Curs 1

2019/2020

Dispozitive şi circuite de microunde pentru radiocomunicații

Disciplina 2018/2019

- 2C/1L, **DCMR (CDM)**
- **Minim 7 prezente (curs+laborator)**
- Curs - **conf. Radu Damian**
  - Marti 14-15, P7
  - E – **50%** din nota
  - **probleme** + (2p prez. curs) + (3 teste) + (bonus activitate)
    - primul test L1 (t2 si t3 neanuntate)
    - 3pz (C) = +0.5p
  - **toate materialele permise**

Disciplina 2018/2019

- 2C/1L, **DCMR (CDM)**
- Laborator – **conf. Radu Damian**
  - Miercuri 10-14 impar ll.12 (par eng.)
  - Joi 14- 16 par
  - L – **25%** din nota
    - prezenta + rezultate personale
  - P – **25%** din nota
    - tema personala

Documentatie

- http://rf-opto.etti.tuiasi.ro

Documentatie

- RF-OPTO
  - http://rf-opto.etti.tuiasi.ro
- Fotografie
  - de trimis prin email: **rdamian@etti.tuiasi.ro**
  - necesara la laborator/curs
  - bonus activitate 0.5p/1p

Fotografii

Studentii care au trimis fotografiile

Grupa: 5402

Nr.	Nume
1	APETRII MARIA

Grupa: 5403

Nr.	Nume
1	ALEXANDRESCU SEBASTIAN

Grupa: 5404

Nr.	Nume
1	APERGHIS MIHAI-ALIN

Grupa: 5405

Nr.	Nume
1	ANGHELUS MARIU

Studentii care inca nu au trimis fotografiile

Grupa: 5304

Nr.	Nume

Grupa: 5402

Nr.	Nume

Grupa: 5403

Nr.	Nume

Grupa: 5404

Nr.	Nume

Fotografii

Date:

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

Trimite email acestui student | Adauga acest student la lista (0)

Detalii curente

Finantare	Buget
Bursa	Fara Bursa

Observatii

Date:

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

Trimite email acestui student | Adauga acest student la lista (0)

Detalii curente

Finantare	Buget
Bursa	Bursa de Studii

Observatii

Date:

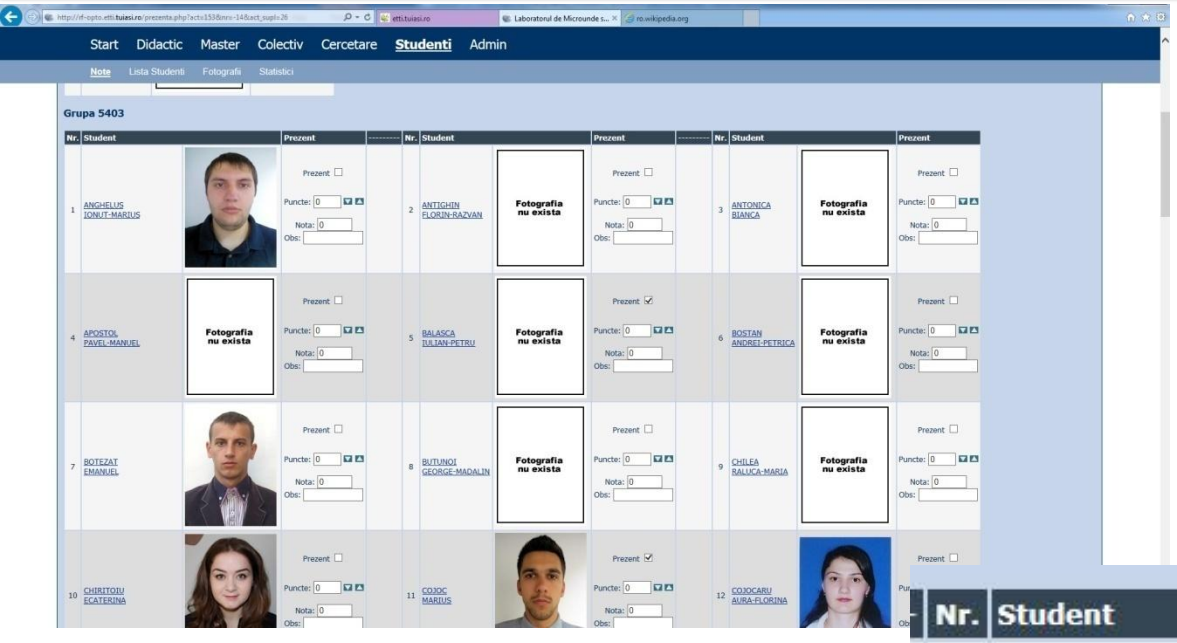
Grupa	5304 (2015/2016)
Specializarea	Tehnologii si sisteme de telecomunicatii
Marca	5184

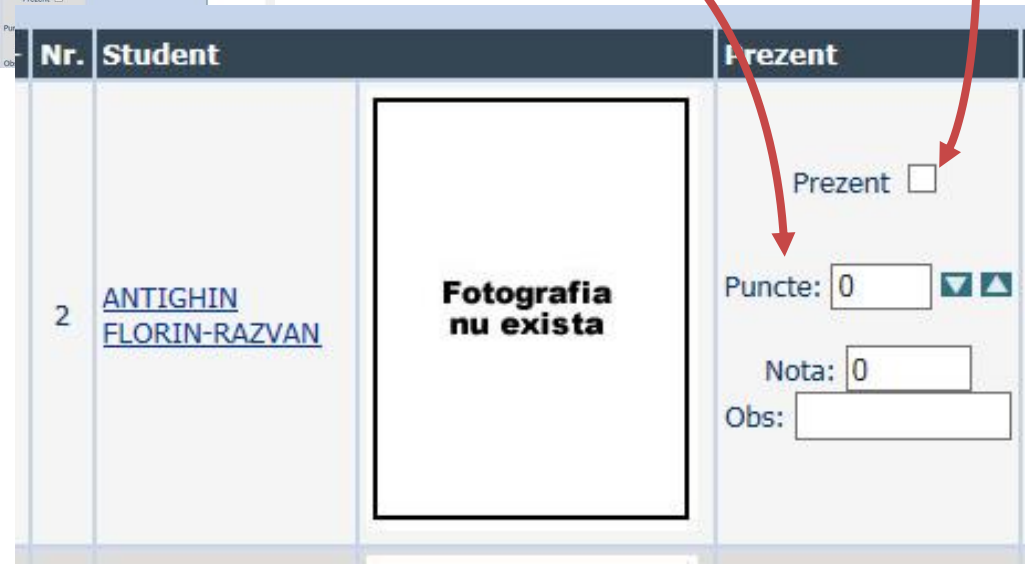
Acceseaza ca acest student

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	**Tehnologii Web**					
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Colocviu 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	-	

Fotografii


Start Didactic Master Colectiv Cercetare Studenti Admin
Note Lista Studenti Fotografii Statistici
Grupa 5403
Nr. Student Prezent
1 ANGHELUS IONUT-MARIUS
2 ANTIGHIN FLORIN-RAZVAN
3 ANTONICA BIANCA
4 APOSTOL PAVEL-MANUEL
5 BALASCA IULIAN-PETRU
6 BOSTAN ANDREI-PETRICA
7 BOTEZAT EMANUEL
8 BUTUNOI GEORGE-MADALIN
9 CHILEA RALUCA-MARIA
10 CHIRITOIU ECATERINA
11 COJOC MARIUS
12 COJOCARU AURA-FLORINA
Fotografia nu exista
Prezent
Puncte: 0
Nota: 0
Obs:


Nr.
Student
Prezent
2
ANTIGHIN FLORIN-RAZVAN
Fotografia nu exista
Prezent
Puncte: 0
Nota: 0
Obs:

Acces

- ~~Personalizat~~

Date:

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

Acceseaza ca acest student

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Puncte	Obs.
TW	Tehnologii Web					
	N	17/01/2014	Nota finala	10	-	
	A	17/01/2014	Colocviu 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	-	

Nume

Email

Cod de verificare

344bd9f

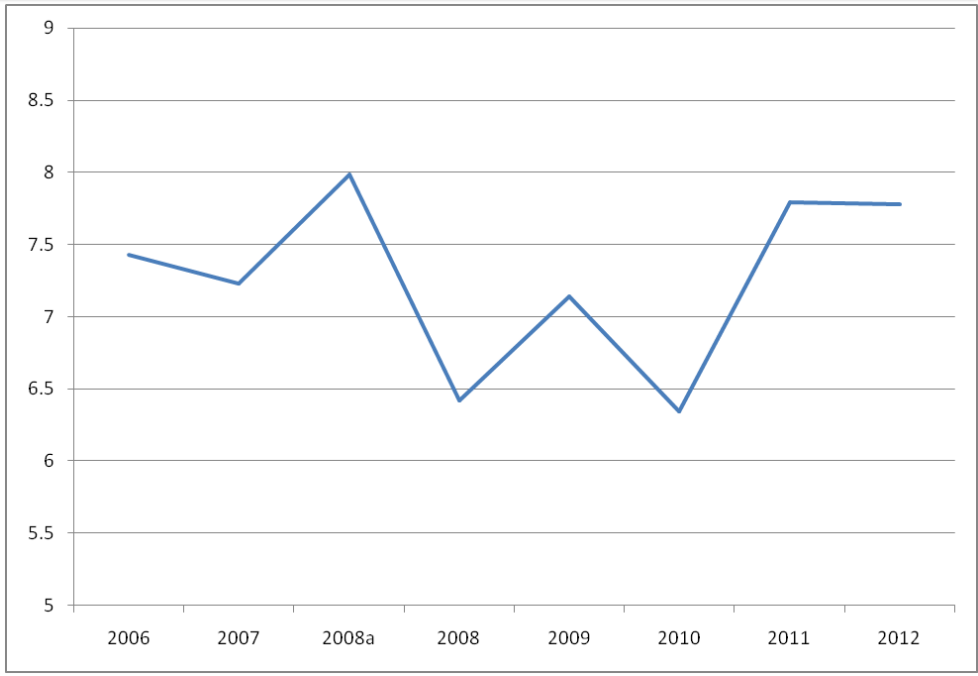
Trimite

MOTTO

- “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”

