access email/password

Main Courses Master Staff Research

Grades Student List Exams Photos

## POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica si telec
Marca	7000000

You access the site as **this student!**

Main Courses Master Staff Research

Grades Student List Exams Photos

## POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica si telec
Marca	7000000

You access the site as **this student (including exams)!**

# Password

## ■ received by email

Important message from RF-OPTO Inbox x

 **Radu-Florin Damian**  
to me, POPESCU ▾

🗣 Romanian ▾ > English ▾ [Translate message](#)



Laboratorul de Microunde si Optoelectronica  
Facultatea de Electronica, Telecomunicatii si Tehnologia Informatiei  
Universitatea Tehnica "Gh. Asachi" Iasi

**In atentia: POPESCU GOPO ION**

Parola pentru a accesa examenele pe server-ul **rf-opto** este  
Parola: [REDACTED]

Identificati-va pe [server](#), cu parola, cat mai rapid, pentru confirmare.

**Memorati** acest mesaj intr-un loc sigur, pentru utilizare ulterioara

**Attention: POPESCU GOPO ION**

The password to access the exams on the **rf-opto** server is  
Password: [REDACTED]

Login to the [server](#), with this password, as soon as possible, for confirmation.

**Save** this message in a safe place for later use

[Reply](#) [Reply all](#) [Forward](#)

Subject	Correspondents
Important message from RF-OPTO	POPESCU GOPO ION
Validation of MD/CR exam from 02/05/2020	[REDACTED]
[REDACTED]	[REDACTED]

From Me <rdamian@etti.tuiasi.ro> ★  
Subject **Important message from RF-OPTO**  
To [REDACTED]  
Cc Me <rdamian@etti.tuiasi.ro> ★



Laboratorul de Microunde si Optoelectronica  
Facultatea de Electronica, Telecomunicatii si Tehnologia Informatiei  
Universitatea Tehnica "Gh. Asachi" Iasi

**In atentia: POPESCU GOPO ION**

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**Attention: POPESCU GOPO ION**

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Password: [REDACTED]

Login to the [server](#), with this password, as soon as possible, for confirmation.

**Save** this message in a safe place for later use

# Online exam manual

- The online exam app used for:
  - ~~lectures (attendance)~~
  - laboratory
  - project
  - ~~examinations~~

## Materials

### Other data

[Manual examen on-line](#) (pdf, 2.65 MB, ro, 🇷🇴)

[Simulare Examen](#) (video). (mp4, 65.12 MB, ro, 🇷🇴)

## Microwave Devices and Circuits (Englis

# Online exam

- always against a **timetable**
  - long period (project submission/laboratory results)
  - ~~short period (tests: 15min, exam: 2h)~~

<b>Announcement</b> 23:59 (10/05/2020)	<b>Support material</b> 00:05 (11/05/2020)	<b>Exam Topics</b> 00:07 (11/05/2020)	<b>Results</b> 00:10 (11/05/2020)	<b>End</b> 00:20 (15/05/2020)	<b>Confirmation</b> 00:20 (16/05/2020)	Next timeframe in: 05 m 43 s <a href="#">Refresh now</a>
---	---	--	--------------------------------------	----------------------------------	---	--

**Announcement**

This is a "fake" exam, introduced to familiarize you with the server interface and to perform the necessary actions during an exam: thesis scan, selfie, use email for co

**Server Time**

All exams are based on the server's time zone (it may be different from local time). For reference time on the server is now:

10/05/2020 23:59:16

# Online results submission

- many numerical values/files

Schema finala	Rezultate - castig	Rezultate - zgomot	Fisier justificare calcul (factor andrei)	Fisier zap (optional)	T1, fisier parametri S	T2, fisier parametri S	Z1	Z2	Z3	Z4	Z5	Z6	Z7	Ze1	Zo1	Ze2	Zo2	Ze3	Zo3	Ze4	Zo4	Ze5	Zo5	Ze6	Zo6	
86 - 5428 - 259 ...	86 - 5428 - 260 ...	86 - 5428 - 261 ...	86 - 5428 - 316 ...	-	86 - 5428 - 314 ...	86 - 5428 - 315 ...	148.33	155.88	202.12	164.35	180.91	30.29	185.19	79.9	37	68.89	45.14	61.83	45.05	57.97	46.02	61.85	45.05	68.8	45.05	
86 - 5622 - 259 ...	86 - 5622 - 260 ...	86 - 5622 - 261 ...	86 - 5622 - 316 ...	86 - 5622 - 262 ...	86 - 5622 - 314 ...	86 - 5622 - 315 ...	26.97	153.5	34.64	35.79	55.56	26.212	10.693	0	0	0	0	0	0	0	0	0	0	0	0	0
86 - 5488 - 259 ...	86 - 5488 - 260 ...	86 - 5488 - 261 ...	86 - 5488 - 316 ...	86 - 5488 - 262 ...	86 - 5488 - 314 ...	86 - 5488 - 315 ...	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
86 - 5391 - 259 ...	86 - 5391 - 260 ...	86 - 5391 - 261 ...	86 - 5391 - 316 ...	-	-	-	50	50	50	50	50	50	50	70.14	40.39	61.85	44.59	55.7	45.2	54.89	45.38	58.65	45.8	70.0	45.8	
86 - 5664 - 259 ...	86 - 5664 - 260 ...	86 - 5664 - 261 ...	86 - 5664 - 316 ...	-	86 - 5664 - 314 ...	86 - 5664 - 315 ...	168.02	150.5	178.28	133.75	92.12	121.67	144.48	94.36	36.19	70.77	42.56	65.69	42.05	55.17	42.29	65.59	42.05	70.7	42.05	
86 - 5665 - 259 ...	86 - 5665 - 260 ...	86 - 5665 - 261 ...	86 - 5665 - 316 ...	-	86 - 5665 - 314 ...	86 - 5665 - 315 ...	162.2	80.8	209.2	140.85	135.1	183.7	167.6	94.58	36.15	78.16	39.77	65.57	45.05	65.57	45.05	78.16	39.77	94.5	39.77	
86 - 5433 - 259 ...	86 - 5433 - 260 ...	86 - 5433 - 261 ...	86 - 5433 - 316 ...	-	86 - 5433 - 314 ...	86 - 5433 - 315 ...	165.138	106.228	226.157	130.134	72.71	180.177	164.616	101.36	36.11	77.22	42.49	68.02	45.62	60	45.42	68.02	45.62	77.2	45.62	
86 - 5608 - 259 ...	86 - 5608 - 260 ...	86 - 5608 - 261 ...	86 - 5608 - 316 ...	-	86 - 5608 - 314 ...	86 - 5608 - 315 ...	150.84	152.5	30.94	32.37	54.36	19.837	29.85	64.14	40.145	54.32	46.32	53.8	46.7	53.8	46.7	54.32	46.32	54.9	46.32	
86 - 5555 - 259 ...	86 - 5555 - 260 ...	86 - 5555 - 261 ...	86 - 5555 - 316 ...	-	86 - 5555 - 314 ...	86 - 5555 - 315 ...	168.001	150.288	178.399	133.115	92.491	121.257	144.126	97.05	36.16	71.13	43.09	65.45	42.12	55.66	42.18	65.45	42.12	71.1	42.12	

# Online results submission

- many numerical values

	Z1	Z2	Z3	Z4	Z5	Z6	Z7
	148.33	155.88	202.12	164.35	180.91	30.29	185.19
	25.97	153.5	34.64	35.79	55.56	26.212	10.692
	0	0	0	0	0	0	0
	50	50	50	50	50	50	50



# Online results submission

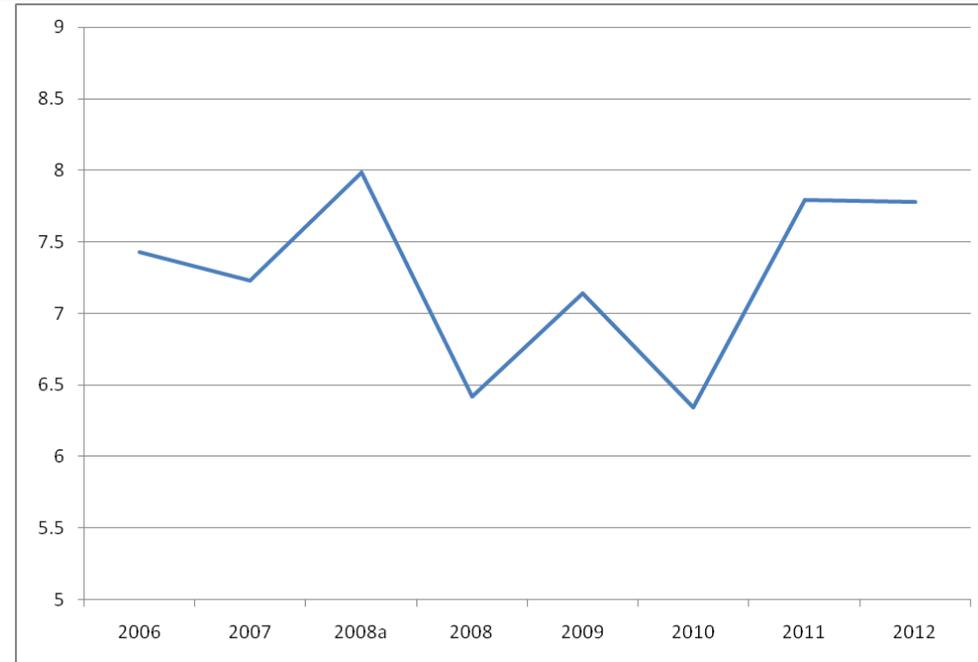
**Grade = Quality of the work +  
+ Quality of the submission**

# MOTTO (RO)

- “Universitatea nu e pentru mase locul de unde emana cunoasterea, ci un obstacol intre individ si diploma pe care i-a harazit-o destinul”
- “Universitatea fiind ceva care se interpune in mod imoral intre individ si dreptul lui natural de a fi diplomat, individul are obligatia morala sa triumfe asupra universitatii prin orice mijloace”
  - Sursa citat: Internet, user: “un student batran si plesuv”

