Teaching program

Matériaux

Academic year 2025-2026

Ecole polytechnique de Nantes Université

October 24, 2025

Contents

Part I

Tables of teaching units

Semester 5 - unit *MAT 3*

Accueil

Manager : CROSNIER Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Computer aided drawing	1.25		7.5					*0*
• Materials and applications (accueil)		2.5						*0*
• Mathématiques (accueil)		12						*0*
• Physics (upgrade-refresher training)		3						*0*
• Materials chemistry (accueil)		3						*0*
TOTAL	1.25	20.5	7.5	0	0	0	0	

Mathematics and applied computing I ECTS : 5

Manager : CHAUVET Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Linear algebra and complex analysis		24				2.5	13	*40*
• Algorithmic and programming		12	10.5			1.5	13	*40*
• Numerical processing of experimental data			7.5				4	*20*
TOTAL	0	36	18	0	0	4	30	

Applied physics I ECTS : 5

Manager : TESSIER Pierre-Yves

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Sensors, instrumentation and measurements	10	9				1.5	11	*40*
• General mechanics		10.5				1	6	*25*
• Optics and materials		15				1.5	9	*35*
TOTAL	10	34.5	0	0	0	4	26	

Materials chemistry I ECTS : 6

Manager : JOUBERT Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Solid state chemistry I	7.5	7.5				1.5	9	*30*
• Introduction to polymer materials	8.75	7.5				1.5	9	*30*
• Thermodynamics of materials		10.5				1	6	*20*
• Materials chemistry - laboratory			12					*20*
TOTAL	16.25	25.5	12	0	0	4	24	

Humanities 5 ECTS : 6

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Business knowledge and entrepreneurship		1.5	13.5					4	*15*
• Project management 1		4.5	7.5					2	*15*
• Physical education and sport 1			21					2	*20*
• Job search strategy and techniques		1.5	9					6	*15*
• English grammar for engineers			22.5						*17.5*
• Business communication			21.5						*17.5*
▷ VIP : english and french as a foreign language				15					*0*
TOTAL	min	7.5	95	0	0	0	0	14	
	max	7.5	95	15	0	0	0	14	

Solid state matter organization ECTS : 6

Manager : JOUBERT Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Chemical bonding		27				3	15	*50*
• Symmetry	13.75	12				2.5	14	*50*
TOTAL	13.75	39	0	0	0	5.5	29	

5th semester common core education programme ECTS : 2

Manager : GADOIN Émilie

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Sustainability issues	10.5	7.5	1.5					*100*
TOTAL	10.5	7.5	1.5	0	0	0	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	min	59.25	258	39	0	0	17.5	123	30
	max	59.25	258	54	0	0	17.5	123	
Face-to-face sum		373.75 à 388.75							

Semester 6 - unit *DD Ingénieur pharmacien*

Mathematics and applied computing II — ECTS : 4

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Generalized functions, integral transforms and partial differential equations		21				2	12	*35*
• Numerical methods 1		21				1.5	12	*35*
• Statistical data analysis and design of experiments	6.25	10.5				2		*30*
TOTAL	6.25	52.5	0	0	0	5.5	24	

Mechanics and materials I — ECTS : 7

Manager : BERTRAND Emmanuel

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Mechanics of deformable solid body		28.5	18			3	25	*45*
• General metallurgy	8.75	19.5	26			3.5	27	*55*
TOTAL	8.75	48	44	0	0	6.5	52	

Internship 3rd year — ECTS : 5

Manager : CROSNIER Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Internship 3rd year					8			*100*
TOTAL	0	0	0	0	8	0	0	

Materials chemistry 2 DD Ingé Pharma — ECTS : 2

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Materials Chemistry II	15	7.5				1.5	12	*65*
• Thermodynamics of materials - 2		10.5				1	6	*35*
TOTAL	15	18	0	0	0	2.5	18	

Applied physics II DD Ingé Pharma — ECTS : 3

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Solid state physics 1	6.25	3				1.5	6	*50*
• Physics and materials - laboratory			24				12	*50*
TOTAL	6.25	3	24	0	0	1.5	18	