Examen

- subiecte individuale
- Note
  - 2006: 7.43
  - 2007: 7.23
  - 2008: 7.98
  - 2008: 6.42
  - 2009: 7.14
  - 2010: 6.34
  - 2011: 7.79
  - 2012: 7.77



- La prima aplicare (neanuntata)
  - 50% din studenti au parasit examenul in primele 10 minute
  - 50% din cei ramasi nu au promovat
  - promovabilitate totala 25%, rata contestatiilor: 0%
- Urmatoarele examinari (anuntate)
  - rata contestatiilor: 0%

Examen

Note

- 2017/2018

Start **Didactic** Master Colectiv Cercetare Studenti Admin

Microunde Comunicatii Optice Optoelectronica Internet Antene Practica Retele Soft didactic

Dispozitive si circuite de microunde pentru radiocomunicatii

Disciplina: DCMR (2017-2018)

Coordonator Disciplina: conf. dr. Radu-Florin Damian
Cod: DOS412T
Tip Disciplina: DOS; Disciplina Optionala, Disciplina de Specialitate
Credite: 4
An de Studiu: 4, **Sem.** 7

Activitati

Curs: Cadru Didactic: conf. dr. Radu-Florin Damian, 2 Ore/Saptamana, Sectie Specializare, Orar:
Laborator: Cadru Didactic: conf. dr. Radu-Florin Damian, 1 Ore/Saptamana, Grupa, Orar:

Evaluare

Tip: **Examen**

A: 50%, (Examen/Colocviu)
B: 25%, (Activitate Seminar/Laborator/Proiect)
D: 25%, (Teme de casa/Lucrari de specialitate)

Note

Rezultate totale

Prezenta

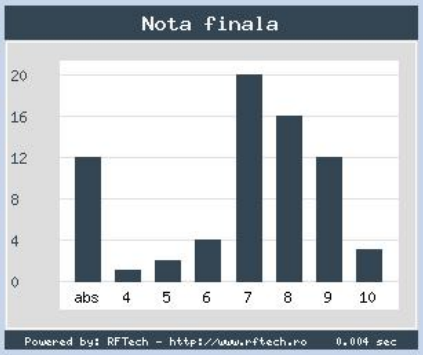
Curs
Laborator

Liste

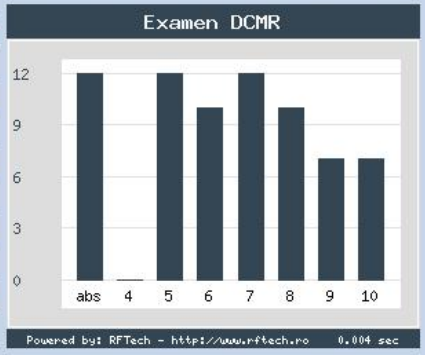
Bonus-uri acumulate (final)
Studenti care nu pot intra in examen

Statistici

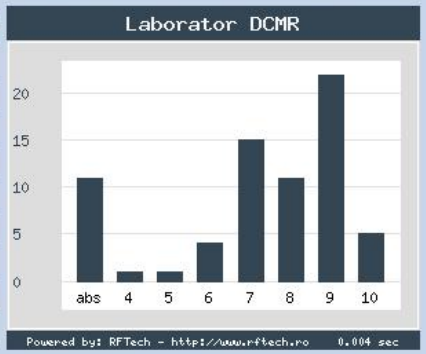
Nota.	Numar
abs	12
4	1
5	2
6	4
7	20
8	16
9	12
10	3
TOTAL	70



Exam.	Numar
abs	12
4	0
5	12
6	10
7	12
8	10
9	7
10	7
TOTAL	70

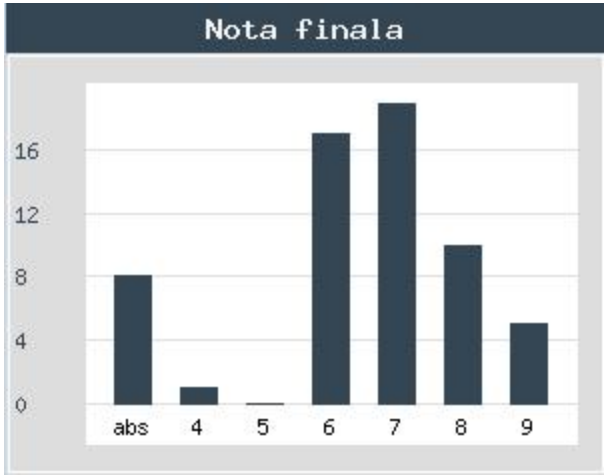


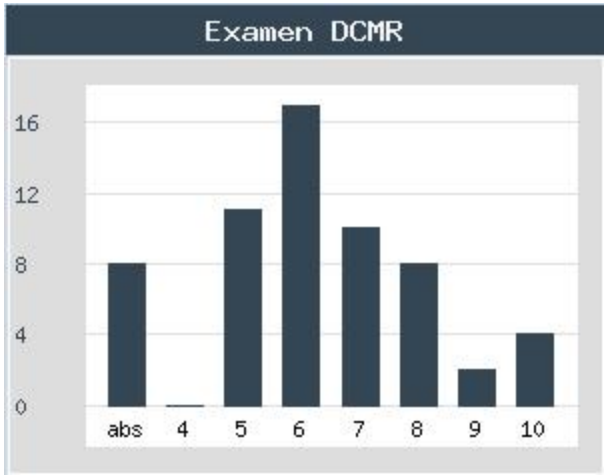
Labo.	Numar
abs	11
4	1
5	1
6	4
7	15
8	11
9	22
10	5
TOTAL	70