# Exam

- individual topics
- Grades
  - 2006: 7.43
  - 2007: 7.23
  - 2008: 7.98
  - 2008: 6.42
  - 2009: 7.14
  - 2010: 6.34
  - 2011: 7.79
  - 2012: 7.77
- First time (unannounced)
  - 50% of the students left the exam in the first 10 minutes
  - 50% of those who stayed did not pass
  - overall passing percentage 25%, litigation rate: 0%
- Next examinations (announced)
  - litigation rate : 0%



# Exam



# Grades

## Microwave Devices and Circuits (English)

**Course: MDC (2020-2021)**

**Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian  
**Code:** EDID407  
**Discipline Type:** DID; Required, Domain  
**Credits:** 3  
**Enrollment Year:** 4, Sem. 8

### Activities

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:  
**Laboratory:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

### Evaluation

Type: Colloquium

**A:** 50%, (Test/Colloquium)  
**B:** 25%, (Seminary/Laboratory/Project Activity)  
**D:** 25%, (Homework/Specialty papers)

### Grades

[Aggregate Results](#)

### Lists

[Bonus points \(final\)](#)

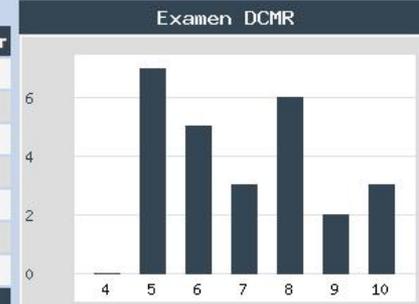
### Statistic

Nota.	Numar
4	0
5	0
6	8
7	7
8	6
9	4
10	1
<b>TOTAL</b>	<b>26</b>



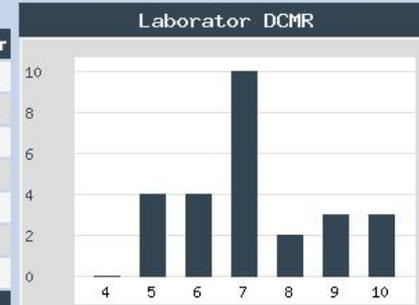
Powered by: RFTech - <http://www.rfttech.ro> 0.006 sec

Exam.	Numar
4	0
5	7
6	5
7	3
8	6
9	2
10	3
<b>TOTAL</b>	<b>26</b>



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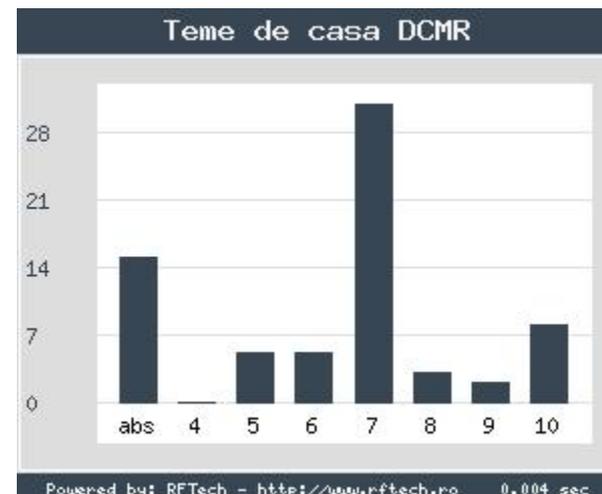
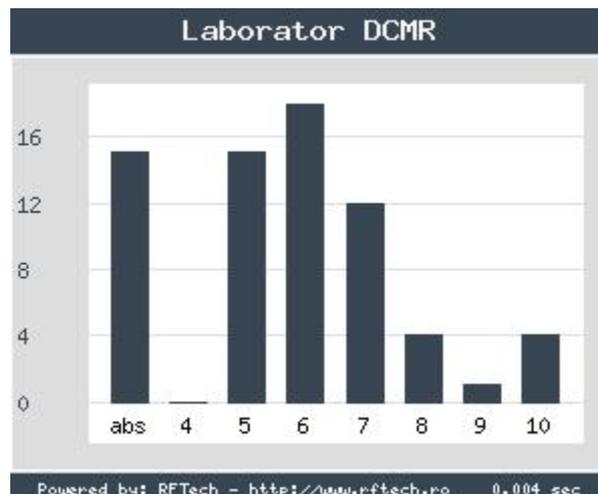
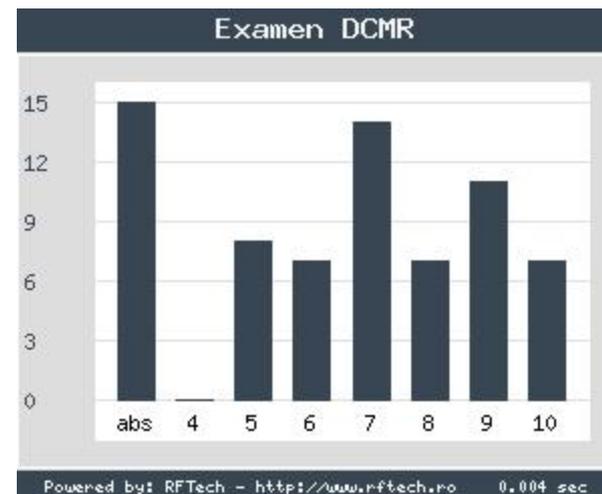
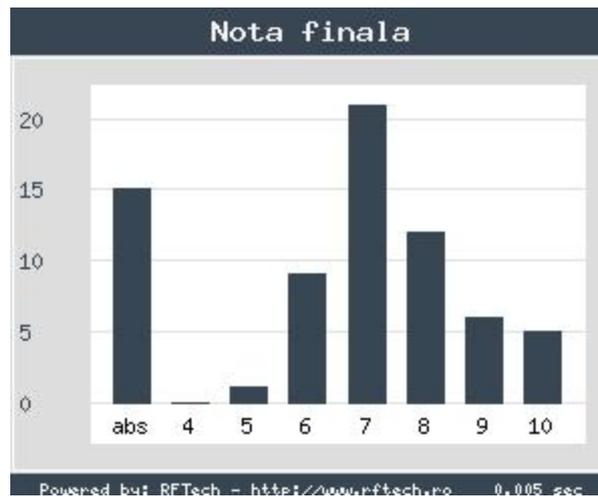
Labo.	Numar
4	0
5	4
6	4
7	10
8	2
9	3
10	3
<b>TOTAL</b>	<b>26</b>



Powered by: RFTech - <http://www.rfttech.ro> 0.004 sec

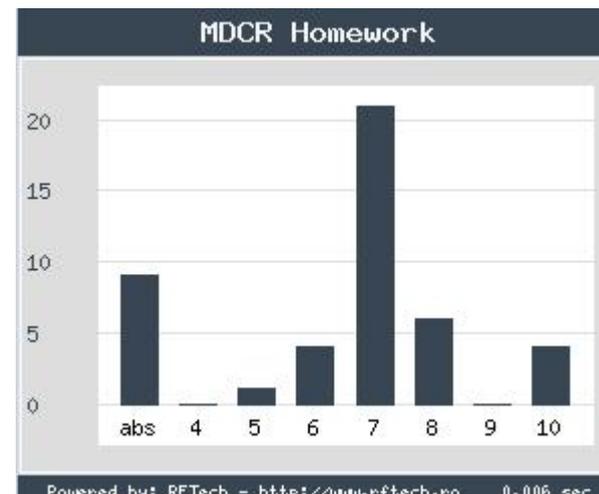
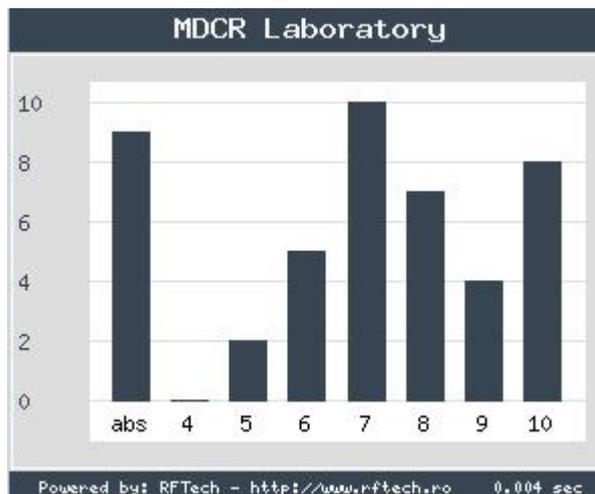
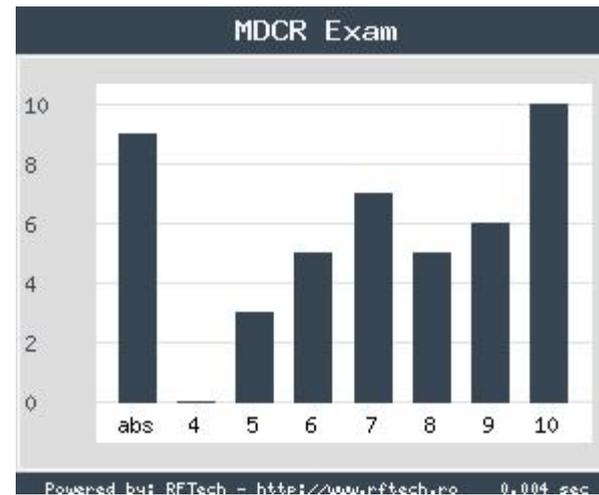
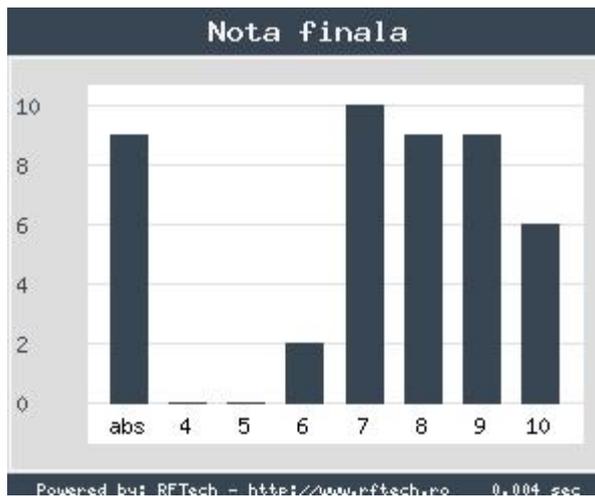
# Grades