Humanities 6 DD Ingé Pharma ECTS : 5

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Serious game		10.5	12				10	*35*
• Physical education and sport 2		21					2	*30*
• Preparing the TOEIC		19.5						*15*
• Presenting and debating		19.5						*15*
• Tutorials			2					*5*
TOTAL	0	70.5	14	0	0	0	12	

Dual course in Pharmacy and Engineering S6 ECTS : 4

Manager : MARCHAL Luc

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Pharmacy Preparation S6								*100*
TOTAL	0	0	0	0	0	0	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	36.25	192	82	0	8	16	124	30
Face-to-face sum	326.25							

Semester 6 - unit *MAT 3*

Mathematics and applied computing II — ECTS : 4

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Generalized functions, integral transforms and partial differential equations		21				2	12	*35*
• Numerical methods 1		21				1.5	12	*35*
• Statistical data analysis and design of experiments	6.25	10.5				2		*30*
TOTAL	6.25	52.5	0	0	0	5.5	24	

Mechanics and materials I — ECTS : 7

Manager : BERTRAND Emmanuel

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Mechanics of deformable solid body		28.5	18			3	25	*45*
• General metallurgy	8.75	19.5	26			3.5	27	*55*
TOTAL	8.75	48	44	0	0	6.5	52	

Humanities 6 — ECTS : 6

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Serious game			10.5	12				10	*20*
• Physical education and sport 2			21					2	*20*
• Economy and controversy mapping			27					10	*25*
• Preparing the TOEIC			19.5						*15*
• Presenting and debating			19.5						*15*
• Tutorials				2					*5*
▷ VIP : english and french as a foreign language				15					*0*
TOTAL	min	0	97.5	14	0	0	0	22	
	max	0	97.5	29	0	0	0	22	

Applied physics II — ECTS : 4

Manager : ANGLERAUD Benoit

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Electronics for measurement systems - laboratory			24				12	*25*
• Fundamentals of heat transfer	1.25	9				1	6	*25*
• Solid state physics 1	6.25	3				1.5	6	*25*
• Physics and materials - laboratory			24				12	*25*
TOTAL	7.5	12	48	0	0	2.5	36	

Materials chemistry 2 ECTS : 3

Manager : PAYEN Christophe

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Materials Chemistry II	15	7.5				1.5	12	*55*
• Diffusion in solids		6				1	4	*20*
• Thermodynamics of materials - 2		10.5				1	6	*25*
TOTAL	15	24	0	0	0	3.5	22	

Internship 3rd year ECTS : 5

Manager : CROSNIER Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Internship 3rd year					8			*100*
TOTAL	0	0	0	0	8	0	0	

6th semester common core education programme ECTS : 1

Manager : GADOIN Émilie

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Sustainability tools S6	6	9						*100*
TOTAL	6	9	0	0	0	0	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECT$
Sum	min	43.5	243	106	0	8	18	156	30
	max	43.5	243	121	0	8	18	156	
Face-to-face sum		410.5 à 425.5							

Semester 7 - unit *DD Ingénieur pharmacien*

Characterisation methods — ECTS : 6

Manager : COUTURIER Laurent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Microscopies and spectroscopies	8.75	1.5				1	6	*25*
• Characterisation methods - laboratory			36				18	*35*
• Radiocrystallography	8.75	10.5				2	11	*40*
TOTAL	17.5	12	36	0	0	3	35	

Durability of materials and electric energy storage — ECTS : 4

Manager : CROSNIER Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Durability : corrosion and electrochemical coating deposition	8.75	7.5				1.5	9	*40*
• Electrochemistry : storage and conversion of decarbonated energy	11.25	9				2	11	*50*
• Materials indicators for eco-design		4.5					4.5	*10*
TOTAL	20	21	0	0	0	3.5	24.5	

Physics of materials and applications — ECTS : 3

Manager : CHAUVET Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Dielectric materials -Magnetic materials	10	3				1.5	8	*35*
• Solid state physics 2	15	9				1.5	13	*65*
TOTAL	25	12	0	0	0	3	21	