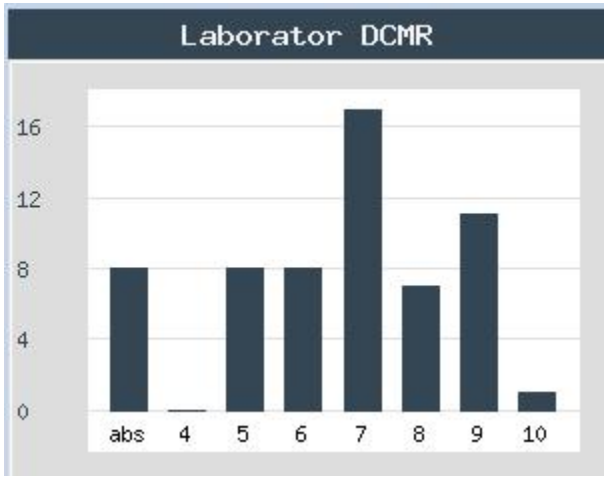


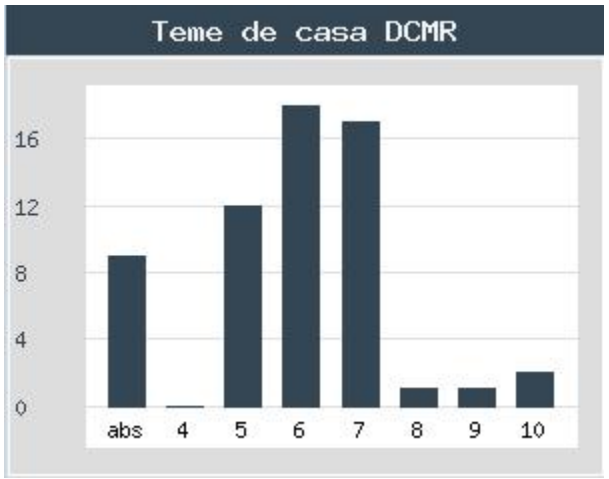
Note

- 2018/2019



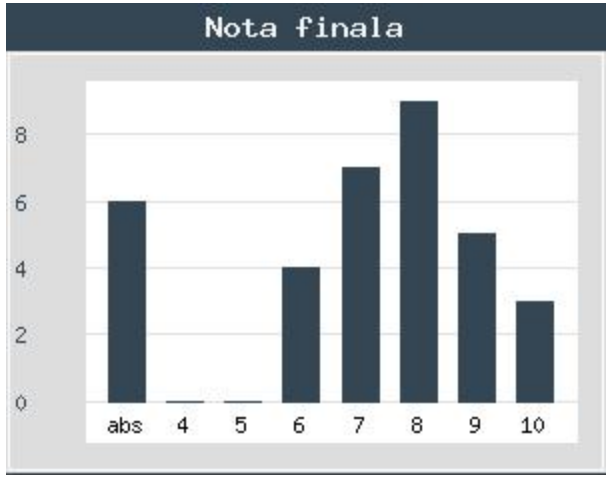


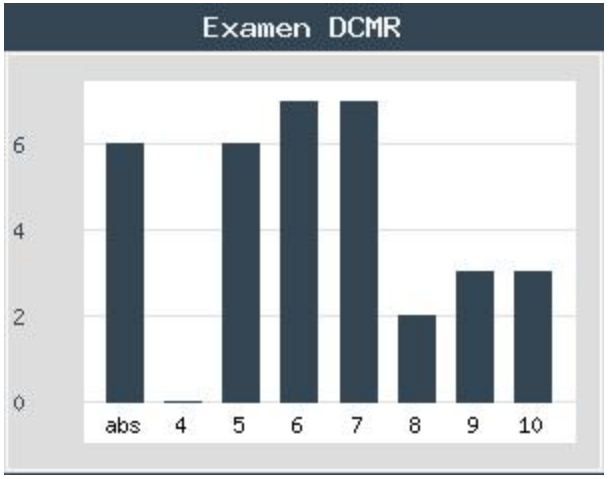


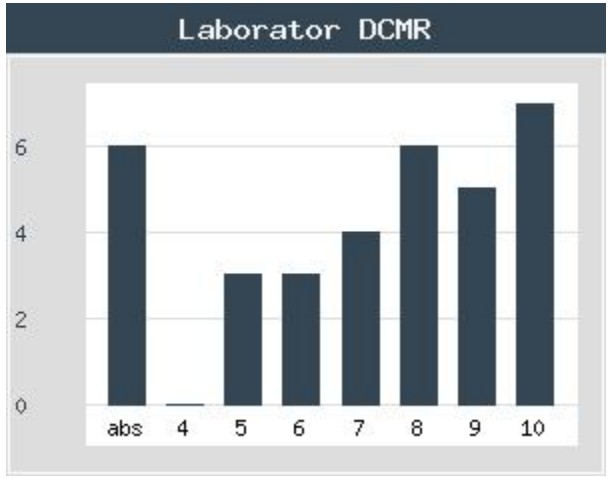


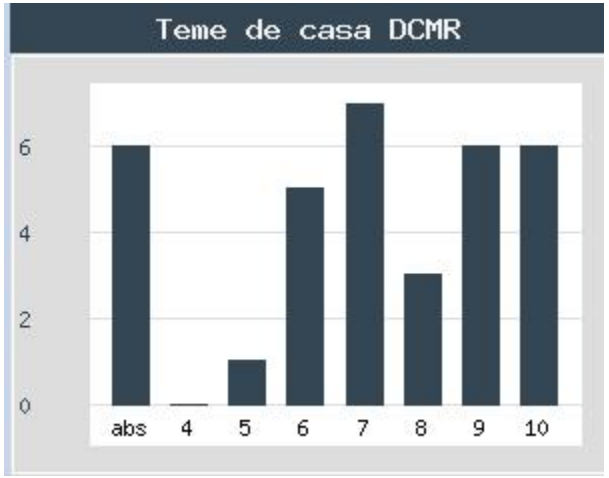
Note

- 2018/2019 -eng









Prezenta, Liste

- Prezenta
- Minim 7 prezente
- Bonus
- Teme proiect
- etc.

Bonus

Grupa	Prezente curs	B. prezenta	B. activitate	B. foto	B. T1	B. T2	B. T3	Total Bonus	Obs.
5405	9	1.5	0	1	0.75	0.2		3.45	-
5405	8	1	0	1	1			3	-
5405	6	1	0	1	1			3	-
5405	7	1	0	1	0.25			2.25	-
5405	2	0	0	1	0.5			1.5	-
5405	11	1.5	0	1	1			3.5	-
5405	9	1.5	0	1	0.75	0.1		3.35	-
5405	0	0	0	0.5	0.375			0.875	-
5405	7	1	0	1	1			3	-
5405	3	0.5	0		0.75			1.25	-
5405	7	1	0	1	0.6			2.6	-
5405	6	1	0	1	0.5		0.1	2.6	-
5405	10	1.5	0	1				2.5	-
5405	12	2	0.5	1	0.625		0.1	4.225	-
5405	6	1	0.5	1	0.6			3.1	-
5405	1	0	0	1	0.5			1.5	-
5405	12	2	0.5	1	0.5		0.5	4.5	-
5405	12	2	1	1	1	0.1	0.25	5.35	-
5406	0	0	0	0.5	0.75			1.25	-

Istoric

Microwave CD | Optical Communications | Optoelectronics | Internet | Antennas | Practica | Networks | Educational software

Examen DCMR 10 feb 2019 (pdf, 934.2 KB, ro,)
Rezolvari 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:

.tuiasi.ro/microwave_cd.php?more=2013

C 2017 Oportunitate de angajare

- Angajare **temporara** disponibila
- Salarizare lunara echivalenta **12800** lei/luna

C 2017 Oportunitate de angajare

- Extrase din evaluările calitative ale studenților (2017):
  - "70% dintre studenti au platit un student de an mai mare sa le faca proiectul, intre 30 si 50 de lei"
- Calcul

$$50\ stud \times 70\% \times 40\ lei = 1400\ lei$$

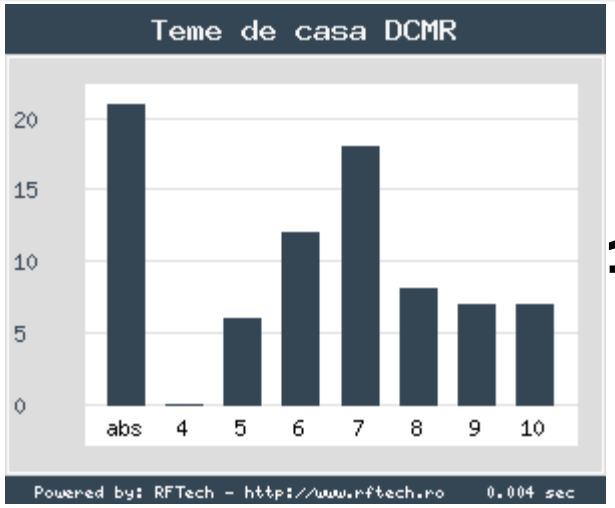
$$50\ stud \times 70\% \times 30\ \min = 17.5\ h$$

$$1\ luna = 4\ sapt \times 5\ zile \times 8\ h = 160\ h$$

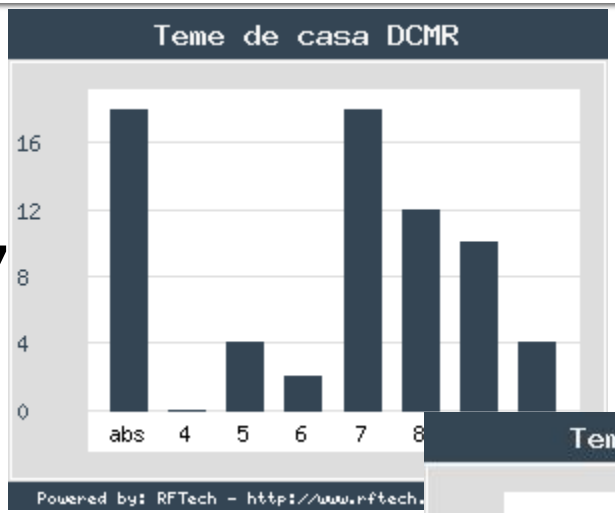
$$\frac{1400\ lei}{17.5\ h} = \frac{12800\ lei}{160\ h} = \frac{12800\ lei}{1\ luna}$$

Efect? – factorul "andrei"

15/6

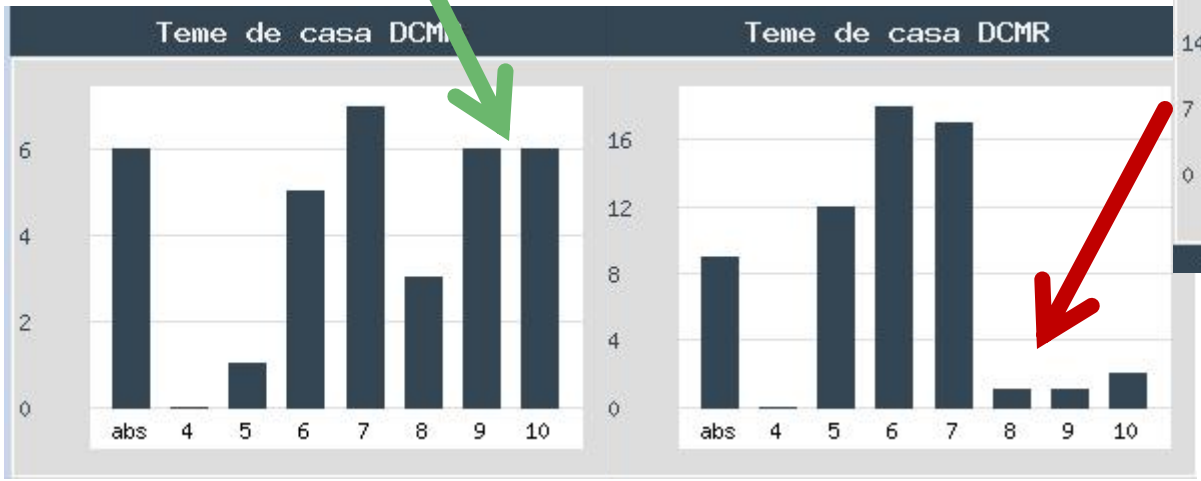


16/7



17/8

18/9



Morala 2017/2018

- Diferența între:
  - un hoț harnic
  - un hoț leneș

Morala 2017/2018

- Hoțul harnic se duce la magazin, cumpăra o rangă, după care se duce personal la locația "crimei" și comite spargerea
- Hoțul leneș își achită ranga prin Internet Banking, și se așteaptă ca proprietarul magazinului de scule să ia ranga, să comită spargerea, să vândă prada și să îi vireze banii in cont

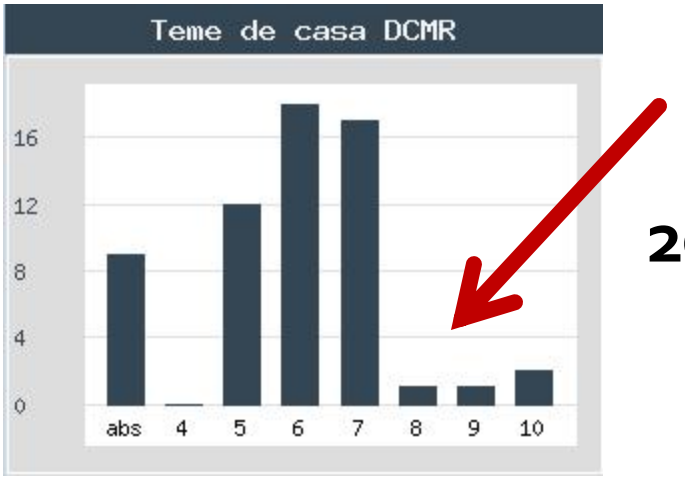
Morala 2017/2018

- Diferența între:
  - un hoț harnic : factorul “andrei” = +1p
  - un hoț leneș : factorul “andrei” = -1p