## ■ 2019/2020



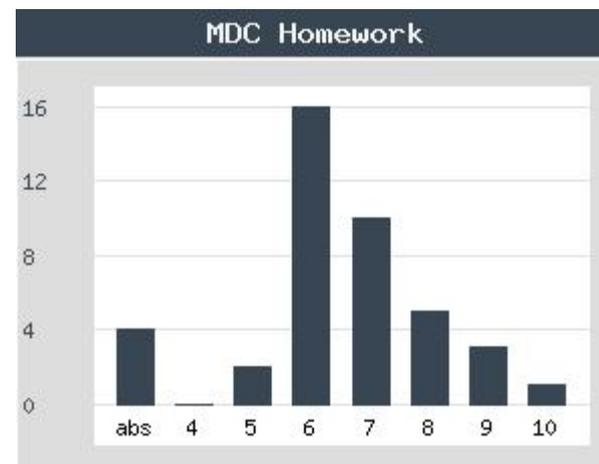
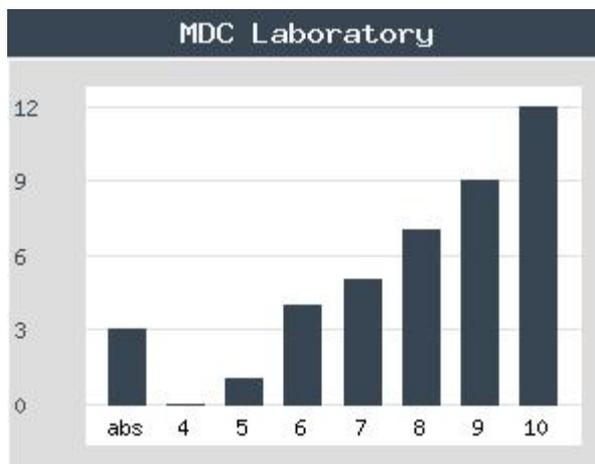
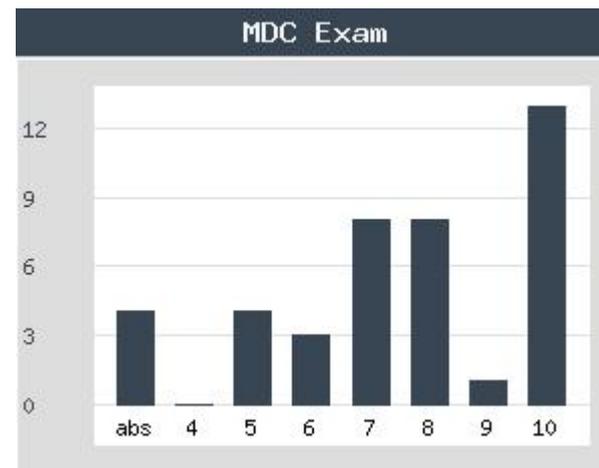
# Grades

## ■ 2019/2020 - eng



# Grades

## ■ 2020/2021 - eng



# Attendance, Lists

## Grades

[Aggregate Results](#)

## Attendance

[Course](#)  
[Laboratory](#)

## Lists

[Studenti care nu pot intra in examen](#)  
[Bonus-uri acumulate \(final\)](#)  
[Punctaj laborator](#)

## Materials

- Attendance
- minimum 7 sessions
- Activity bonus
- Homework
- individual data
- etc.

# Bonus

Group	Course attendance	B. attendance	B. supplemental	B. photo	B. T1	B. T2	B. T3	Total Bonus	Obs.
5411	4.6	0.5		1		0	0.1	1.6	-
5411	17	2.5		1	0.75	0	0.5	4.75	-
5411	12.6	2		1		0	0.1	3.1	-
5411	9.6	1.5		1	0.25		0	2.75	-
5411	5.2	0.5		1		0	0	1.5	-
5411	12	2		0.5		0		2.5	-
5411	16.15	2.5		0.5	0.5	0.3		3.8	-
5411	18	2.5	1.5	1	0		0.1	5.1	-
5411	15.725	2.5		1	0.75	0	0	4.25	-
5411	18	2.5	1.75	1	0.63	0	1	6.88	-
5411	1.2	0		1				1	-
5411	13	2	0.5	1	0.13	0	0	3.63	-
5411	15.375	2.5		1	1	0		4.5	-
5411	5.075	0.5	0.05	0				0.55	-
5411	1.8	0		0.5			0.1	0.6	-
5411	17.5	2.5	0.4	1	1		0.2	5.1	-

# Previous years

## Optoelectronics

### Course: OPTO (2019-2020)

**Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian

**Code:** DID405M

**Discipline Type:** DID; Required, Domain

**Credits:** 4

**Enrollment Year:** 4, Sem. 8

### Activities

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:

**Laboratory:** Instructor: Assist.P. Dr. Petre-Daniel Matasaru, 1 Hours/Week, Group, Timetable:

### Evaluation

Type: **Colloquium**

**A:** 50%, (Test/Colloquium)

**B:** 30%, (Seminary/Laboratory/Project Activity)

**C:** 20%, (Tests during semester)

### Previous years

2018-2019

2017-2018

2016-2017

2015-2016

2014-2015

More years...

Server-ul "rf-opto" pastreaza istoricul materialelor pentru anii anteriori  
Alegeti anul recent corespunzator pentru vizualizare sau "More years" pentru a afisa mai multi ani din istoric

# Previous years

[Microwave CD](#)

[Optical Communications](#)

[Optoelectronics](#)

[Internet](#)

[Antennas](#)

[Practica](#)

[Networks](#)

[Educational software](#)

[Examen DCMR 10 feb 2019](#) (pdf, 934.2 KB, ro, 🇷🇴)

[Rezolvări DCMR 10 feb 2019](#) (pdf, 825.2 KB, ro, 🇷🇴)

[Detalii notare DCMR/MDCR 2018 2019](#) (htm, 13.05 KB, ro, 🇷🇴)

## Other data

[Factorul "Andrei"](#) (pdf, 15.85 MB, ro, 🇷🇴)

## Previous years

2017-2018

2016-2017

2015-2016

2014-2015

2013-2014

More years...

## Microwave Devices and Circuits for Radiocommunications

### Course: DCMR (2017-2018)

**Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian

**Code:** DOS412T

**Discipline Type:** DOS; Alternative, Specialty

**Credits:** 4

**Enrollment Year:** 4, Sem. 7

### Activities

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:

**Laboratory:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 1 Hours/Week, Group, Timetable:

# Previous years, 2004-2023

## Previous years

2018-2019

2017-2018

2016-2017

2015-2016

2014-2015

More years...

## Optoelectronics

### Course: OPTO (2018-2019)

**Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian

**Code:** DIS405M

**Discipline Type:** DID; Required, Domain

**Credits:** 3

**Enrollment Year:** 4, Sem. 8

### Activities

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization S

**Laboratory:** Instructor: Assist.P. Dr. Petre-Daniel Matasaru, 1 Hours/Week, Group, T

### Evaluation

Type: **Colloquium**

**A:** 50%, (Test/Colloquium)

**B:** 30%, (Seminary/Laboratory/Project Activity)

**C:** 20%, (Tests during semester)

### Grades

[Aggregate Results](#)

### Attendance

## Previous years

2018-2019

2017-2018

2016-2017

2015-2016

2014-2015

2013-2014

2012-2011

## Optoelectronics, Structures, Technologies, Circuits

### Course: OSTC (2013-2014)

**Course Coordinator:** Assoc.P. Dr. Radu-Florin Damian

**Code:** DIS405M

**Discipline Type:** DIS; Required, Specialty

**Credits:** 4

**Enrollment Year:** 4, Sem. 7

### Activities

**Course:** Instructor: Assoc.P. Dr. Radu-Florin Damian, 2 Hours/Week, Specialization Section, Timetable:

**Laboratory:** Instructor: Assist.P. Dr. Petre-Daniel Matasaru, 1 Hours/Week, Half Group, Timetable:

### Evaluation

Type: **Colloquium**

**A:** 66%, (Test/Colloquium)

**B:** 17%, (Seminary/Laboratory/Project Activity)

**D:** 17%, (Homework/Specialty papers)

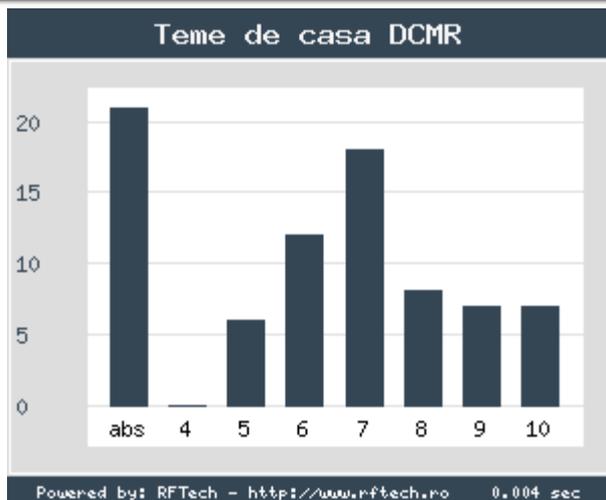
### Grades

[Aggregate Results](#)

