

Optoelectronică

Curs 1

2023/2024

- ▶ La facultate, profesorul intreaba:
 - Intrebare de "nota 10": cum ma numesc?
Toti tac.
 - Intrebare de "nota 8": la ce obiect aveti examen?
Toti tac.
 - Intrebare de "nota 5": ce culoare are manualul (site-ul laboratorului)?
- Din ultimele randuri se aude o voce:
- Vrea sa ne pice magaru'!

Disciplina 2023/2024

- ▶ 2C/1L Optoelectronică **OPTO**
- ▶ **Minim 7 prezente curs + laborator**
- ▶ Curs – conf. **Radu Damian**
 - an IV μ E
 - Marti 14(**:10**)-16:00, P8
 - E – 70% din nota (50%+20%)
 - **20% test (VP) la curs**, saptamana 4-6?
 - probleme + (2p prez. curs)
 - toate materialele permise
- ▶ Laborator – **drd. Stefan Stoica**
 - an IV μ E
 - Marti 16-20 par
 - Max. 7 prezente
 - L – 30% din nota (+Caiet de laborator)

Orar 2023/2024

▶ Curs

◦ Marti 14(:10)–16:00, P8

◦ ~~2C~~ ⇒ ~~3C~~

• ~~$14 * 2/3 \approx 9.33$~~

• ~~$9 : 10 C \approx 9C + E$~~

Cuprins

- ▶ **Lumina ca undă electromagnetică*** (ecuațiile lui Maxwell, ecuația undelor, parametri de propagare)
- ▶ **Elemente de fotometrie și radiometrie*** (mărimi energetice/luminoase)
- ▶ **Fibra optică** (realizare, principiu de funcționare, atenuare, dispersie, banda de frecvență)
- ▶ **Cabluri optice** (tehnologie, conectori, lipire – splice)
- ▶ **Proiectare sistemică a legăturii pe fibra optică** (bandă de frecvență, balanța puterilor)
- ▶ **Emitătoare optice** (LED și dioda laser – realizare fizică și funcționare)
- ▶ **Receptoare optice** (dioda PIN, dioda cu avalanșă – realizare fizică și funcționare)
- ▶ **Amplificatoare transimpedanță** (parametri, scheme tipice, TIA în buclă deschisă, cu reacție, diferențiale, control automat al câștigului)
- ▶ **Realizarea circuitelor pentru controlul emițătoarelor optice** (parametri, scheme tipice, controlul puterii, multiplexoare)
- ▶ **Dispozitive de captare a energiei solare** (principiu de funcționare, utilizare, proiectare)

* – VP

Bibliografie

- ▶ <http://rf-opto.etti.tuiasi.ro>
- ▶ Irinel Casian-Botez, "Structuri Optoelectronice", Ed. "CANOVA", Iasi 2001, ISBN 973-96099-2-9
- ▶ Behzad Razavi – Design of Integrated Circuits for Optical Communications, Mc Graw Hill
- ▶ John Powers – An Introduction to Fiber Optic Systems
- ▶ IBM – Understanding Optical Communications: on-line <http://www.redbooks.ibm.com>
- ▶ Radu Damian, I Casian, D Matăsaru – „Comunicatii Optice” , Indrumar de laborator, 2005
- ▶ MIT Course – Fundamentals of Photovoltaics, <https://ocw.mit.edu>

Documentatie



STARECAT.COM

Documentatie

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

[Microwave CD](#) [Optical Communications](#) [Optoelectronics](#) [Internet](#) [Antennas](#) [Technology/Noise](#) [Practica](#)

Optoelectronics

Course: OPTO (2023-2024)

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

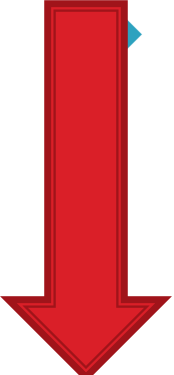
2022-2023	2021-2022	2020-2021	2019-2020	2018-2019	More years...
---------------------------	---------------------------	---------------------------	---------------------------	---------------------------	-------------------------------

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

Documentatie

- ▶ RF-OPTO
 - <http://rf-opto.etti.tuiasi.ro>
- ▶ Fotografie
 - “examen” online
 - necesara la laborator/curs

Istoric



Main **Courses** Master Staff Research Students

Microwave CD Optical Communications **Optoelectronics** Internet Antennas Technology/Noise Practica

Optoelectronics

Course: OPTO (2023-2024)

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

2022-2023	2021-2022	2020-2021	2019-2020	2018-2019	More years...
-----------	-----------	-----------	-----------	-----------	---------------

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

Istoric 2004–2022

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 Section
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)

Grades

[Aggregate Results](#)

Attendance

Previous years

2018-2019

2017-2018

2016-2017

2015-2016

2014-2015

2013-2014

2012-2013

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

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	5184

[Acceseaza ca acest student](#)

Note obtinute

Disciplina	Tip	Data	Descriere	Nota	Pondere	Obs.
TW						
	N	17/01/2014	Nota Finala	10	-	
	A	17/01/2014	Colocenta 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:

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

Fotografii

Start Didactic Master Colectiv Cercetare **Studenti** Admin

Note Lista Studenti Fotografii Statistici

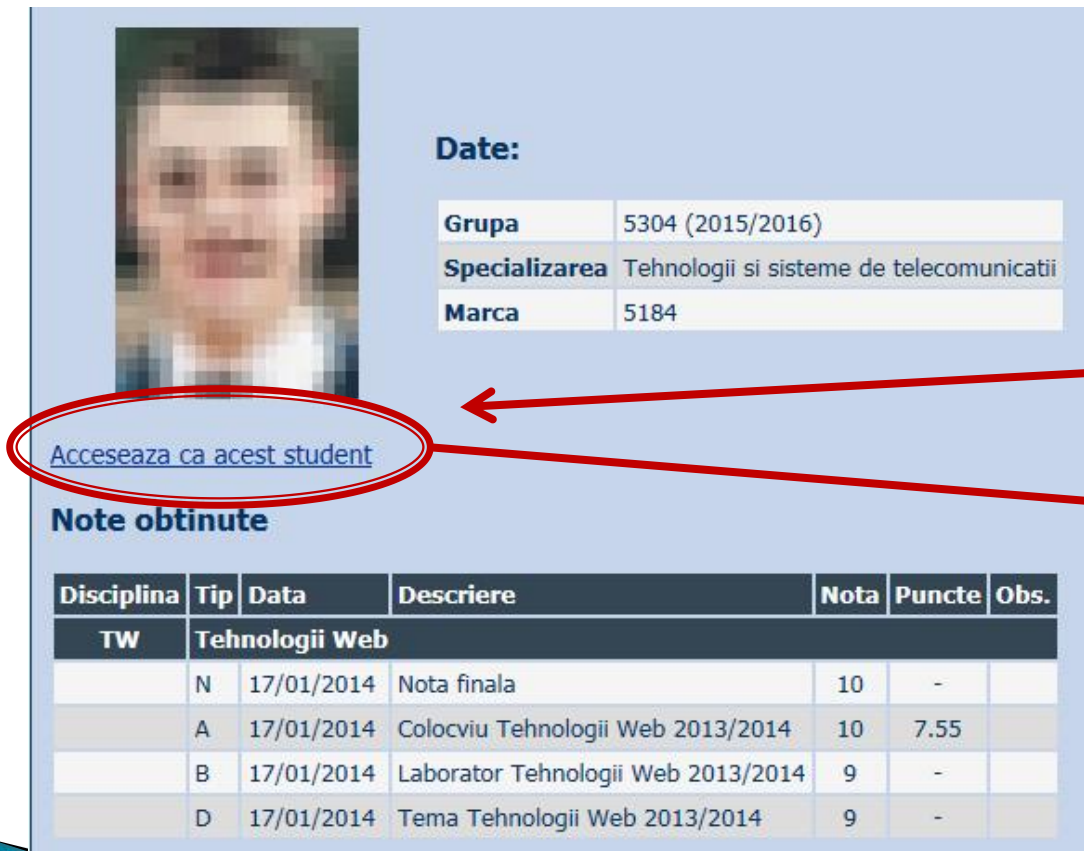
Grupa 5403

Nr. Student	Prezent	Nr. Student	Prezent	Nr. Student	Prezent
1 ANGHIELUS 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 IULIAN-PETRU	<input checked="" type="checkbox"/> Puncte: 0 Nota: 0 Obs:	6 BOSTAN ANDREI-PETRIKA	<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 COJOCARI AURA-FLORINA	<input type="checkbox"/> Puncte: 0 Nota: 0 Obs:

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

Acces

▶ Personalizat



Student profile card showing a photo, personal details, and a table of grades.

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	-	

Form for student access with the following fields:

- Nume:
- Email:
- Cod de verificare:
- Trimite:

Red circles highlight the Email field, the verification code field, and the verification code itself. Red arrows point from the 'Acceseaza ca acest student' link to the Email and verification code fields.

Bonus (~0.5–4.15)

Disciplina: Optoelectronica, structuri, tehnologii, circuite

An: 2015/2016

Bonus-uri care se aplica la nota de la teza obtinute prin:

- prezenta la curs (0.5p / 3pr)
- 3 miniteste aplicate la curs (max. 3 X 1.5p)
- contributie la site rf-opto (foto <C5=1p, >C5=0.5p)

Nr.	Student	Grupa	Prezente curs	Bonus prezenta	Bonus foto	Bonus T1	Bonus T2	Bonus T3	Total Bonus	Obs.
1	CIOLPAN OCTAVIAN	5306	3	0.5					0.5	-
2	NITA COSTEL-CATALIN	5307	4	0.5	1				1.5	-
3	BARON BOGDAN-IONUT	5405	12	2	1	0.5		0.75	4.25	-

Prezenta

[Curs](#)
[Laborator](#)

Liste

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

- ▶ **Minim** 7 prezente
- ▶ 0.5p/3prez
- ▶ 3 teste
- ▶ foto <C3 / <C5

Online

- ▶ acces la **examene** necesita **parola** primita prin **email**

English | Romana |

Start Didactic Master Colectiv Cercetare Stud

Note Lista Studenti Examene Fotografii

POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica si telecomunicatii
Marca	7000021

Acceseaza ca acest student | [cere acces la licente](#)

Note obtinute

Inca nu a fost notat.

Start Didactic Master Colectiv C

Note Lista Studenti Examene Fotografii

Identificare

Introduceti numele si adresa de email utilizata la inscriere

Nume
POPESCU GOPO

E-mail/Parola

Introduceti codul afisat mai jos

4db4457

Trimite

Online

► acces email/parola

Start Didactic Master Colectiv

Note Lista Studenti Examene Fotografii

POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica
Marca	7000021

Se acceseaza site-ul [ca acest student!](#)

Start Didactic Master Colectiv C

Note Lista Studenti Examene Fotografii

POPESCU GOPO ION

Fotografia nu exista

Date:

Grupa	5700 (2019/2020)
Specializarea	Inginerie electronica s
Marca	7000021

Se acceseaza site-ul [ca acest student \(inclusiv examene\)!](#)

Parola

▶ primita prin 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 atentie: 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 MIDCR exam from 02/05/2020

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 atentie: 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

Adrese email

▶ Sefii de grupa!