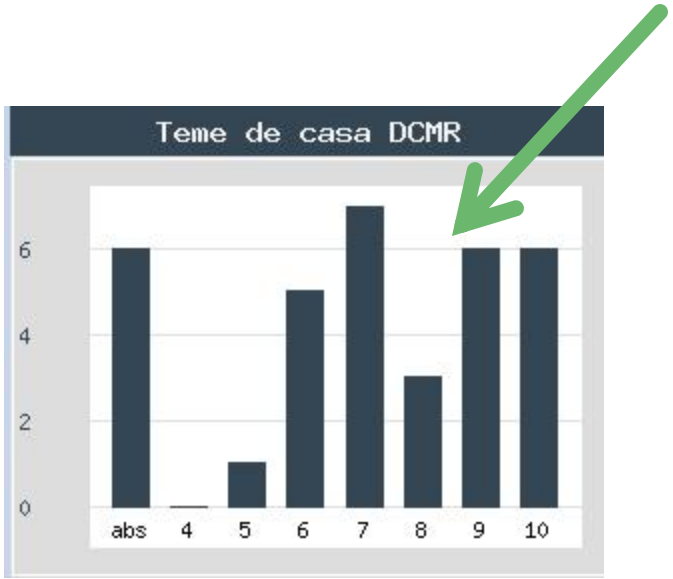
Proiect 2019/2020

- factorul “andrei” = **-2p**

2018/9



2018/9 (e)



C 2019 Oportunitate de angajare

- Angajare **temporara** disponibila
- Salarizare lunara echivalenta **9600** lei/luna

$$50\ stud \text{ x } 70\% \text{ x } (\cancel{30})\ \mathbf{60}\ min = 35\ h$$

$$50\ stud \text{ x } 70\% \text{ x } (\cancel{40})\ \mathbf{60}\ lei = 2100\ lei$$

$$1\ luna = 4\ sapt \times 5\ zile \times 8\ h = 160\ h$$

$$\frac{2100\ lei}{35\ h} = \frac{9600\ lei}{160\ h} = \frac{9600\ lei}{1\ luna}$$

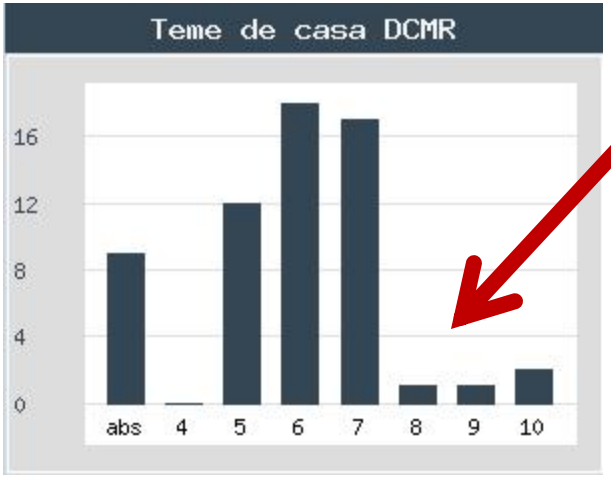
C 2019 Oportunitate de angajare

- Concurenta ☺

$$50\ stud \text{ x } (\cancel{70})\ \mathbf{35}\% \text{ x } (\cancel{40})\ \mathbf{60}\ lei = 1050\ lei$$

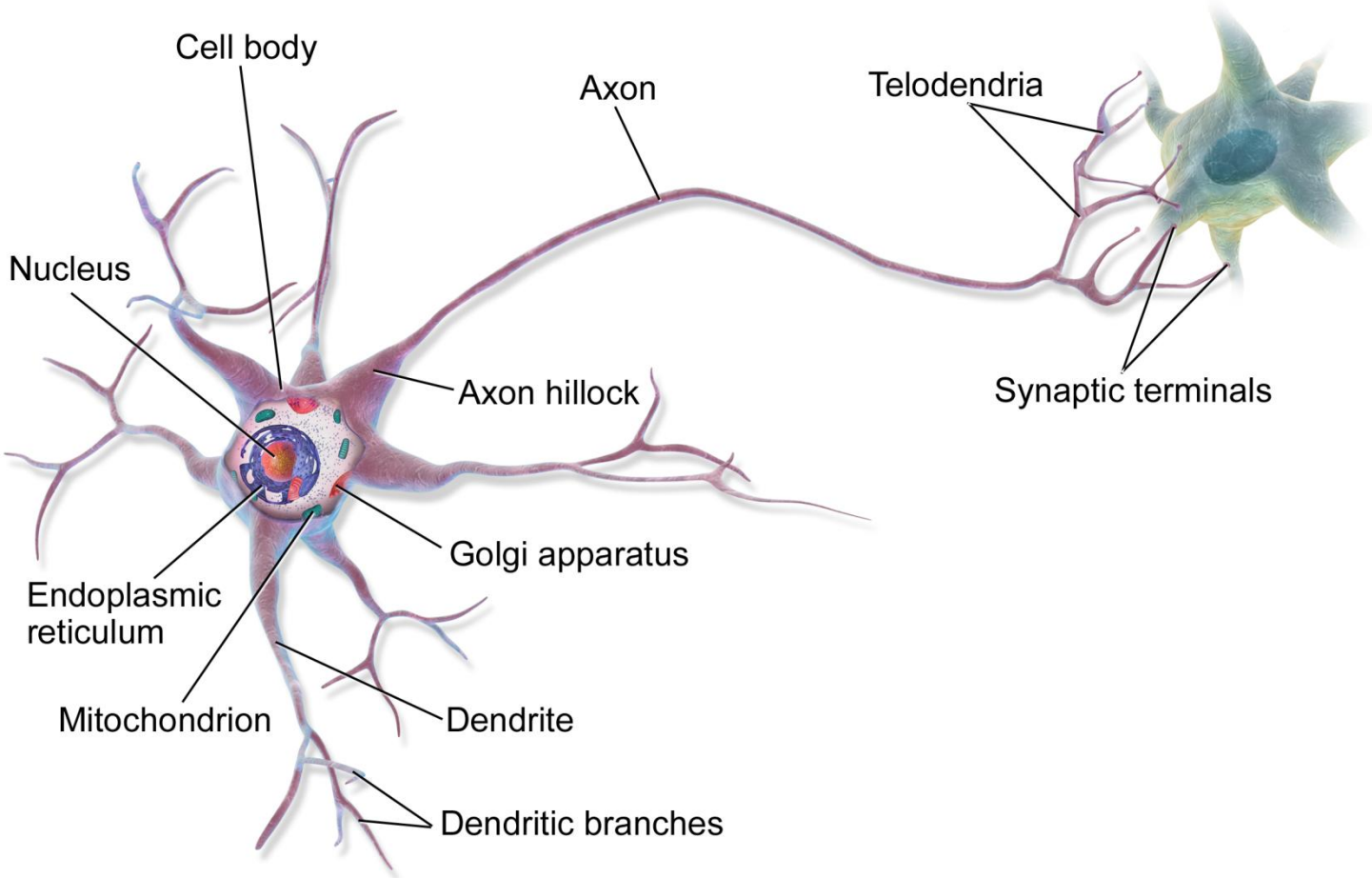
$$\frac{1050\ lei}{17.5\ h} = \frac{9600\ lei}{160\ h} = \frac{9600\ lei}{1\ luna}$$