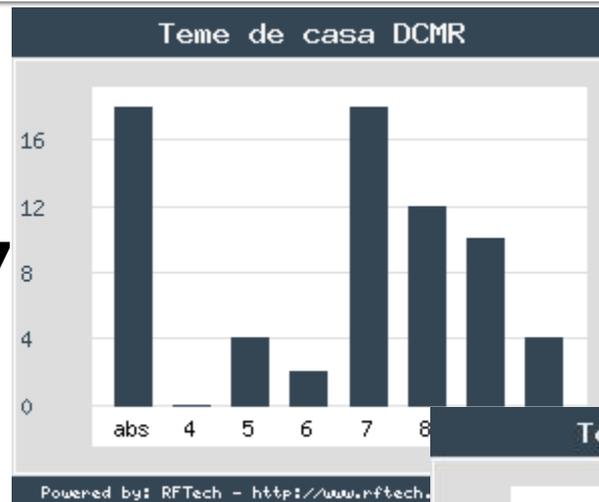
### Materials

# Effect? – “andrei” factor

15/6



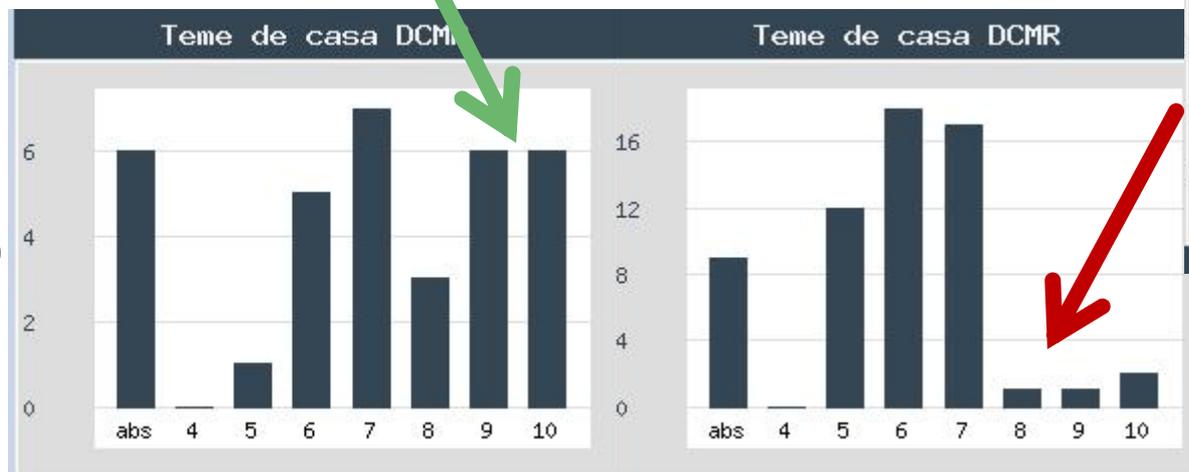
16/7



17/8

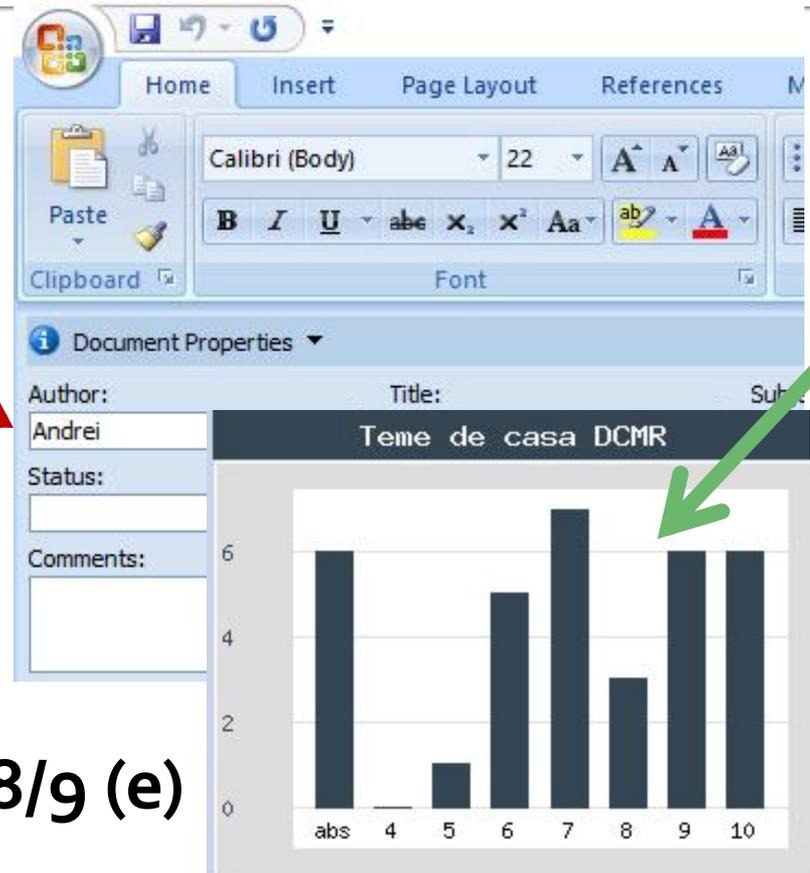


18/9

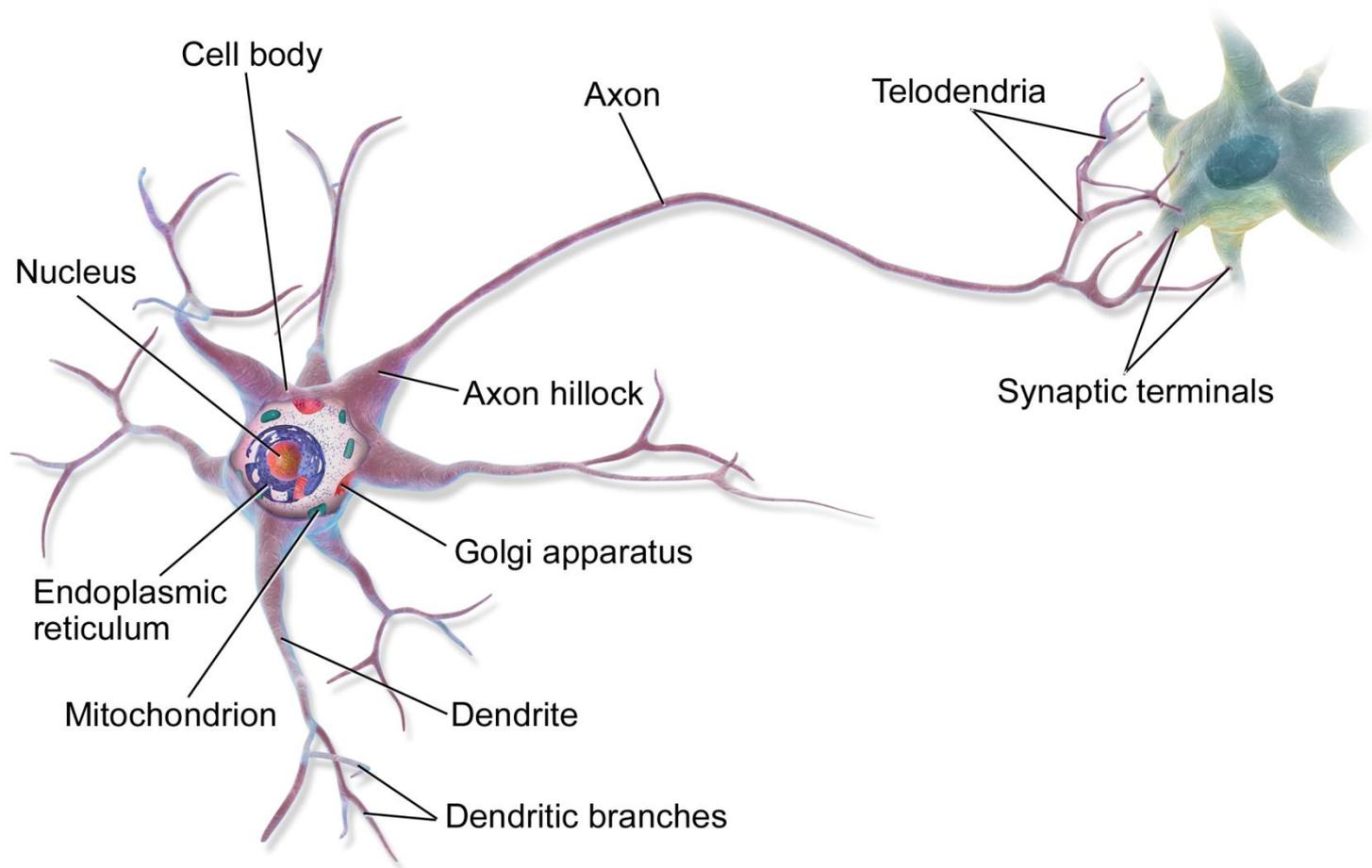


# Project 2019/2020

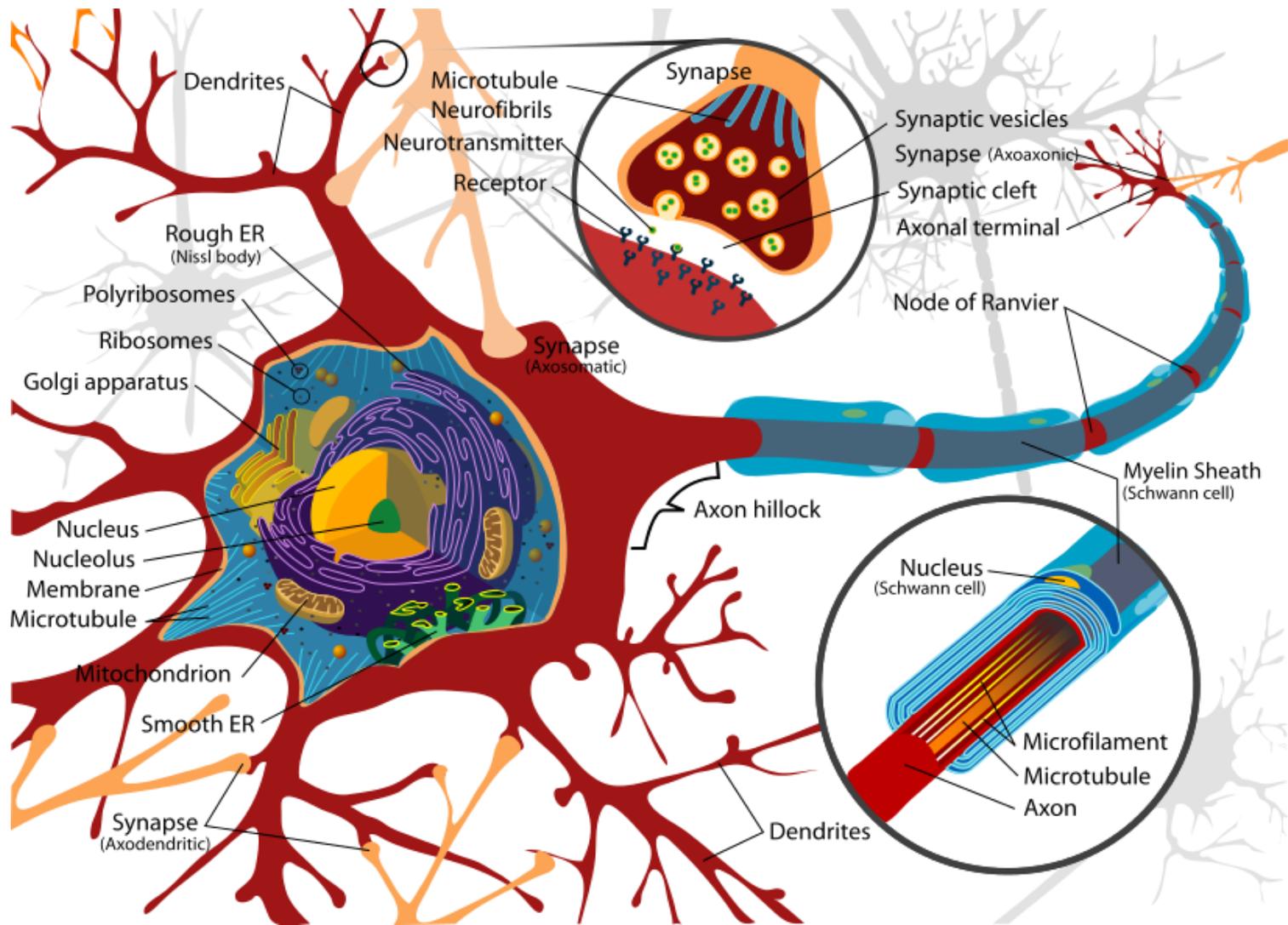