Rheology — ECTS : 4

Manager : TANCRET Franck

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Rheology and thermomechanics of polymers	10	12				2	12	*55*
• Plasticity of metals and metal forming	3.75	12				1.5	9	*45*
TOTAL	13.75	24	0	0	0	3.5	21	

Humanities 7 DD Ingé Pharma ECTS : 5

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Physical education and sport 3		21					2	*15*
• Negotiation	3	7.5					2	*15*
• Communication and Professional Relationships		12					4.5	*15*
• Circular economy	4.5	3					6	*10*
• Becoming a professional		19						*30*
• Tutorials			2					*5*
• Responsible management 1		4.5					3	*10*
TOTAL	7.5	67	2	0	0	0	17.5	

Engineering sciences DD Ingé Pharma ECTS : 4

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Artificial intelligence for materials		12						*40*
• Numerical methods 2			20				10	*60*
TOTAL	0	12	20	0	0	0	10	

Dual course in Pharmacy and Engineering S7 ECTS : 4

Manager : MARCHAL Luc

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Pharmacy Preparation S7								*100*
TOTAL	0	0	0	0	0	0	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	83.75	148	58	0	0	13	129	30
Face-to-face sum	302.75							

Semester 7 - unit *MAT 4*

Engineering sciences — ECTS : 5

Manager : ANGLERAUD Benoit

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Electrical engineering		12	8			1.5	11	*40*
• Artificial intelligence for materials		12						*25*
• Numerical methods 2			20				10	*35*
TOTAL	0	24	28	0	0	1.5	21	

Characterisation methods — ECTS : 6

Manager : COUTURIER Laurent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Microscopies and spectroscopies	8.75	1.5				1	6	*25*
• Characterisation methods - laboratory			36				18	*35*
• Radiocrystallography	8.75	10.5				2	11	*40*
TOTAL	17.5	12	36	0	0	3	35	

Durability of materials and electric energy storage — ECTS : 4

Manager : CROSNIER Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Durability : corrosion and electrochemical coating deposition	8.75	7.5				1.5	9	*40*
• Electrochemistry : storage and conversion of decarbonated energy	11.25	9				2	11	*50*
• Materials indicators for eco-design		4.5					4.5	*10*
TOTAL	20	21	0	0	0	3.5	24.5	

Physics of materials and applications — ECTS : 3

Manager : CHAUVET Olivier

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Dielectric materials -Magnetic materials	10	3				1.5	8	*35*
• Solid state physics 2	15	9				1.5	13	*65*
TOTAL	25	12	0	0	0	3	21	

Humanities 7 — ECTS : 6

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Organizational analysis		4.5	6					3	*15*
• Physical education and sport 3			21					2	*10*
• Negotiation		3	7.5					2	*10*
• Communication and Professional Relationships			12					4.5	*10*
• Circular economy		4.5	3					6	*10*
• Becoming a professional			19						*30*
• Tutorials				2					*5*
• Responsible management 1			4.5					3	*10*
0 à 1 ▷ Modern language 2			18						*15*
0 à 1 ▷ Preparing the TOEIC			18						*15*
0 à 1 ▷ French as a foreign language			18						*15*
TOTAL	min	12	73	2	0	0	0	20.5	
	max	12	91	2	0	0	0	20.5	

Rheology — ECTS : 4

Manager : TANCRET Franck

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Rheology and thermomechanics of polymers	10	12				2	12	*55*
• Plasticity of metals and metal forming	3.75	12				1.5	9	*45*
TOTAL	13.75	24	0	0	0	3.5	21	

7th semester interspeciality — ECTS : 2

Manager : MARCHAL Luc

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
1 opt ▷ Entrepreneurship S7				36				*1*
1 opt ▷ Great Event S7				36				*1*
1 opt ▷ Research S7				36				*1*
1 opt ▷ Transitions S7				36				*1*
1 opt ▷ Sustainable building instrumented model S7				36				*1*
1 opt ▷ Electric assistance intermediate vehicle S7				36				*1*
▷ Ecodesign of a Data Center S7				36				*1*
TOTAL	0	0	0	36	0	0	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	min	88.25	166	66	36	0	14.5	143	30
	max	88.25	184	66	36	0	14.5	143	
Face-to-face sum		370.75 à 388.75							