2018/9

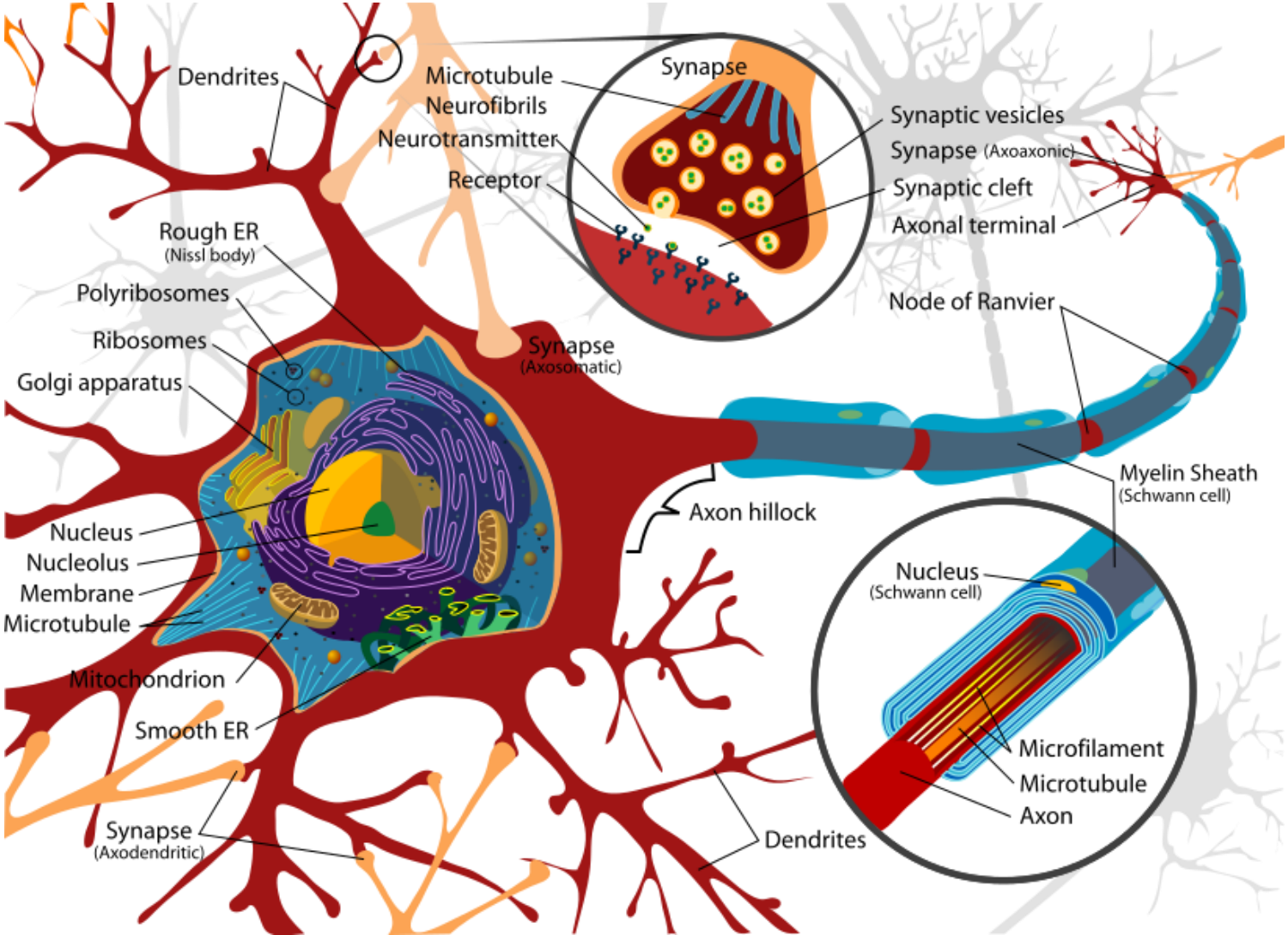


2018/9 (e)

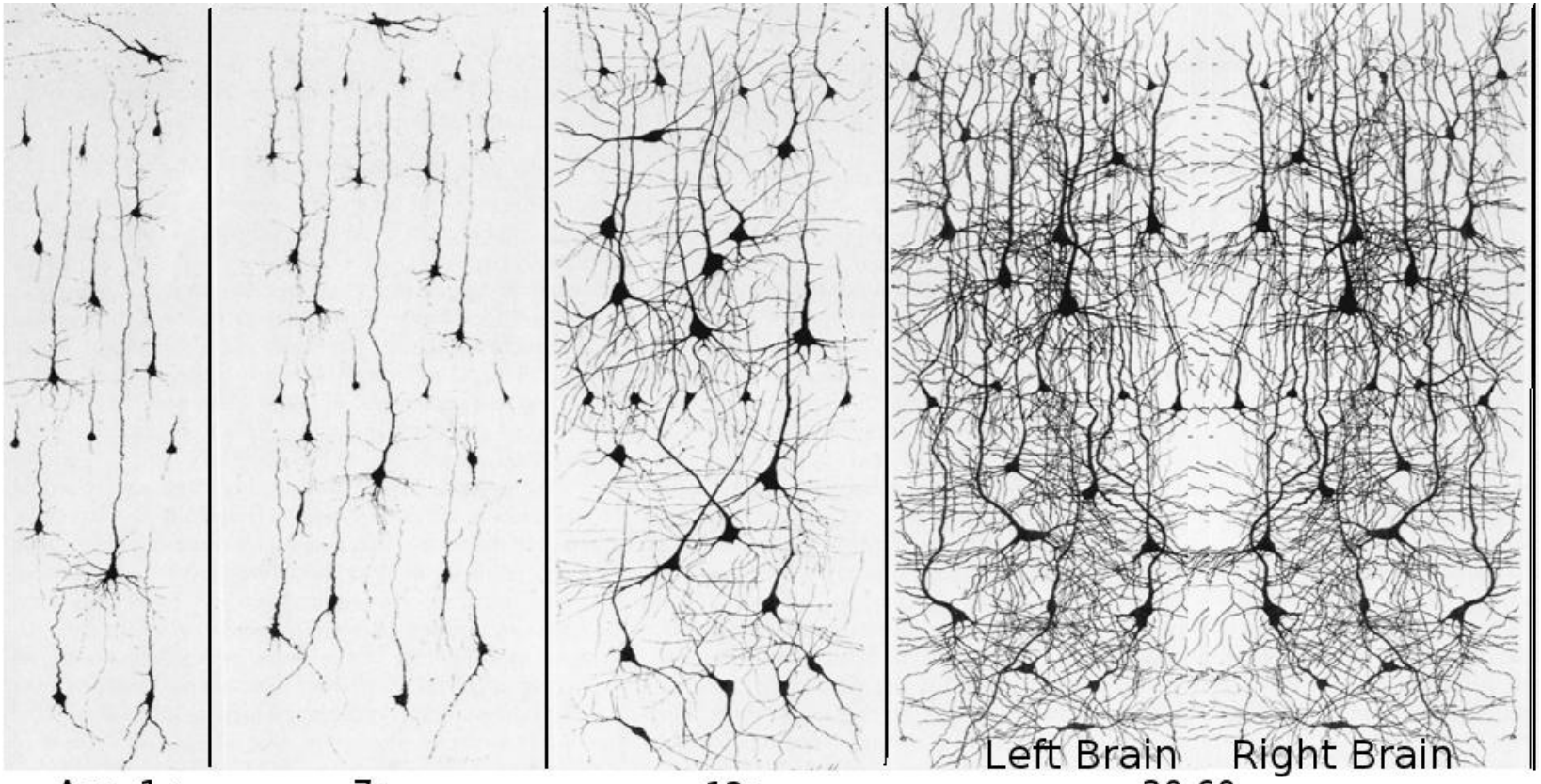
Scop curs 1


Cell body
Axon
Telodendria
Nucleus
Axon hillock
Synaptic terminals
Golgi apparatus
Endoplasmic
reticulum
Mitochondrion
Dendrite
Dendritic branches

Scop curs 2


Dendrites
Microtubule
Neurofibrils
Neurotransmitter
Receptor
Synapse
Synaptic vesicles
Synapse (Axoaxonic)
Synaptic cleft
Axonal terminal
Rough ER
(Nissl body)
Polyribosomes
Ribosomes
Golgi apparatus
Synapse
(Axosomatic)
Node of Ranvier
Myelin Sheath
(Schwann cell)
Axon hillock
Nucleus
Nucleolus
Membrane
Microtubule
Mitochondrion
Smooth ER
Synapse
(Axodendritic)
Nucleus
(Schwann cell)
Microfilament
Microtubule
Axon
Dendrites

Scop curs 3



Age 1+
Infant-
-birth

7+
Child-

13+
-Teen

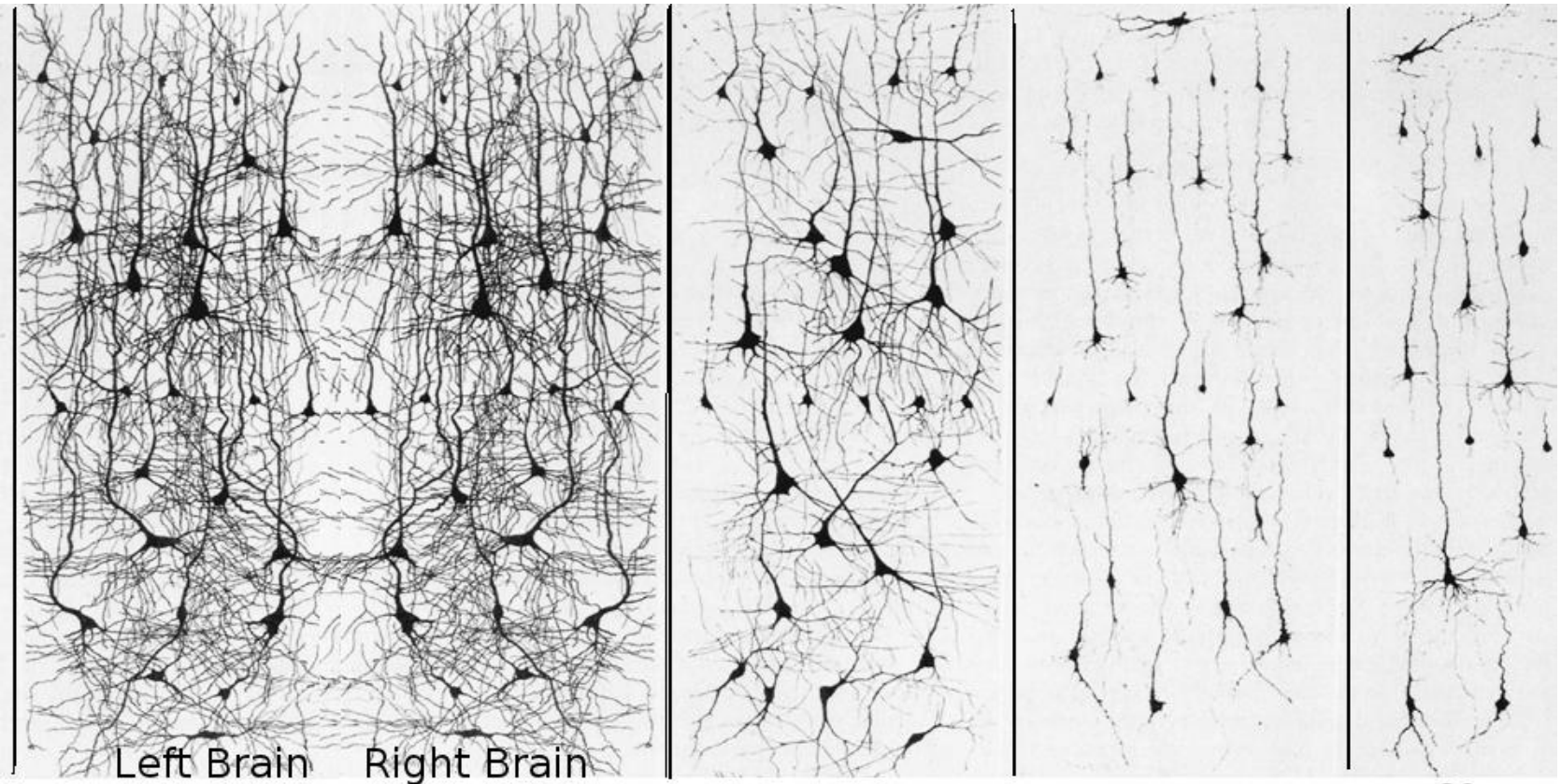
30-60
Adult (Peak)