- factorul "andrei" = -2p



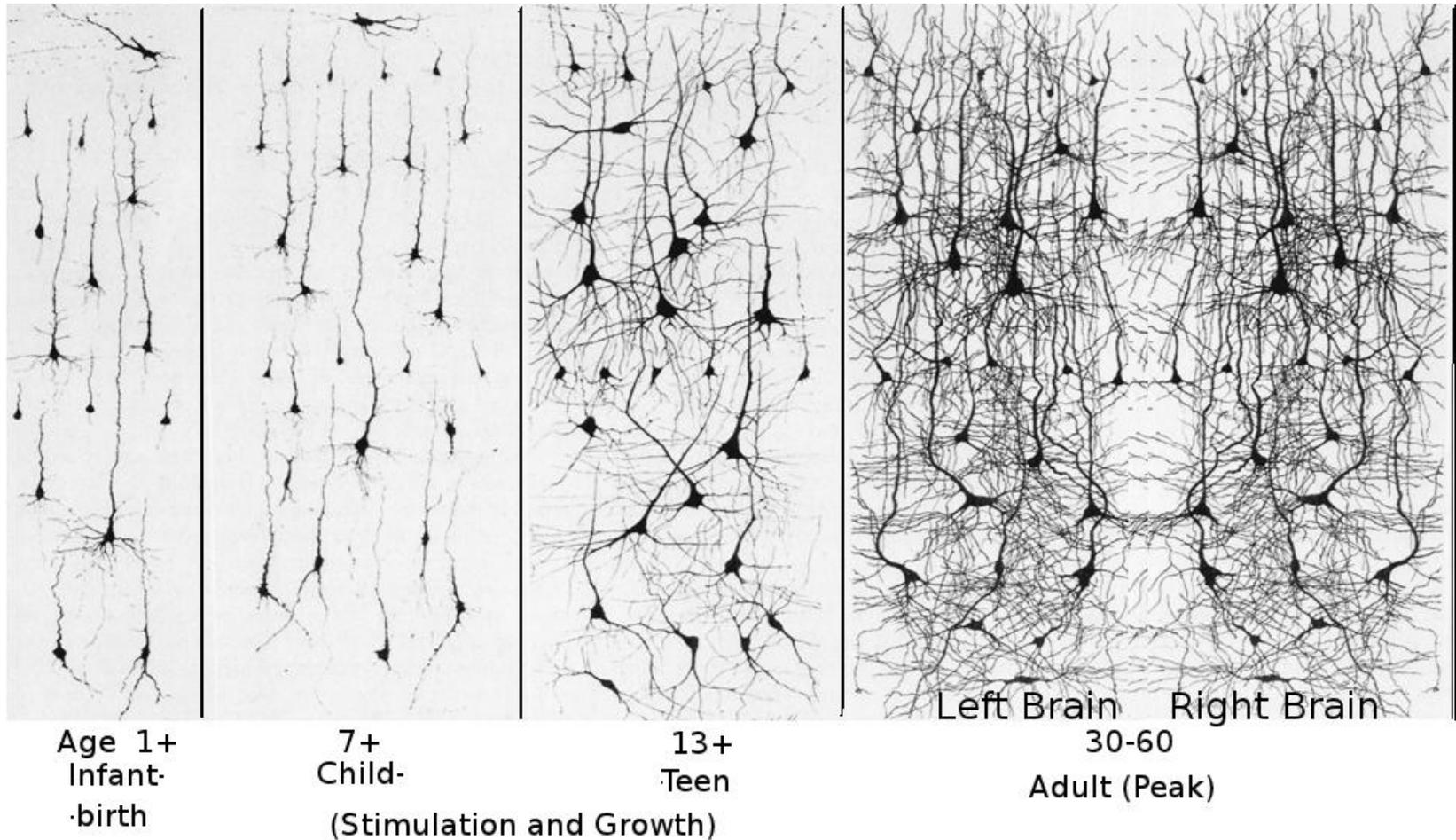
# Course Objectives 1



# Course Objectives 2



# Course Objectives 3



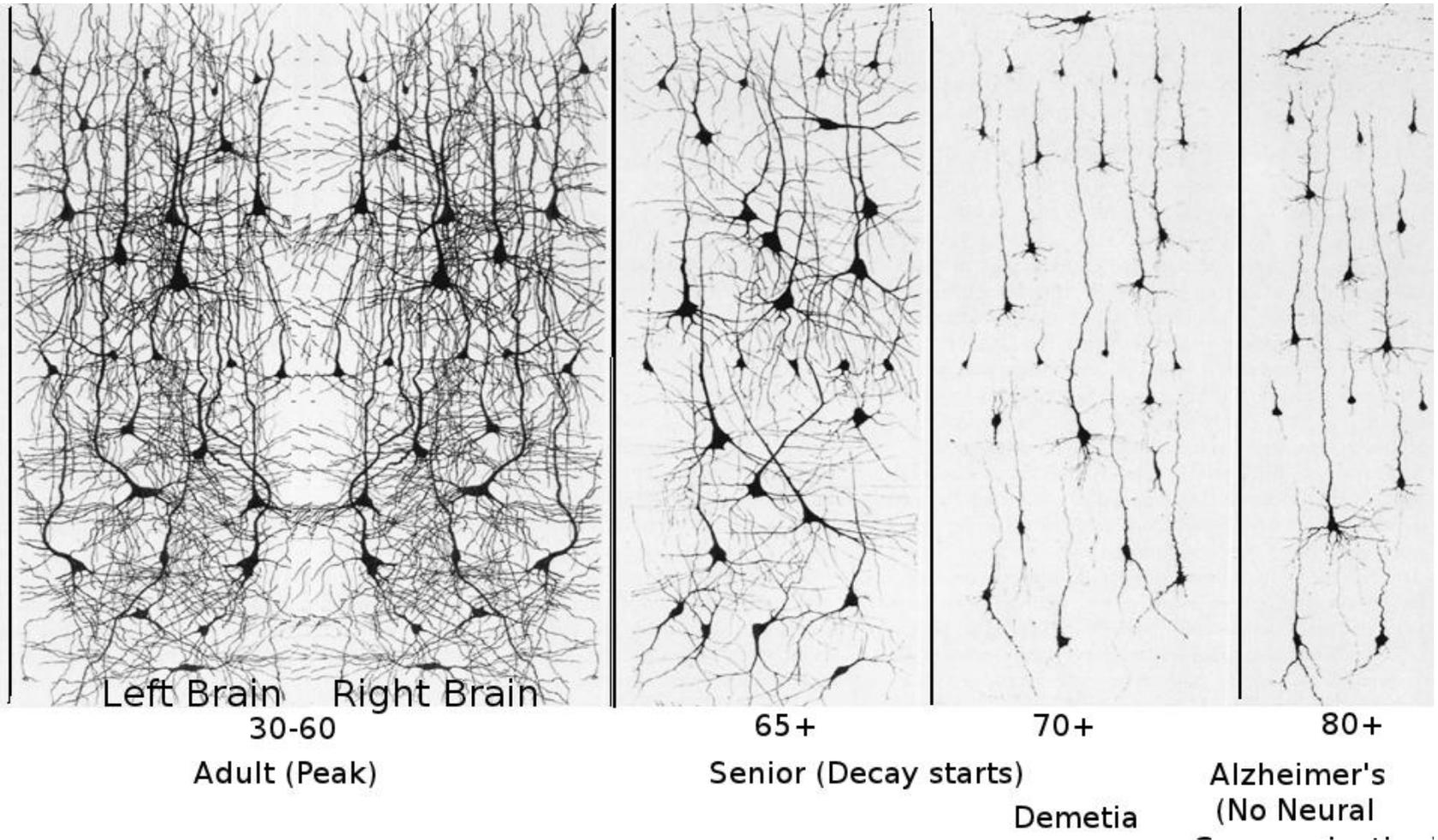
# Course Objectives 4



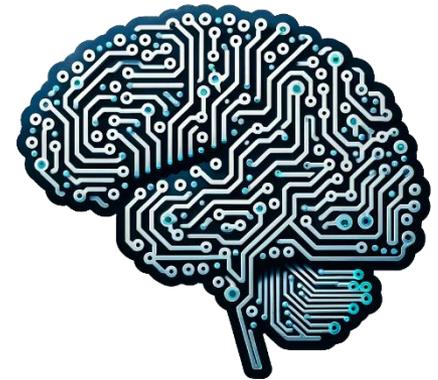
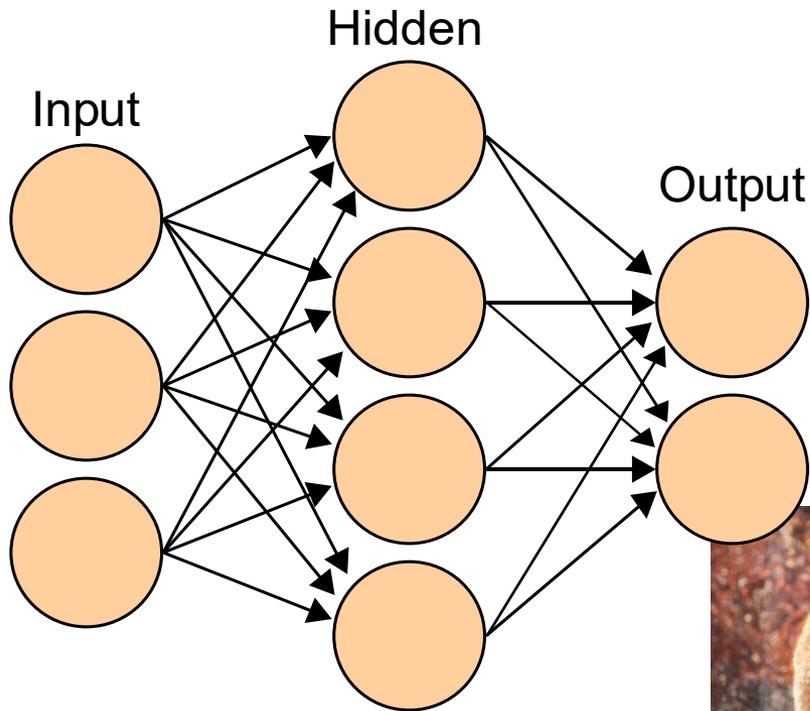
**“Engineering”  
Sinapses**