- lista cu adrese de email **utilizate** de toti studentii care doresc acces la toate informatiile de pe site
 - poate fi @student.etti.tuiasi.ro (@gmail @yahoo etc.)
- -> **rdamian@etti.tuiasi.ro**

Manual examen online

- ▶ Aplicatia de examen online utilizata la:
 - ~~curs (prezenta)~~
 - ~~miniteste~~
 - ~~examen~~

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

Examen online

- ▶ intotdeauna **contratimp**
 - perioada lunga (prezenta curs/fotografii)
 - perioada scurta (teste: 15min, examen: 2h)

Start Didactic Master Colectiv Cercetare **Studenti**

Note Lista Studenti **Examene** Fotografii

Anunț
17:28 (29/04/2020)

Material suport
17:30 (29/04/2020)

Subiecte
17:32 (29/04/2020)

Rezultate
17:35 (29/04/2020)

Finalizare
17:45 (29/04/2020)

Confirmare
17:45 (30/04/2020)

urmatorul interval de timp in.
01 m 08 s
[Reincarca acum](#)

Anunț

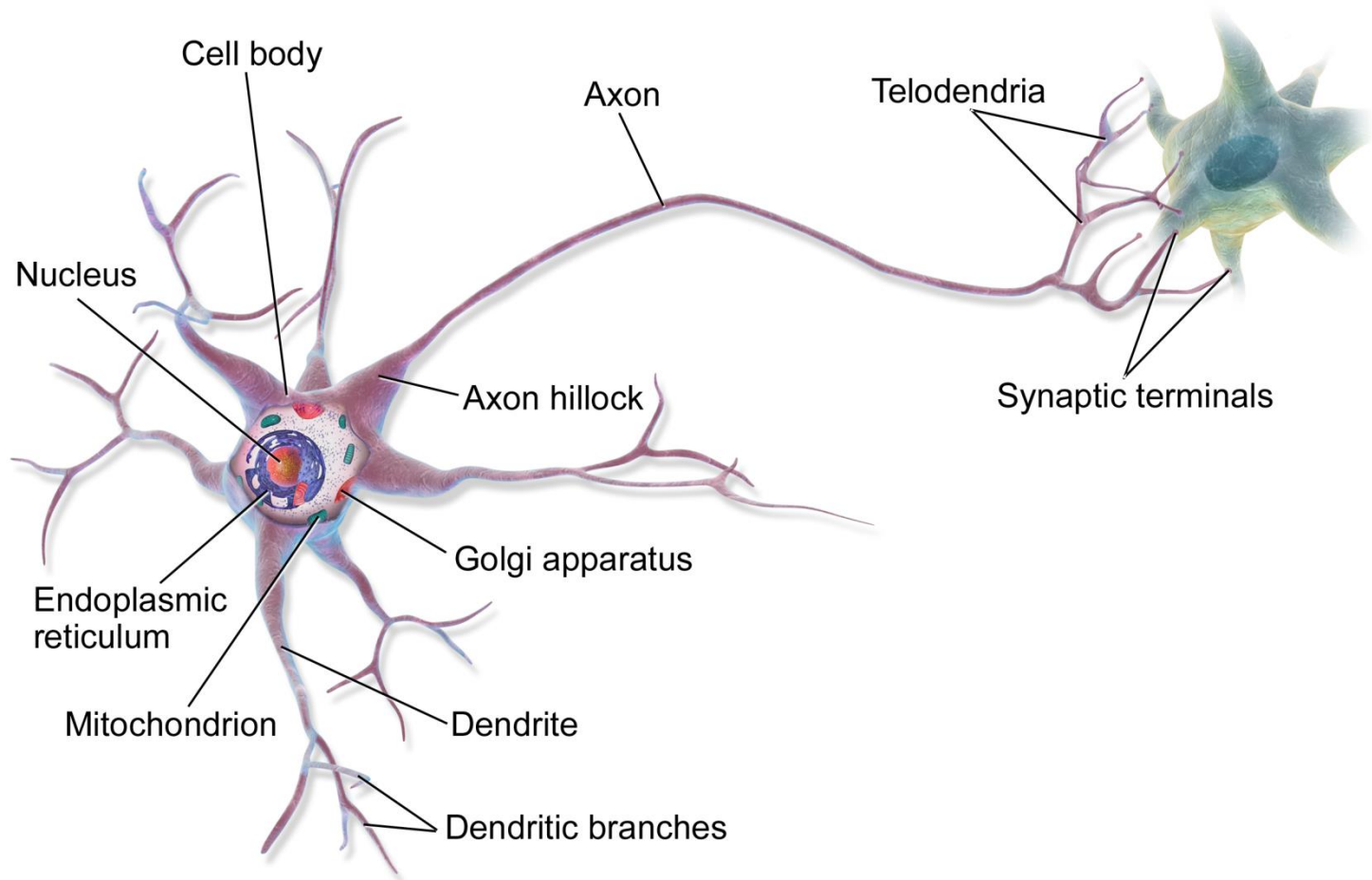
In acest examen se verifica diverse actiuni ale studentilor pentru examen