(Stimulation and Growth)

Scop curs 4

Sinapse
"inginerești"

Termen



30-60

Adult (Peak)

65+

Senior (Decay starts)

70+

Demetia

80+

Alzheimer's
(No Neural

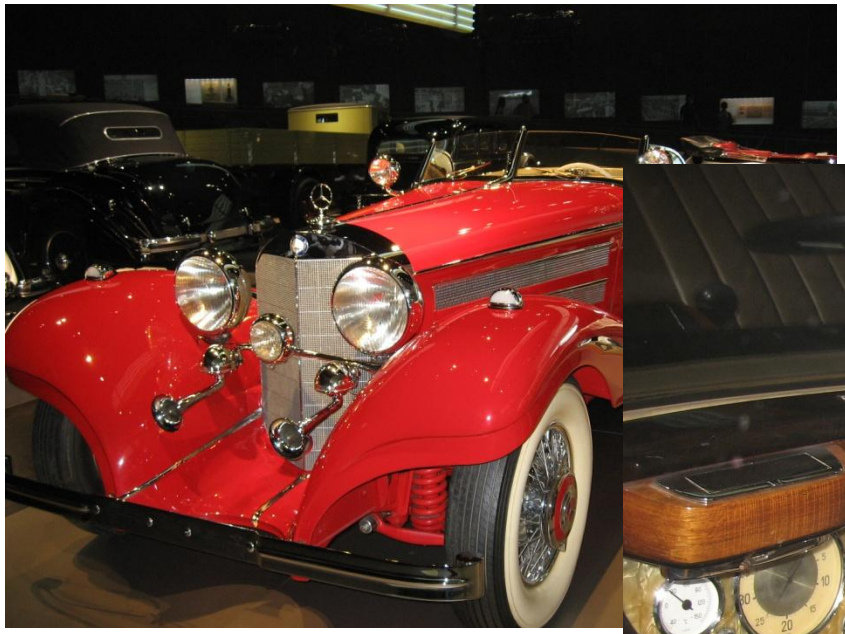
Cuprins

- Linii de transmisie
- Adaptarea de impedanța
- Cuploare direcționale
- Divizoare de putere
- Amplificatoare de microunde
- Filtre de microunde
- Oscilatoare de microunde ?

Bibliografie

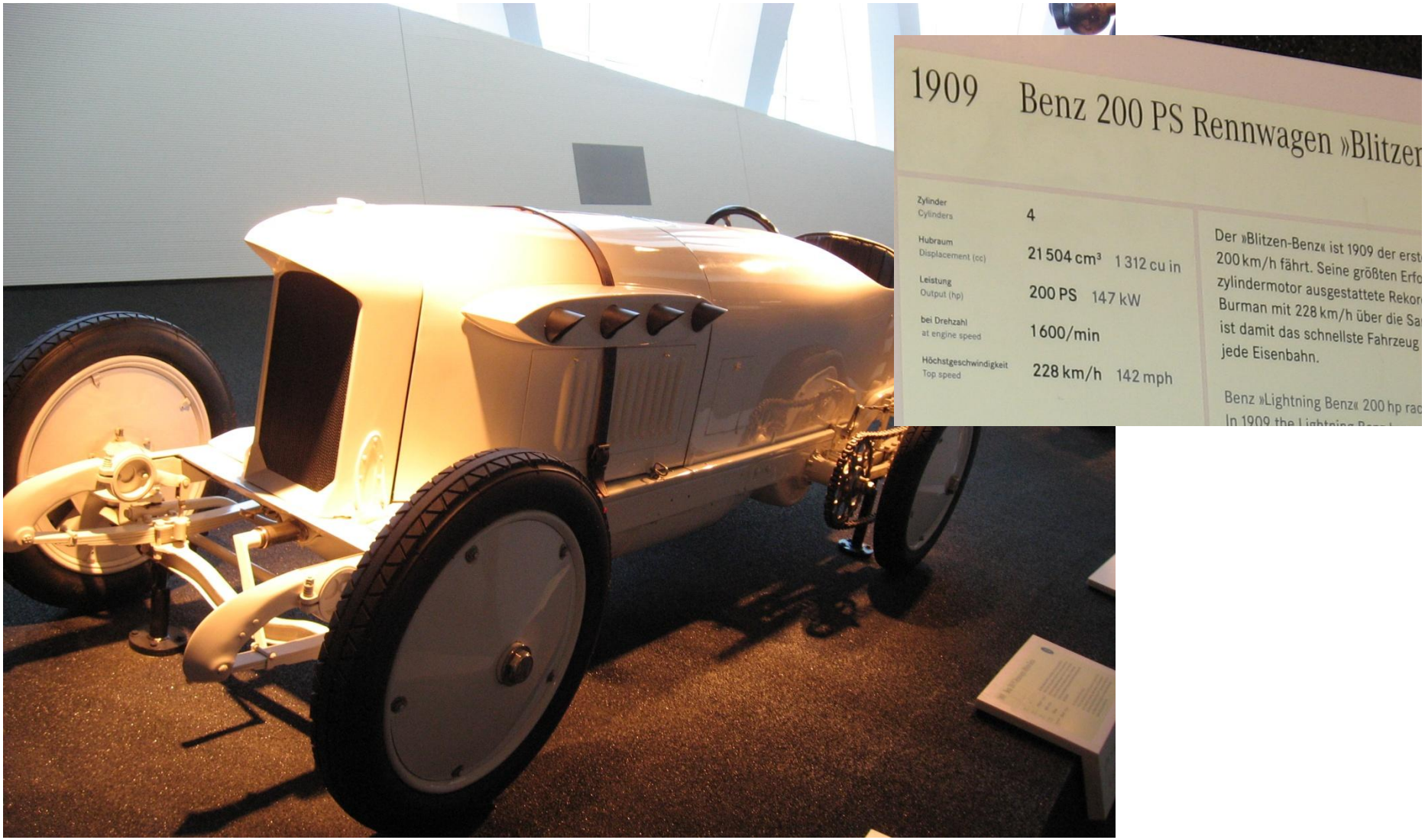
- http://rf-opto.etti.tuiasi.ro
- Irinel Casian-Botez: "Microunde vol. 1: Proiectarea de circuit", Ed. TEHNOPRES, 2008
- David Pozar, Microwave Engineering, Wiley; 4th edition , 2011, ISBN : 978-1-118-29813-8 (E), ISBN : 978-0-470-63155-3 (P)

~1930



~1930

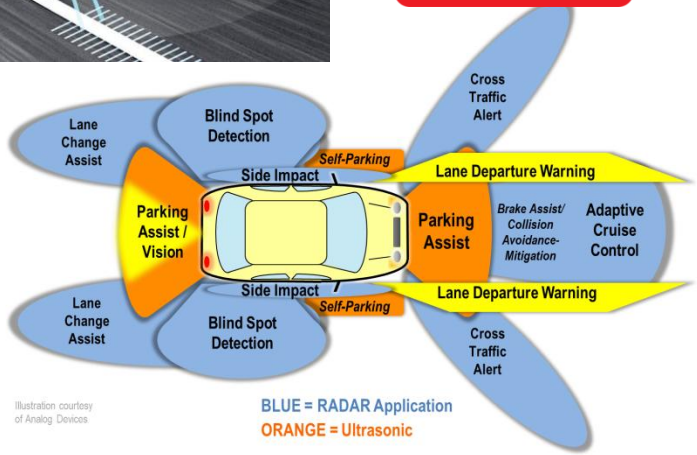
1909


1909
Benz 200 PS Rennwagen »Blitzen
Zylinder
Cylinders
4
Hubraum
Displacement (cc)
21 504 cm³ 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 erst
200 km/h fährt. Seine größten Erfo
zylindermotor ausgestattete Rekor
Burman mit 228 km/h über die Sa
ist damit das schnellste Fahrzeug
jede Eisenbahn.
Benz »Lightning Benz« 200 hp rac