# Deadline



# IA/AI



# IA/AI+ IN/NI

**SUPERVISED  
LEARNING**



**UNSUPERVISED  
LEARNING**



**REINFORCEMENT  
LEARNING**



# Course Topics

- Transmission lines
- Impedance matching and tuning
- Directional couplers
- Power dividers
- Microwave amplifier design
- Microwave filters
- ~~Oscillators and mixers?~~

# Textbooks

- <https://rf-opto.etti.tuiasi.ro>
- Irinel Casian-Botez: "Microunde vol. 1: Proiectarea de circuit", Ed. TEHNOPRES, 2008
- **David Pozar**, Microwave Engineering, Wiley; 4th edition , 2011, ISBN : 978-1-118-29813-8 (E), ISBN : 978-0-470-63155-3 (P)

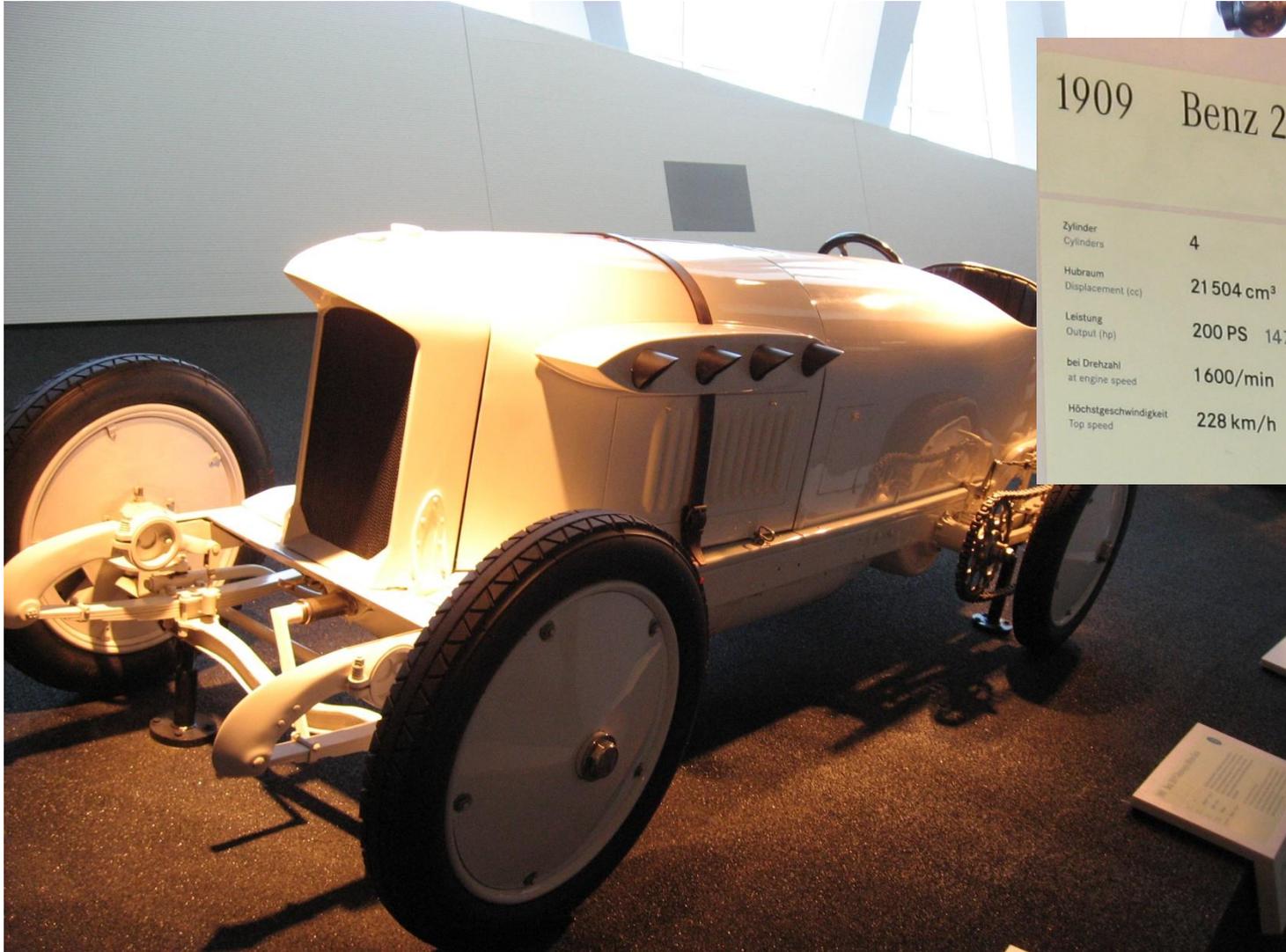
~1930



~1930



# 1909



## 1909 Benz 200 PS Rennwagen »Blitzen«

Zylinder Cylinders	4
Hubraum Displacement (cc)	21 504 cm <sup>3</sup> 1 312 cu in
Leistung Output (hp)	200 PS 147 kW
bei Drehzahl at engine speed	1 600/min
Höchstgeschwindigkeit Top speed	228 km/h 142 mph

Der »Blitzen-Benz« ist 1909 der erste 200 km/h fährt. Seine größten Erfolge erzielt er mit einem 4-Zylinder-Motor ausgestattet. Rekordhalter Burman mit 228 km/h über die Sarawak-Brücke ist damit das schnellste Fahrzeug auf jeder Eisenbahn.

Benz »Lightning Benz« 200 hp race car  
In 1909 the Lightning Benz...

# 1930-1950



# Technology

> 2010



< 1950

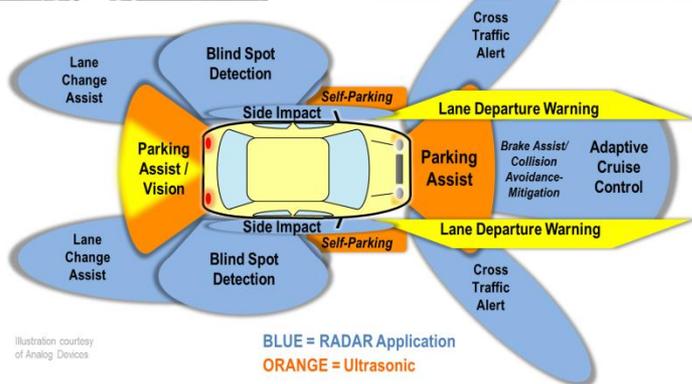
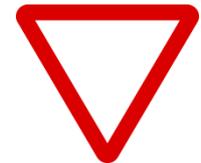


Illustration courtesy of Analog Devices

# Technology

$1 \times 1 = 1$	$2 \times 1 = 2$	$3 \times 1 = 3$	$4 \times 1 = 4$	$5 \times 1 = 5$
$1 \times 2 = 2$	$2 \times 2 = 4$	$3 \times 2 = 6$	$4 \times 2 = 8$	$5 \times 2 = 10$
$1 \times 3 = 3$	$2 \times 3 = 6$	$3 \times 3 = 9$	$4 \times 3 = 12$	$5 \times 3 = 15$
$1 \times 4 = 4$	$2 \times 4 = 8$	$3 \times 4 = 12$	$4 \times 4 = 16$	$5 \times 4 = 20$
$1 \times 5 = 5$	$2 \times 5 = 10$	$3 \times 5 = 15$	$4 \times 5 = 20$	$5 \times 5 = 25$
$1 \times 6 = 6$	$2 \times 6 = 12$	$3 \times 6 = 18$	$4 \times 6 = 24$	$5 \times 6 = 30$
$1 \times 7 = 7$	$2 \times 7 = 14$	$3 \times 7 = 21$	$4 \times 7 = 28$	$5 \times 7 = 35$
$1 \times 8 = 8$	$2 \times 8 = 16$	$3 \times 8 = 24$	$4 \times 8 = 32$	$5 \times 8 = 40$
$1 \times 9 = 9$	$2 \times 9 = 18$	$3 \times 9 = 27$	$4 \times 9 = 36$	$5 \times 9 = 45$
$1 \times 10 = 10$	$2 \times 10 = 20$	$3 \times 10 = 30$	$4 \times 10 = 40$	$5 \times 10 = 50$
$6 \times 1 = 6$	$7 \times 1 = 7$	$8 \times 1 = 8$	$9 \times 1 = 9$	$10 \times 1 = 10$
$6 \times 2 = 12$	$7 \times 2 = 14$	$8 \times 2 = 16$	$9 \times 2 = 18$	$10 \times 2 = 20$
$6 \times 3 = 18$	$7 \times 3 = 21$	$8 \times 3 = 24$	$9 \times 3 = 27$	$10 \times 3 = 30$
$6 \times 4 = 24$	$7 \times 4 = 28$	$8 \times 4 = 32$	$9 \times 4 = 36$	$10 \times 4 = 40$
$6 \times 5 = 30$	$7 \times 5 = 35$	$8 \times 5 = 40$	$9 \times 5 = 45$	$10 \times 5 = 50$
$6 \times 6 = 36$	$7 \times 6 = 42$	$8 \times 6 = 48$	$9 \times 6 = 54$	$10 \times 6 = 60$
$6 \times 7 = 42$	$7 \times 7 = 49$	$8 \times 7 = 56$	$9 \times 7 = 63$	$10 \times 7 = 70$
$6 \times 8 = 48$	$7 \times 8 = 56$	$8 \times 8 = 64$	$9 \times 8 = 72$	$10 \times 8 = 80$
$6 \times 9 = 54$	$7 \times 9 = 63$	$8 \times 9 = 72$	$9 \times 9 = 81$	$10 \times 9 = 90$
$6 \times 10 = 60$	$7 \times 10 = 70$	$8 \times 10 = 80$	$9 \times 10 = 90$	$10 \times 10 = 100$