Ora pe server

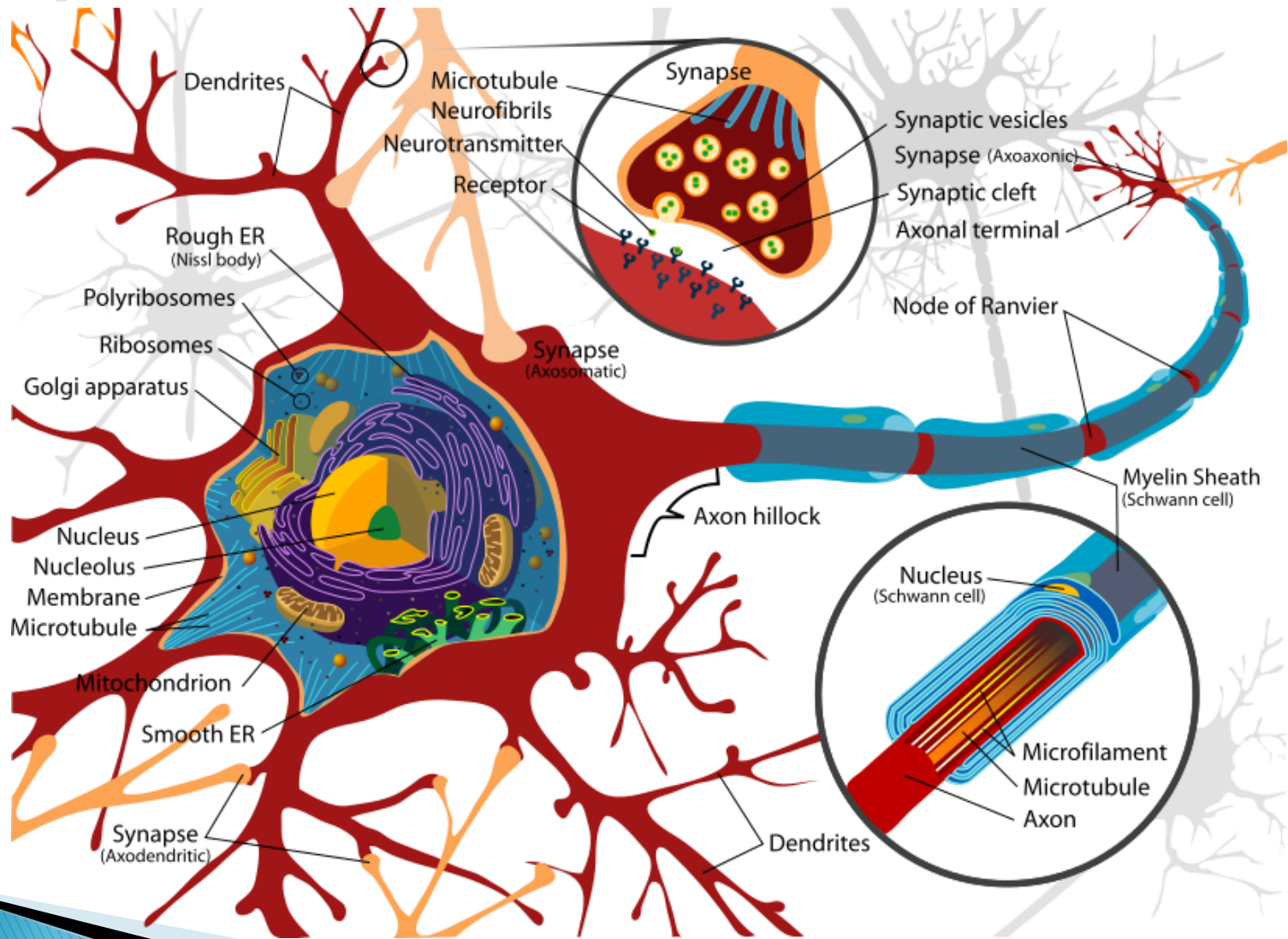
toate examenele sunt bazate pe fusul orar al server-ului (ar putea sa fie diferit de timpul local). Pentru referinta ora pe server este acum:

29/04/2020 17:28:51

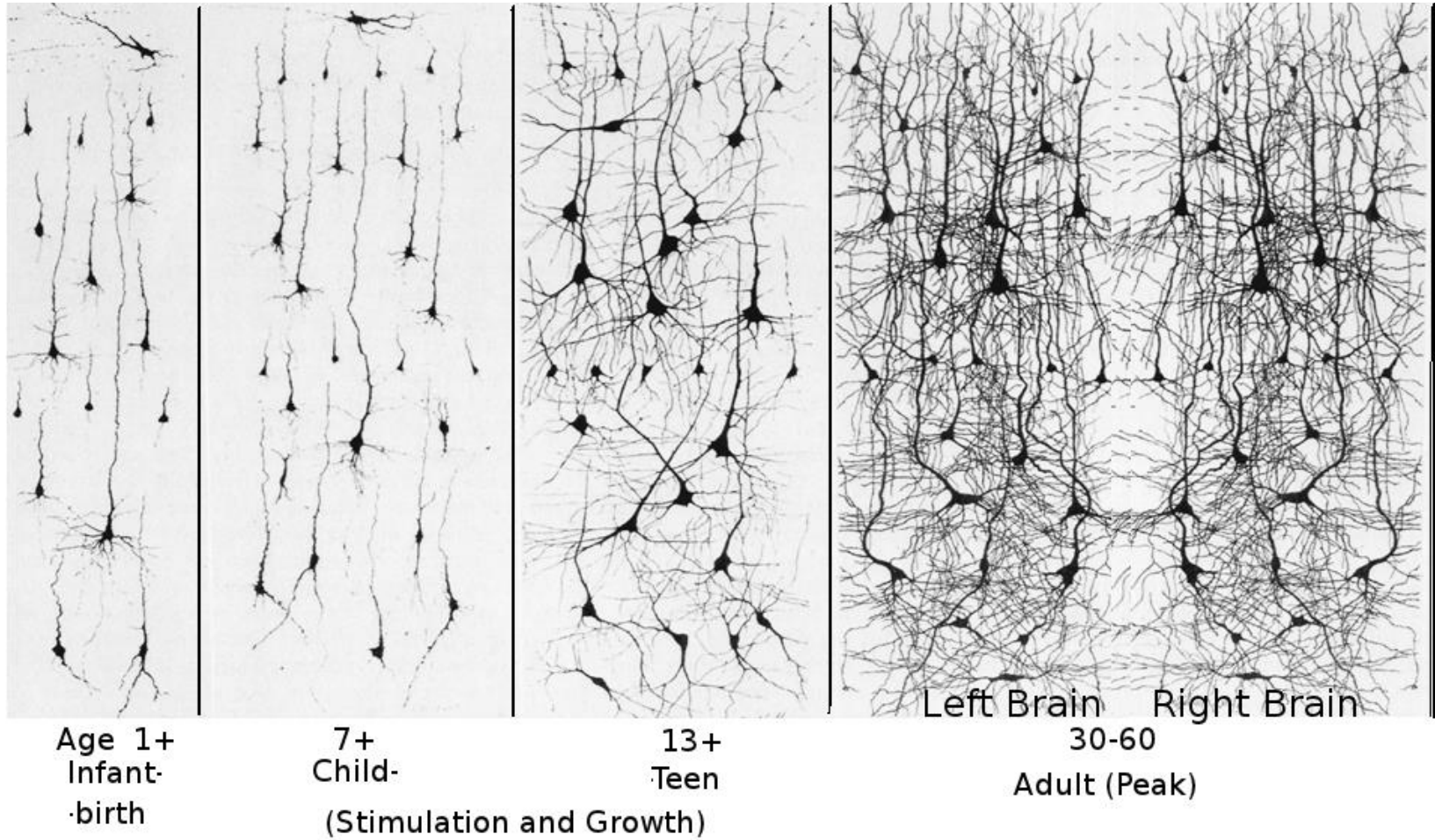
Scop 1



Scop 2



Scop 3



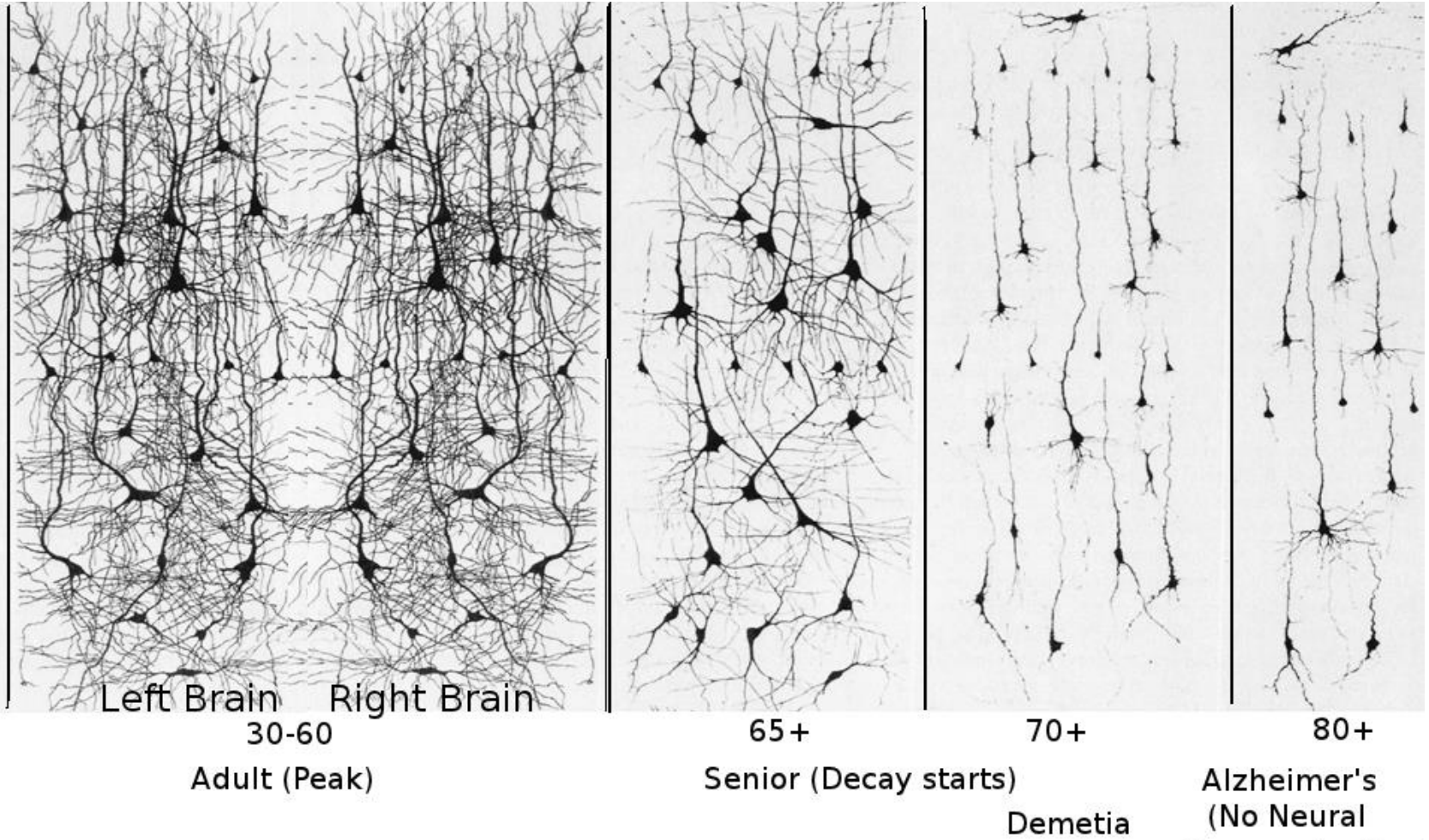
Scop 4



**Sinapse
“ingineresti”**



Termen



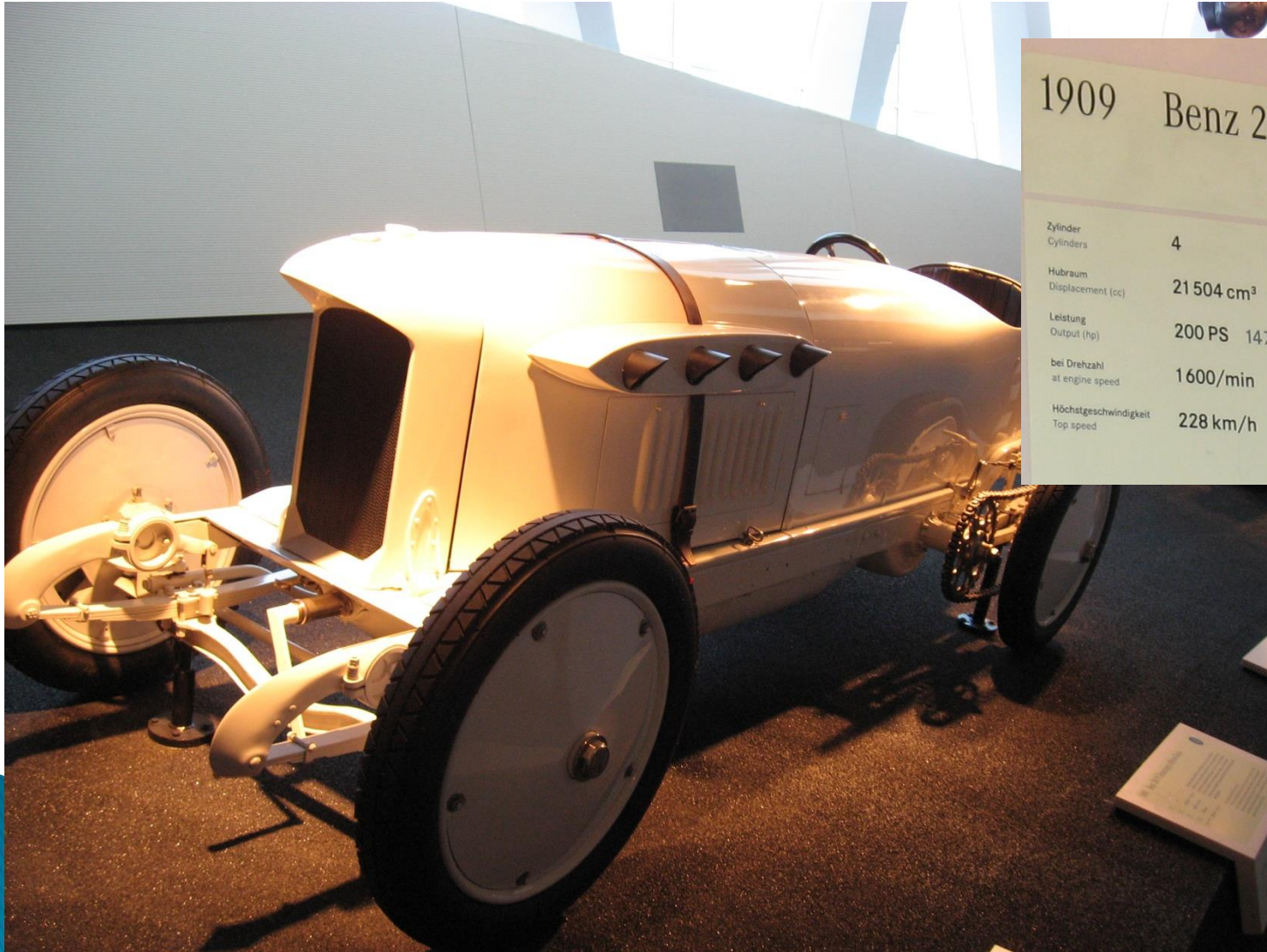
~1930



~1930



1909



1909 Benz 200 PS Rennwagen »Blitzen-Benz«

Zylinder Cylinders	4
Hubraum Displacement (cc)	21 504 cm ³ 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 Hermann Burman mit 228 km/h über die Saragat-Strasse ist damit das schnellste Fahrzeug der Welt vor jeder Eisenbahn.

Benz »Lightning Benz« 200 hp racing car
In 1909 the Lightning Benz was the fastest car in the world.