1930-1950

Tehnologie

> 2010

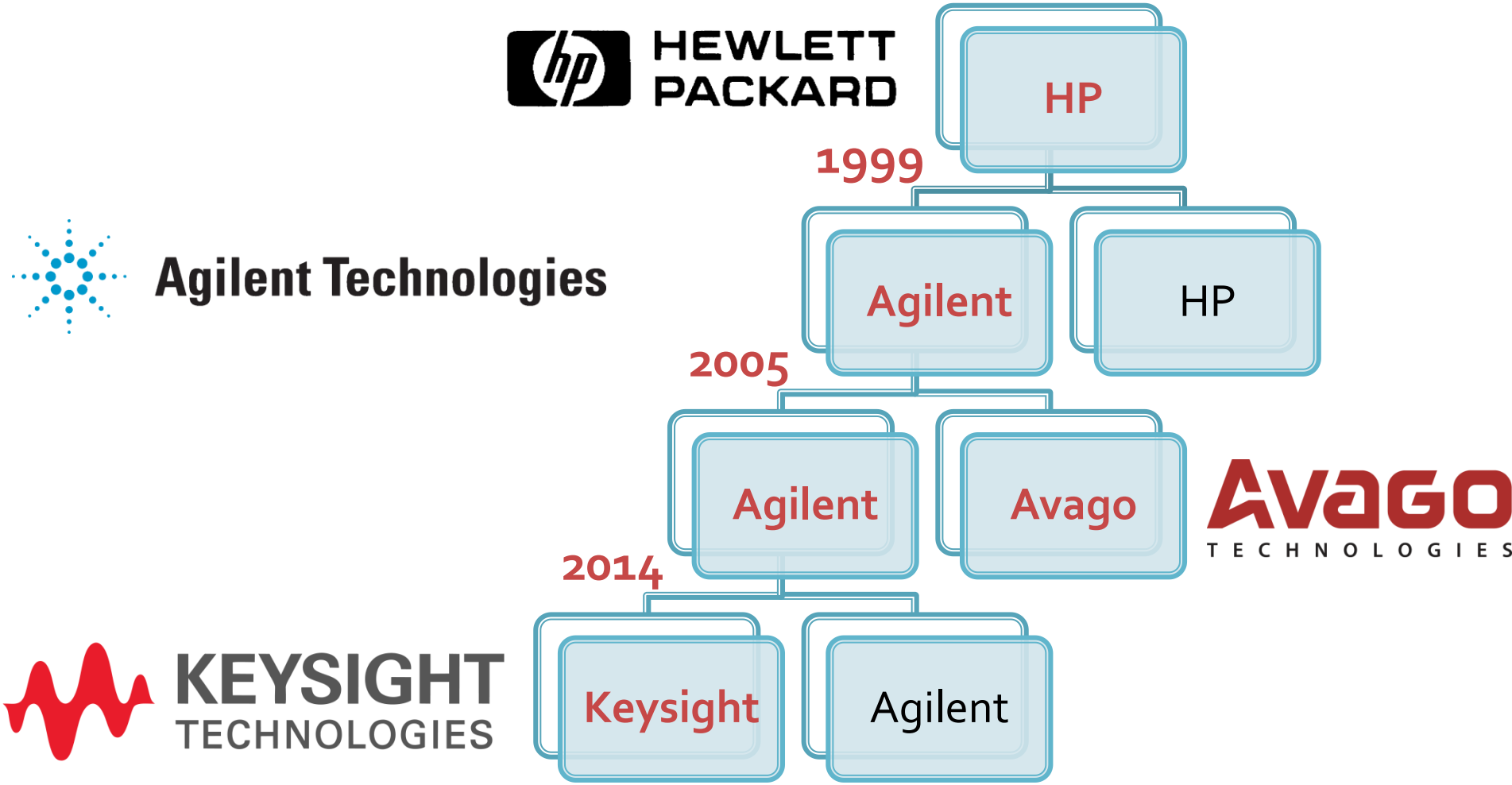


< 1950

Tehnologie

1x1 = 1 1x2 = 2 1x3 = 3 1x4 = 4 1x5 = 5 1x6 = 6 1x7 = 7 1x8 = 8 1x9 = 9 1x10 = 10	2x1 = 2 2x2 = 4 2x3 = 6 2x4 = 8 2x5 = 10 2x6 = 12 2x7 = 14 2x8 = 16 2x9 = 18 2x10 = 20	3x1 = 3 3x2 = 6 3x3 = 9 3x4 = 12 3x5 = 15 3x6 = 18 3x7 = 21 3x8 = 24 3x9 = 27 3x10 = 30	4x1 = 4 4x2 = 8 4x3 = 12 4x4 = 16 4x5 = 20 4x6 = 24 4x7 = 28 4x8 = 32 4x9 = 36 4x10 = 40	5x1 = 5 5x2 = 10 5x3 = 15 5x4 = 20 5x5 = 25 5x6 = 30 5x7 = 35 5x8 = 40 5x9 = 45 5x10 = 50
6x1 = 6 6x2 = 12 6x3 = 18 6x4 = 24 6x5 = 30 6x6 = 36 6x7 = 42 6x8 = 48 6x9 = 54 6x10 = 60	7x1 = 7 7x2 = 14 7x3 = 21 7x4 = 28 7x5 = 35 7x6 = 42 7x7 = 49 7x8 = 56 7x9 = 63 7x10 = 70	8x1 = 8 8x2 = 16 8x3 = 24 8x4 = 32 8x5 = 45 8x6 = 48 8x7 = 56 8x8 = 64 8x9 = 72 8x10 = 80	9x1 = 9 9x2 = 18 9x3 = 27 9x4 = 36 9x5 = 45 9x6 = 54 9x7 = 63 9x8 = 72 9x9 = 81 9x10 = 90	10x1 = 10 10x2 = 20 10x3 = 30 10x4 = 40 10x5 = 50 10x6 = 60 10x7 = 70 10x8 = 80 10x9 = 90 10x10 = 100

2x1 = 2
2x2 = 4
2x3 = 6
2x4 = 8
2x5 = 10
2x6 = 12
2x7 = 14
2x8 = 16
2x9 = 18
2x10 = 20

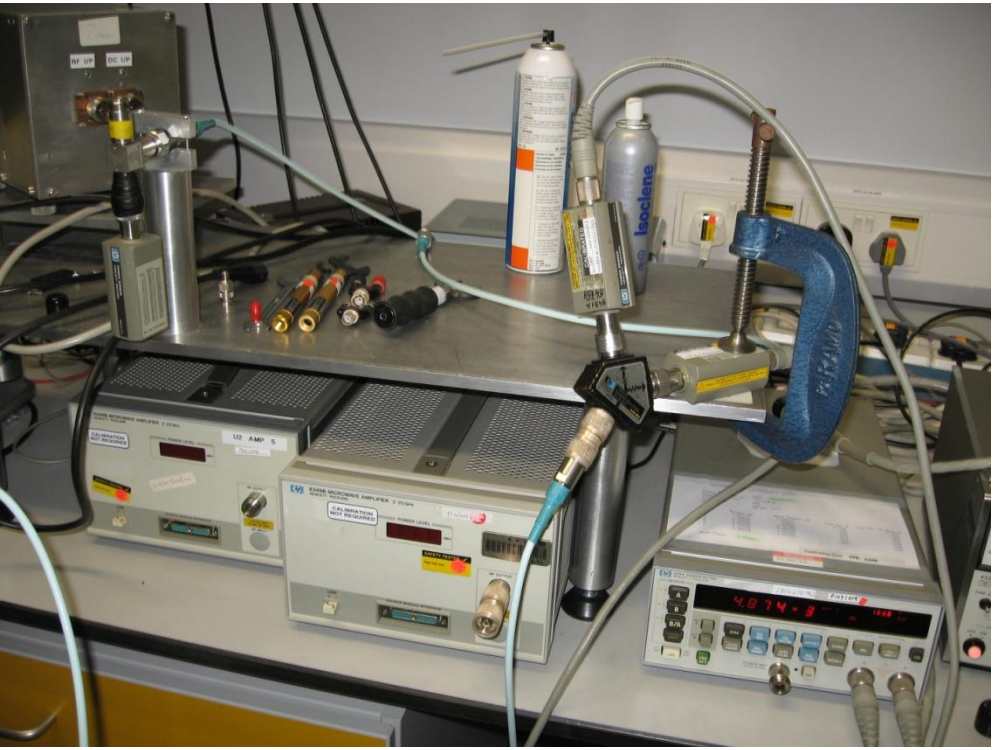

HEWLETT PACKARD
HP
1999
Agilent Technologies
Agilent
HP
2005
Agilent
Avago
AVAGO TECHNOLOGIES
2014
KEYSIGHT TECHNOLOGIES
Keysight
Agilent

NPL, Londra


HEWLETT PACKARD
8510


NATIONAL PHYSICAL LABORATORY
HEWLETT PACKARD
NETWORK ANALYZER
8510
SAFETY TESTED

NPL, Londra




8349B MICROWAVE AMPLIFIER 2-20GHz
HEWLETT PACKARD
CALIBRATION NOT REQUIRED
POWER LE


438A POWER METER
HEWLETT • PACKARD
SENSOR
A
B


8349B MICROWAVE AMPLIFIER 2-20GHz
HEWLETT PACKARD
CALIBRATION NOT REQUIRED
POWER LEVEL

Examen: Reprezentare logaritmică

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

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

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

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 μW
-30 dBm	= 1 μW
-60 dBm	= 1 nW

[dBm] + [dB] = [dBm]

[dBm/Hz] + [dB] = [dBm/Hz]

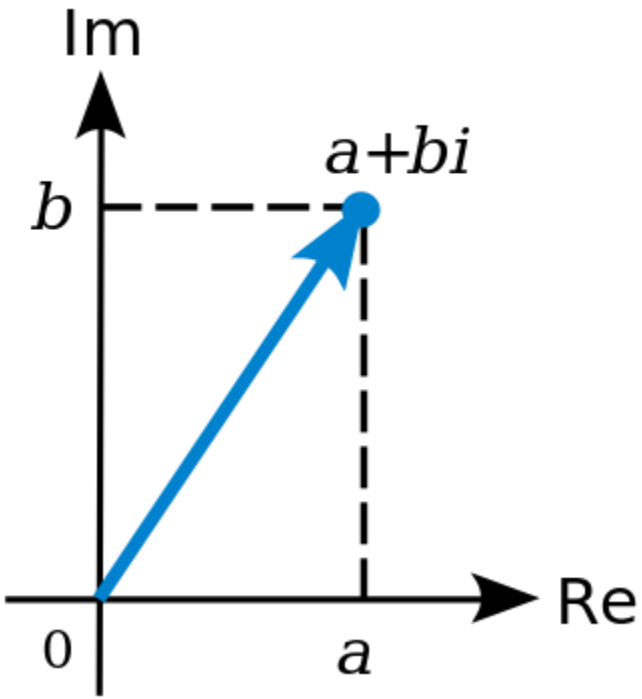
[x] + [dB] = [x]