Most used!!

$$2 \times 1 = 2$$

$$2 \times 2 = 4$$

$$2 \times 3 = 6$$

$$2 \times 4 = 8$$

$$2 \times 5 = 10$$

$$2 \times 6 = 12$$

$$2 \times 7 = 14$$

$$2 \times 8 = 16$$

$$2 \times 9 = 18$$

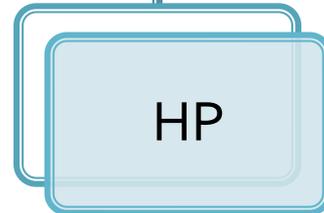
$$2 \times 10 = 20$$



HEWLETT  
PACKARD



1999



2005



**AVAGO**  
TECHNOLOGIES

2014



 **Agilent Technologies**

 **KEYSIGHT**  
TECHNOLOGIES

# NPL, London



# NPL, London



# Examen: Logarithmic scales

$$\text{dB} = 10 \cdot \log_{10} (P_2 / P_1)$$

0 dB	= 1
+ 0.1 dB	= 1.023 (+2.3%)
+ 3 dB	= 2
+ 5 dB	= 3
+ 10 dB	= 10
-3 dB	= 0.5
-10 dB	= 0.1
-20 dB	= 0.01
-30 dB	= 0.001

$$\text{dBm} = 10 \cdot \log_{10} (P / 1 \text{ mW})$$

0 dBm	= 1 mW
3 dBm	= 2 mW
5 dBm	= 3 mW
10 dBm	= 10 mW
20 dBm	= 100 mW
-3 dBm	= 0.5 mW
-10 dBm	= 100 $\mu$ W
-30 dBm	= 1 $\mu$ W
-60 dBm	= 1 nW

$$[\text{dBm}] + [\text{dB}] = [\text{dBm}]$$

$$[\text{dBm/Hz}] + [\text{dB}] = [\text{dBm/Hz}]$$

$$[x] + [\text{dB}] = [x]$$

# Computing Loss/Gain in circuits

$$\text{Gain/Loss} = \frac{P_{out}}{P_{in}}$$

$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left( \frac{P_{out}}{P_{in}} \right)$$


$$\text{Loss[dB]} = [-] 10 \cdot \log_{10} \left( \frac{P_{out}}{P_0} \cdot \frac{P_0}{P_{in}} \right)$$

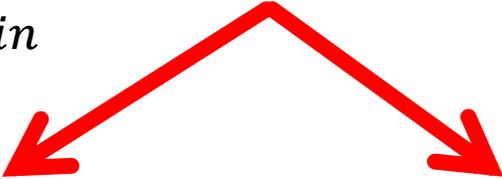
$$\text{Loss[dB]} = [-] 10 \cdot \left[ \log_{10} \left( \frac{P_{out}}{P_0} \right) - \log_{10} \left( \frac{P_{in}}{P_0} \right) \right]$$

$$\text{Loss[dB]} = [-] (P_{out}[\text{dBm}] - P_{in}[\text{dBm}])$$



# Computing Loss/Gain in circuits

$$\text{Loss} = \frac{P_{out}}{P_{in}} < 1 \qquad \text{Loss[dB]} = 10 \cdot \log_{10} \left( \frac{P_{out}}{P_{in}} \right) < 0$$


$$\text{Loss/Attenuation[dB]} = [-] 10 \cdot \log_{10} \left( \frac{P_{out}}{P_{in}} \right)$$

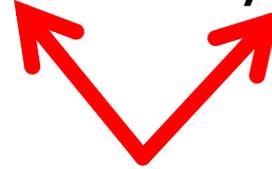
$$\text{Gain} = \frac{P_{out}}{P_{in}} > 1 \qquad \text{Gain[dB]} = 10 \cdot \log_{10} \left( \frac{P_{out}}{P_{in}} \right) > 0$$

$$\text{Attenuation[dB/km]} = \frac{\text{Loss[dB]}}{\text{Length[km]}}$$

# Computing Loss/Gain in circuits

Loss/Attenuation  $\rightarrow P_{out} < P_{in} \rightarrow P_{out}[\text{dBm}] < P_{in}[\text{dBm}]$

$$P_{out}[\text{dBm}] = P_{in}[\text{dBm}] - \text{Loss/Attenuation}[\text{dB}]$$



Gain/Amplification  $\rightarrow P_{out} > P_{in} \rightarrow P_{out}[\text{dBm}] > P_{in}[\text{dBm}]$

$$P_{out}[\text{dBm}] = P_{in}[\text{dBm}] + \text{Gain/Amplification}[\text{dB}]$$

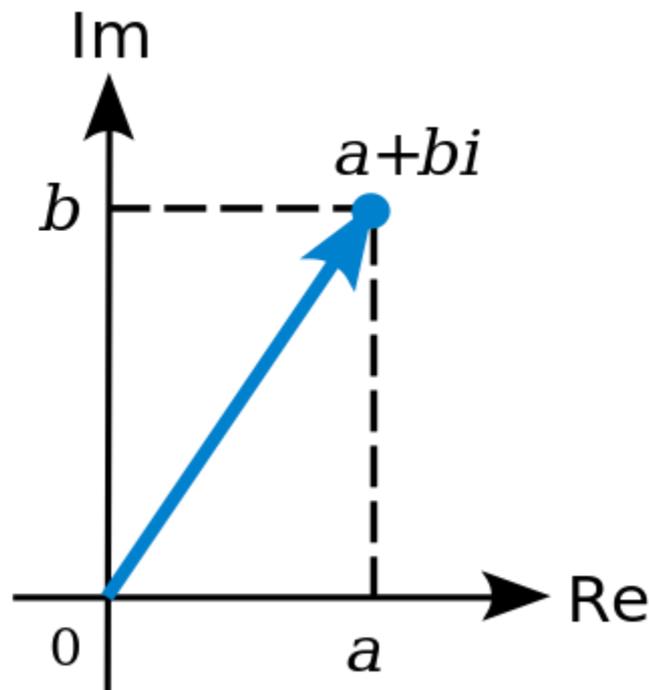


# Exam

- Complex numbers arithmetic!!!!
- $z = a + j \cdot b ; j^2 = -1$

# Complex plane

- abscissa – real part
- ordinate – imaginary part
- any of them can be negative, whole plane, 4 quadrants



# Elementary operations

- Addition

$$z + w = (a + j \cdot b) + (c + j \cdot d) = (a + c) + j \cdot (b + d)$$

- Subtraction

$$z - w = (a + j \cdot b) - (c + j \cdot d) = (a - c) + j \cdot (b - d)$$

- Multiplication

$$z \cdot w = (a + j \cdot b) \cdot (c + j \cdot d) = (a \cdot c - b \cdot d) + j \cdot (b \cdot c + a \cdot d)$$

- Division

$$z / w = \frac{a + j \cdot b}{c + j \cdot d} = \frac{(a + j \cdot b) \cdot (c - j \cdot d)}{(c + j \cdot d) \cdot (c - j \cdot d)} = \left( \frac{a \cdot c + b \cdot d}{c^2 + d^2} \right) + j \cdot \left( \frac{b \cdot c - a \cdot d}{c^2 + d^2} \right)$$

# Conjugate

- $z$       $z = a + j \cdot b$
- $z^*$      $z^* = a - j \cdot b$
- Symmetry over the real axis

$$\operatorname{Re}(z) = a = \frac{1}{2} \cdot (z + z^*)$$

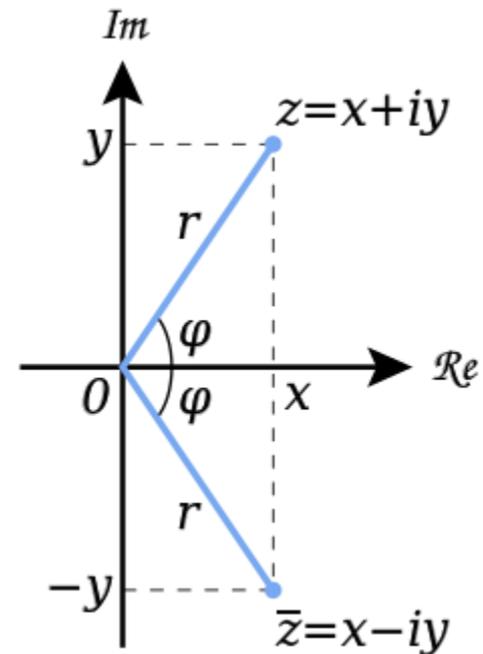
$$\operatorname{Im}(z) = b = \frac{1}{2 \cdot j} \cdot (z - z^*) = \frac{j}{2} \cdot (z^* - z)$$

$$(z + w)^* = z^* + w^*$$

$$(z - w)^* = z^* - w^*$$

$$(z \cdot w)^* = z^* \cdot w^*$$

$$(z / w)^* = z^* / w^*$$



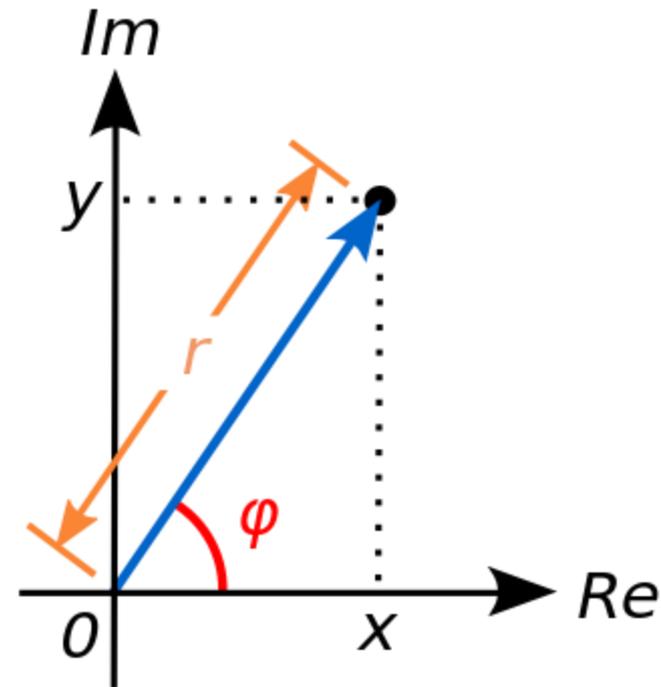
# Polar representation

- Polar representation
  - modulus
  - phase relative to the real axis

$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$|z| = \sqrt{a^2 + b^2}$$

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{nedefinit} & a = 0 \end{cases}$$