1930-1950



Tehnologie

> 2010

< 1950

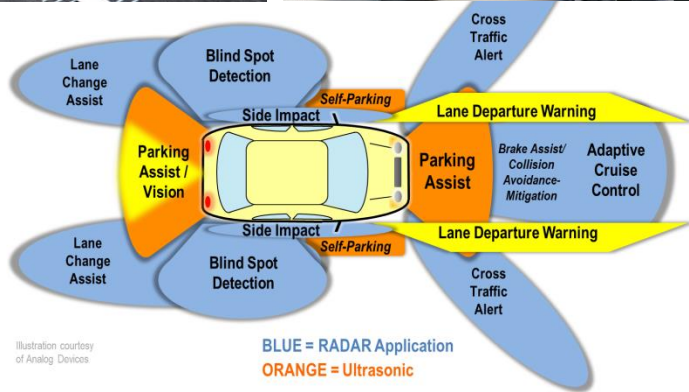


Illustration courtesy of Analog Devices

Tehnologie

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

$$2 \times 1 = 2$$

$$2 \times 2 = 4$$

$$2 \times 3 = 6$$

$$2 \times 4 = 8$$

$$2 \times 5 = 10$$

$$2 \times 6 = 12$$

$$2 \times 7 = 14$$

$$2 \times 8 = 16$$

$$2 \times 9 = 18$$

$$2 \times 10 = 20$$

Examen

- ▶ subiecte individuale
- ▶ Note
 - 2007: $9.67 \pm 0.66 / 8.81 \pm 1.22$
 - 2008: $6.24 \pm 1.36 / 4.82 \pm 2.10$
 - 2009: 5.10 ± 1.46
 - 2010: 3.89 ± 1.32
- ▶ 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