Examen

- Operatii cu numere complexe!
- $z = a + j \cdot b$; $\mathbf{j^2 = -1}$

Plan complex

- abscisa – partea reala
- ordonata – partea imaginara
- oricare poate fi negativa, intregul plan, 4 cadrane



Operatii

- Adunare

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

- Scadere

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

- Inmultire

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

- Impartire

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

Complex Conjugat

- z $\quad z = a + j \cdot b$
- z^* $\quad z^* = a - j \cdot b$
- Simetric fata de axa **reala**

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

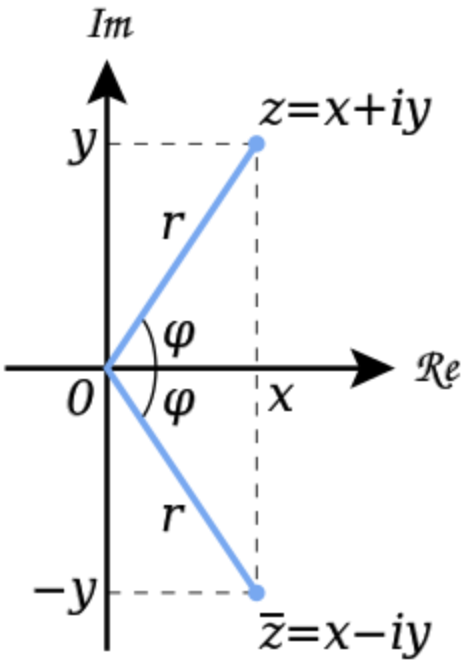
$$\mathrm{Im}(z) = b = \frac{1}{2 \cdot j} \cdot \left(z - z^*\right) = \frac{j}{2} \cdot \left(z^* - z\right)$$

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

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

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

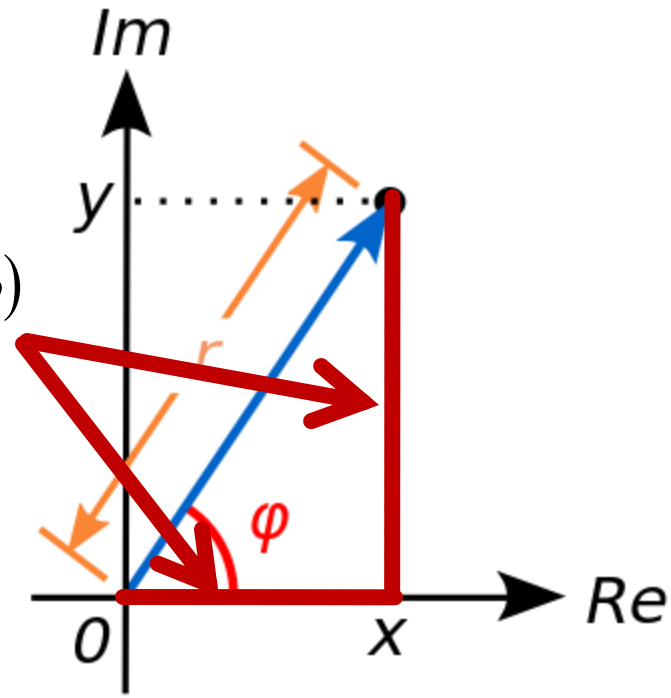
$$(z / w)^* = z^* / w^*$$



Reprezentare polara

- Reprezentare polara
  - modul
  - faza

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



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

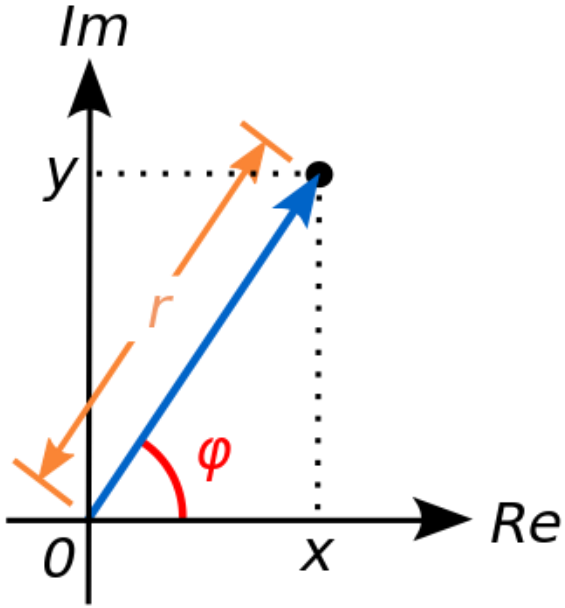
$$\varphi = \arg(z) = \begin{cases} \arctan\left(\frac{b}{a}\right), & a > 0 \\ \arctan\left(\frac{b}{a}\right) + \pi, & a < 0, b \geq 0 \\ \arctan\left(\frac{b}{a}\right) - \pi, & a < 0, b < 0 \\ \frac{\pi}{2}, -\frac{\pi}{2}, nedefinit & a = 0 \end{cases}$$

Reprezentare polara

- Formula lui Euler

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

- Reprezentare polara



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

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

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

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

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

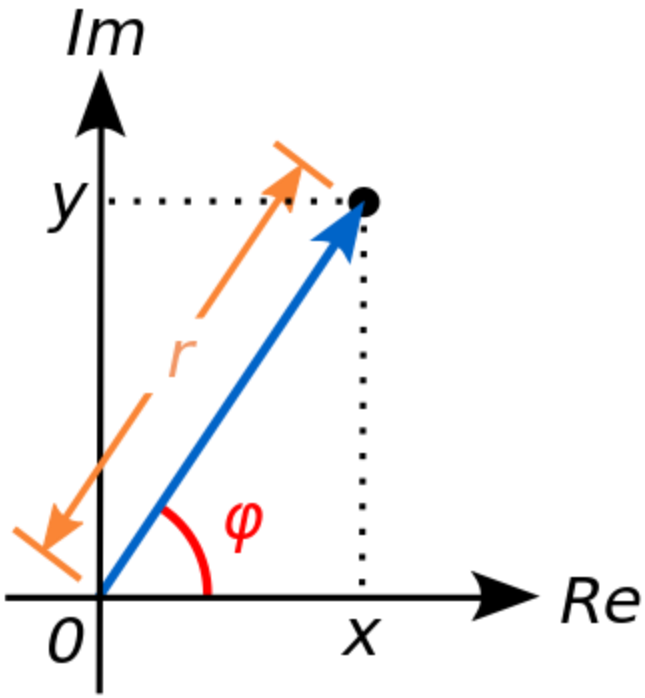
$$z/w = \frac{|z|\cdot e^{j\cdot\varphi}}{|w|\cdot e^{j\cdot\theta}} = \frac{|z|}{|w|}\cdot e^{j\cdot\varphi}\cdot e^{-j\cdot\theta} = \frac{|z|}{|w|}\cdot e^{j\cdot(\varphi-\theta)} = \frac{|z|}{|w|}\cdot\left[\cos(\varphi-\theta) + j\cdot\sin(\varphi-\theta)\right]$$

Reprezentare polara

- Reprezentare polara

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

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



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

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

$$z^* = \left(|z| \cdot e^{j\cdot\varphi}\right)^* = |z| \cdot \left(\cos\varphi + j \cdot \sin\varphi\right)^* = |z| \cdot \left(\cos\varphi - j \cdot \sin\varphi\right) =$$

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

Reprezentare polara

- unitate de masura standard – radiani
- unitate de masura traditionala in microunde – **grade format zecimal** (55.89°)

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

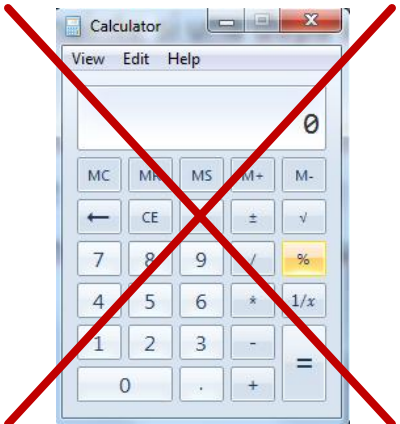
$$\varphi[°] = 180° \cdot \frac{\varphi[rad]}{\pi} \qquad \varphi[rad] = \pi \cdot \frac{\varphi[°]}{180°}$$

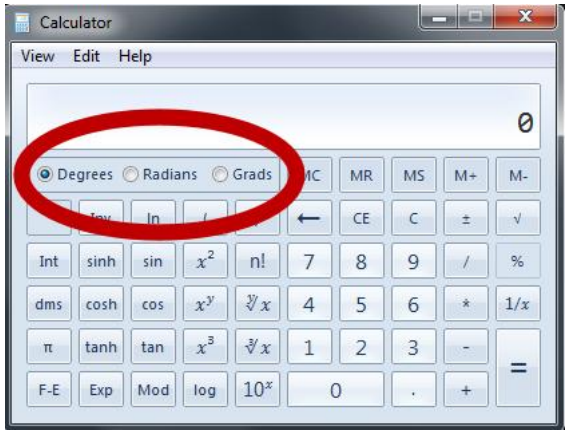
Reprezentare polara

- **Atentie la reprezentarea unghiurilor!!**
  - programele matematice – lucreaza standard in radiani
    - e necesara o **conversie** inainte si una dupa aplicarea unei functii trigonometrice
  - calculatoarele (stiintifice) au posibilitatea (de obicei) de a stabili unitatea de masura pentru unghiuri
    - e necesara **verificarea** unitatii de masura curente

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

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





Contact

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