# Polar representation

- Euler's formula

$$e^{j \cdot x} = \cos x + j \cdot \sin x; \forall x \in R$$

- Polar representation

$$z = a + j \cdot b = |z| \cdot e^{j \cdot \varphi}$$

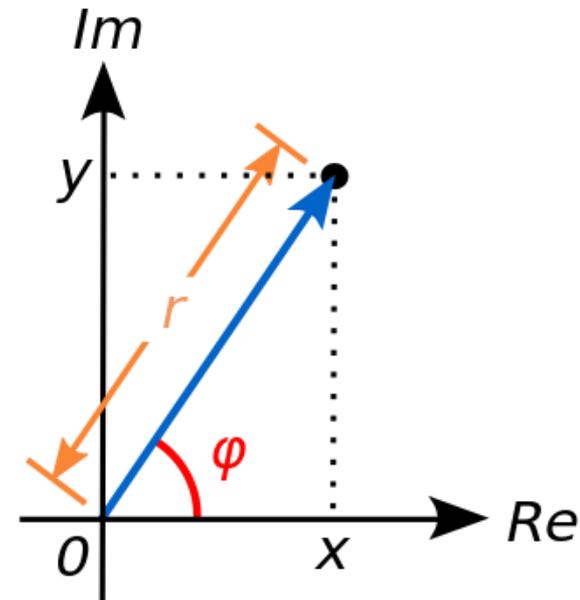
$$z = a + j \cdot b = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)$$

$$z^n = (|z| \cdot e^{j \cdot \varphi})^n = |z|^n \cdot e^{j \cdot n \cdot \varphi} = |z|^n \cdot [\cos(n \cdot \varphi) + j \cdot \sin(n \cdot \varphi)]$$

→ 
$$\sqrt{z} = (|z| \cdot e^{j \cdot \varphi})^{1/2} = \sqrt{|z|} \cdot e^{j \cdot \frac{\varphi}{2}} = \sqrt{|z|} \cdot \left( \cos \frac{\varphi}{2} + j \cdot \sin \frac{\varphi}{2} \right)$$

$$z \cdot w = |z| \cdot e^{j \cdot \varphi} \cdot |w| \cdot e^{j \cdot \theta} = |z| \cdot |w| \cdot e^{j \cdot (\varphi + \theta)} = |z| \cdot |w| \cdot [\cos(\varphi + \theta) + j \cdot \sin(\varphi + \theta)]$$

$$z/w = \frac{|z| \cdot e^{j \cdot \varphi}}{|w| \cdot e^{j \cdot \theta}} = \frac{|z|}{|w|} \cdot e^{j \cdot \varphi} \cdot e^{-j \cdot \theta} = \frac{|z|}{|w|} \cdot [\cos(\varphi - \theta) + j \cdot \sin(\varphi - \theta)]$$



# Polar representation

- Polar representation

$$|z| = \sqrt{a^2 + b^2}$$

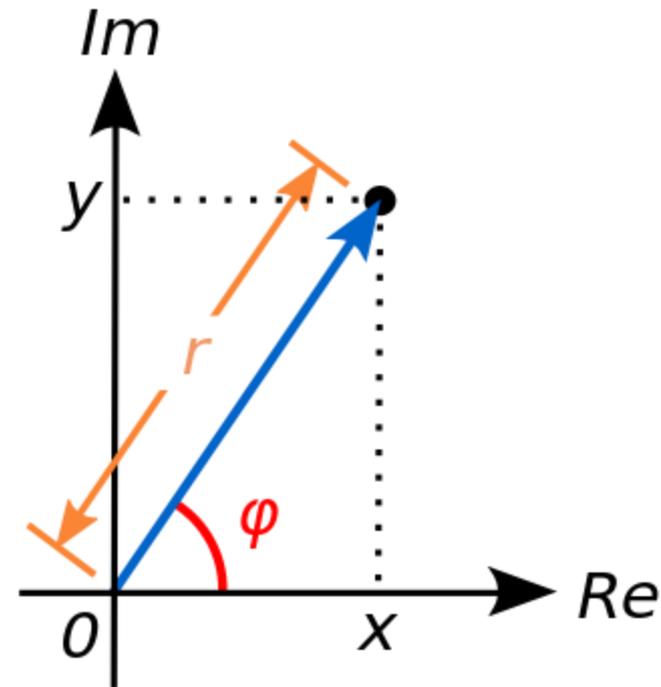
$$|z|^2 = z \cdot z^*$$

⇒ ⇒

$$|e^{j \cdot x}| = |\cos x + j \cdot \sin x| = \sqrt{\cos^2 x + \sin^2 x} = 1$$

$$|e^{j \cdot x}| = 1; \quad \forall x \in R$$

$$\begin{aligned} z^* &= (|z| \cdot e^{j \cdot \varphi})^* = |z| \cdot (\cos \varphi + j \cdot \sin \varphi)^* = |z| \cdot (\cos \varphi - j \cdot \sin \varphi) = \\ &= |z| \cdot [\cos(-\varphi) + j \cdot \sin(-\varphi)] = |z| \cdot e^{-j \cdot \varphi} \end{aligned}$$

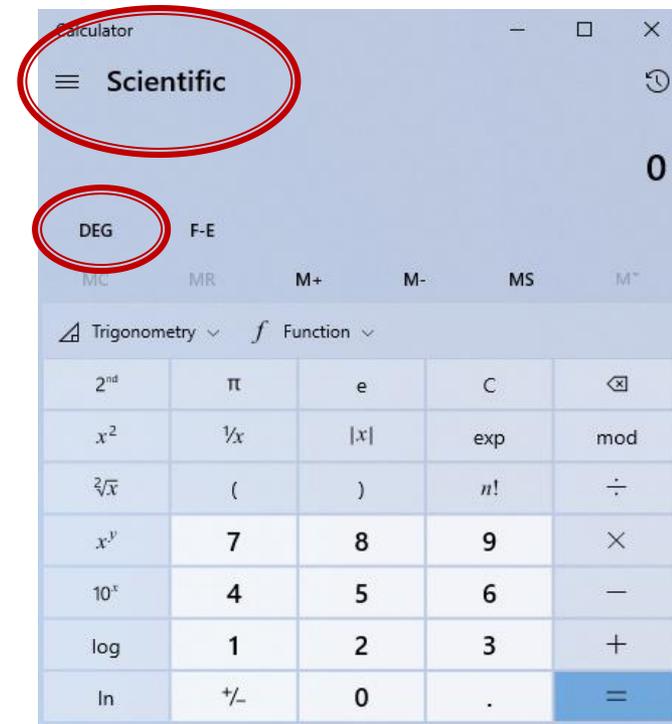


# Polar representation

- standard unit for angles – radians
- microwaves traditional unit for angles – **degrees in decimal form** ( $55.89^\circ$ )

$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, \text{nedefinit} & a = 0 \end{cases}$$

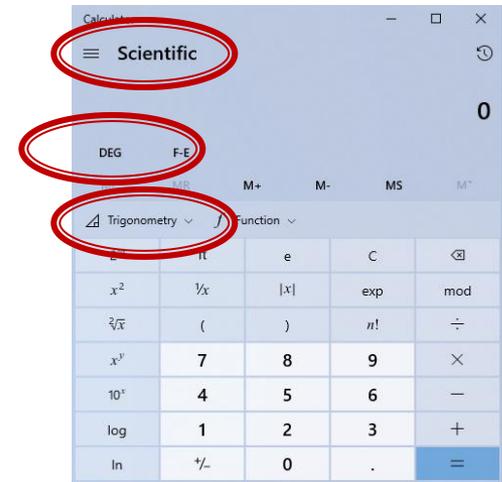
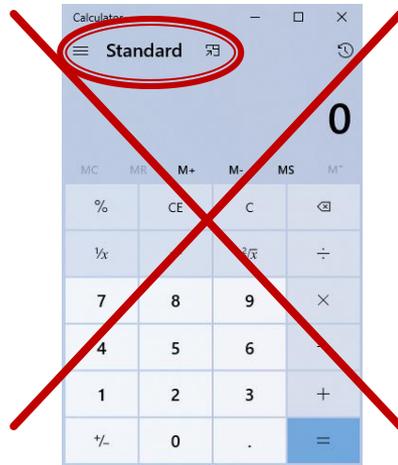
$$\varphi[^\circ] = 180^\circ \cdot \frac{\varphi[\text{rad}]}{\pi} \qquad \varphi[\text{rad}] = \pi \cdot \frac{\varphi[^\circ]}{180^\circ}$$



# Polar representation

- **Attention to angle numerical values!!**
  - math software – work in standard unit: radians
    - a **conversion** is necessary before and after using a trigonometric function (sin, cos, tan, atan, tanh)
  - scientific calculators have the built-in option of choosing the angle unit
    - always **double check** current working unit

$$\varphi[^\circ] = 180^\circ \cdot \frac{\varphi[rad]}{\pi}$$
$$\varphi[rad] = \pi \cdot \frac{\varphi[^\circ]}{180^\circ}$$



# Contact

- Microwave and Optoelectronics Laboratory
- <https://rf-opto.etti.tuiasi.ro>
- [rdamian@etti.tuiasi.ro](mailto:rdamian@etti.tuiasi.ro)