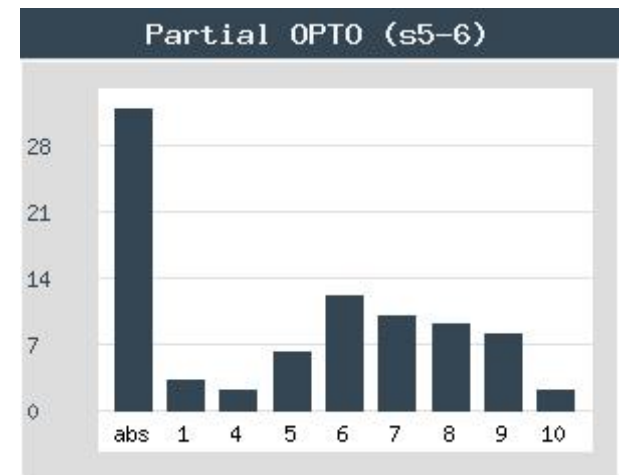
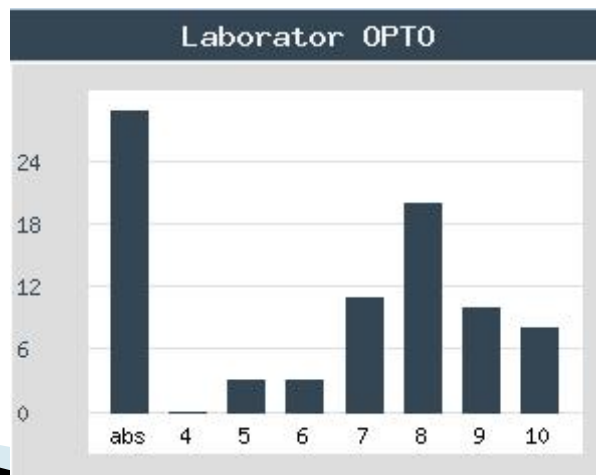
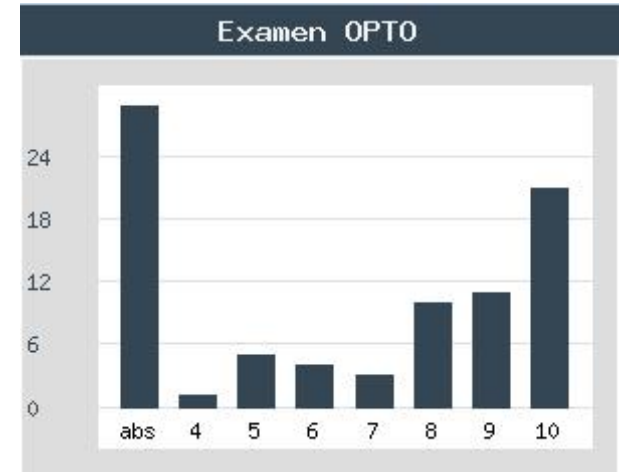
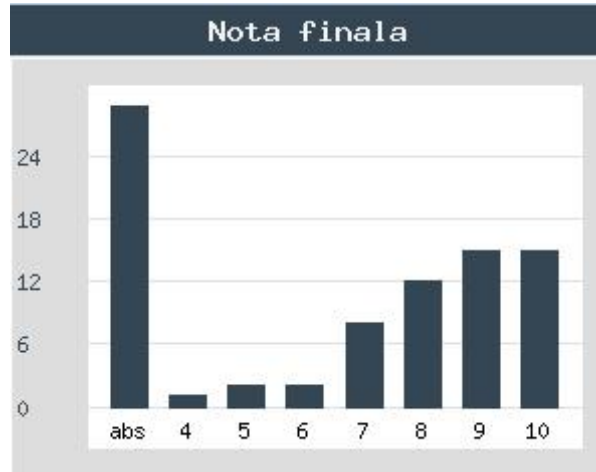


Examen

- ▶ subiecte **individuale**

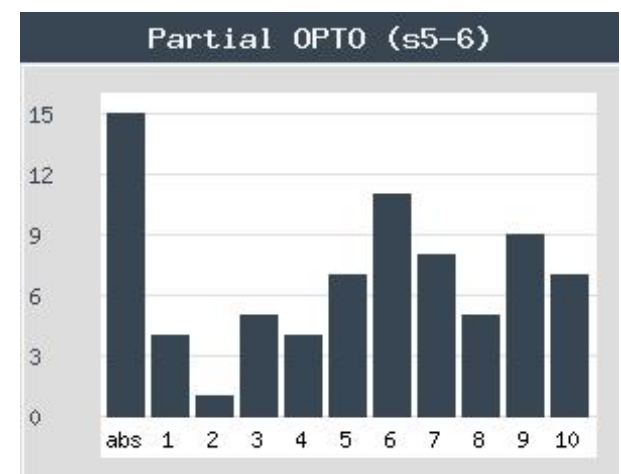
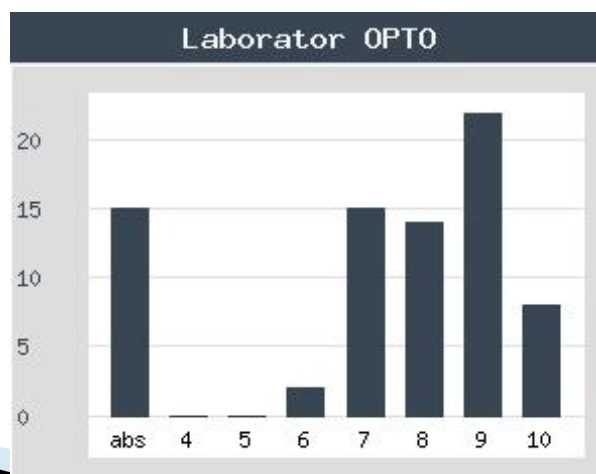
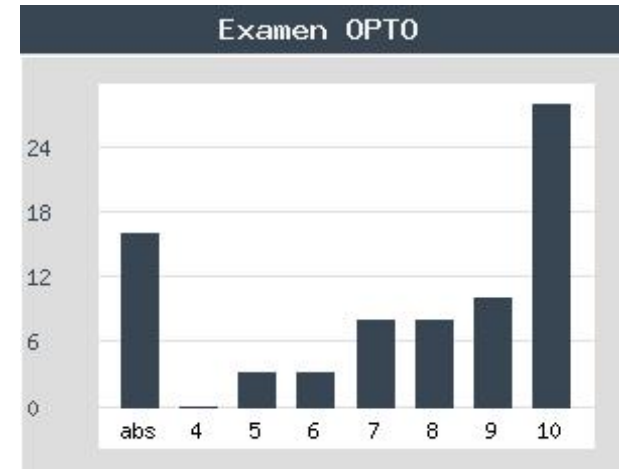
Note

▶ 2018/2019 – clasic



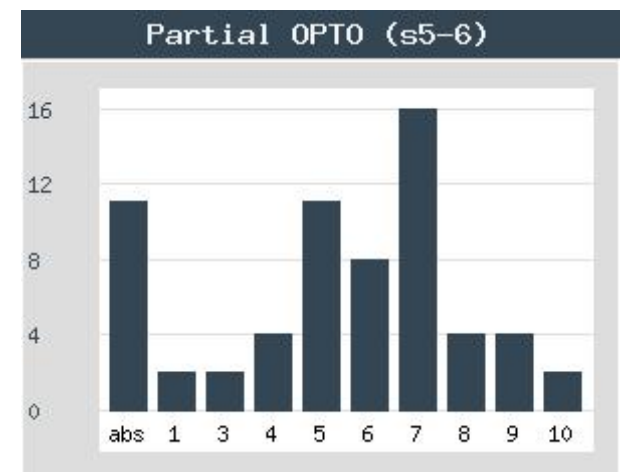
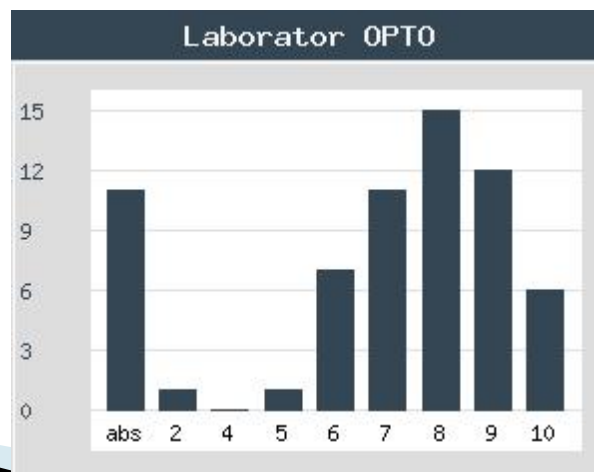
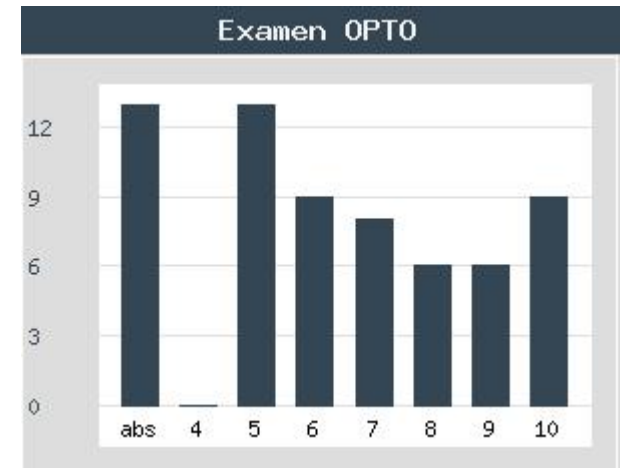
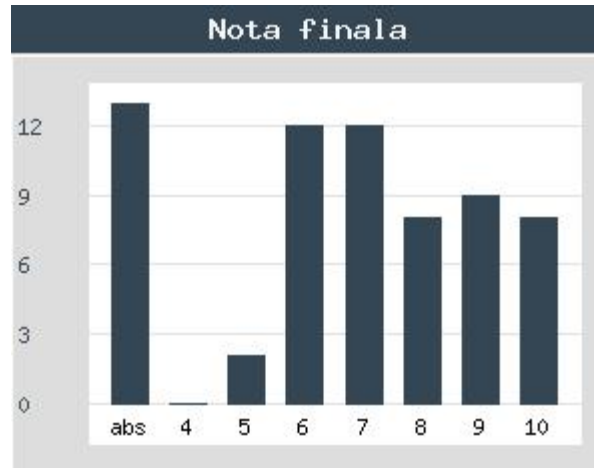
Note

▶ 2019/2020 – online



Note

▶ 2022/2023 – classic



Reprezentare logaritmică

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

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

$$0 \text{ dB} = 1$$

$$+ 0.1 \text{ dB} = 1.023 (+2.3\%)$$

$$+ 3 \text{ dB} = 2$$

$$+ 5 \text{ dB} = 3$$

$$+ 10 \text{ dB} = 10$$

$$-3 \text{ dB} = 0.5$$

$$-10 \text{ dB} = 0.1$$

$$-20 \text{ dB} = 0.01$$

$$-30 \text{ dB} = 0.001$$

$$0 \text{ dBm} = 1 \text{ mW}$$

$$3 \text{ dBm} = 2 \text{ mW}$$

$$5 \text{ dBm} = 3 \text{ mW}$$

$$10 \text{ dBm} = 10 \text{ mW}$$

$$20 \text{ dBm} = 100 \text{ mW}$$

$$-3 \text{ dBm} = 0.5 \text{ mW}$$

$$-10 \text{ dBm} = 100 \mu\text{W}$$

$$-30 \text{ dBm} = 1 \mu\text{W}$$

$$-60 \text{ dBm} = 1 \text{ nW}$$

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

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

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

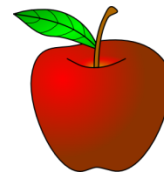
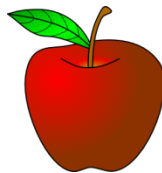
Calculul atenuarii/amplificarii

$$\text{Atenuare/Amplificare} = \frac{P_{out}}{P_{in}}$$

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

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

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



Contact

- ▶ Laboratorul de microunde si optoelectronica
- ▶ <http://rf-opto.etti.tuiasi.ro>
- ▶ rdamian@etti.tuiasi.ro