Semester 8 - unit *DD Ingénieur pharmacien*

Polymers and composites ECTS : 3

Manager : LESTRIEZ Bernard

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Adhesion, bonding, interfaces	11.25	4.5				1.5	9	*40*
• Composite materials	10					1.5	9	*25*
• Polymeric materials - laboratory project				17.5			9	*35*
TOTAL	21.25	4.5	0	17.5	0	3	27	

Internship 4th year ECTS : 10

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Internship 4th year					13			*100*
TOTAL	0	0	0	0	13	0	0	

Humanities 8 DD Ingé Pharma ECTS : 3

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Responsible management 2		3					1	*10*
• Physical education and sport 4		19.5					2	*30*
• Recruitment Pitch		15					5	*25*
• Intercultural exploration : understanding differences		18						*35*
TOTAL	0	55.5	0	0	0	0	8	

Ceramics, glasses and thin solid films DD Ingé Pharma ECTS : 5

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Ceramics and glasses	12.5	6				2	11	*35*
• Thin film materials	10	4.5				1.5	8	*30*
• Ceramics and inorganic materials - laboratory project				32			16	*35*
TOTAL	22.5	10.5	0	32	0	3.5	35	

Dual course in Pharmacy and Engineering S8 ECTS : 4

Manager : MARCHAL Luc

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Pharmacy Preparation S8								*100*
TOTAL	0	0	0	0	0	0	0	

Metallurgy and durability of materials DD Ingé Pharma ECTS : 5

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Physical metallurgy		16.5				1.5	9	*30*
• Metallic materials - laboratory project				32			14	*40*
• Welding and foundry	15	1.5				1.5	9	*30*
TOTAL	15	18	0	32	0	3	32	

Sum of semester

	Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	58.75	88.5	0	81.5	13	9.5	102	30
Face-to-face sum	238.25							

Semester 8 - unit *MAT 4*

Polymers and composites — ECTS : 3

Manager : LESTRIEZ Bernard

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Adhesion, bonding, interfaces	11.25	4.5				1.5	9	*40*
• Composite materials	10					1.5	9	*25*
• Polymeric materials - laboratory project				17.5			9	*35*
TOTAL	21.25	4.5	0	17.5	0	3	27	

Ceramics, glasses and thin solid films — ECTS : 6

Manager : BROUSSE Thierry

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Ceramics and glasses	12.5	6				2	11	*25*
• Thin film materials	10	4.5				1.5	8	*15*
• Semiconducting materials and devices	13.75	3	12			1.5	16	*30*
• Ceramics and inorganic materials - laboratory project				32			16	*30*
TOTAL	36.25	13.5	12	32	0	5	51	

Metallurgy and durability of materials — ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Fracture-Fatigue-Creep	10	12				2	12	*30*
• Physical metallurgy		16.5				1.5	9	*20*
• Metallic materials - laboratory project				32			14	*30*
• Welding and foundry	15	1.5				1.5	9	*20*
TOTAL	25	30	0	32	0	5	44	

Humanities 8 — ECTS : 4

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• A critical perspective on business			9					3	*20*
• Responsible management 2			3					1	*5*
• Physical education and sport 4			19.5					2	*20*
• Recruitment Pitch			15					5	*20*
• Intercultural exploration : understanding differences			18						*35*
0 à 1 ▷ Modern language 2			18						*1.5*
0 à 1 ▷ Achieving TOEIC			18						*1.5*
0 à 1 ▷ French as a foreign language			18						*1.5*
TOTAL	min	0	64.5	0	0	0	0	11	
	max	0	82.5	0	0	0	0	11	

Internship 4th year — ECTS : 10

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Internship 4th year					13			*100*
TOTAL	0	0	0	0	13	0	0	

8th semester interspeciality — ECTS : 1

Manager : MARCHAL Luc

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Ecological transition for sustainable development 2		9						*0.25*
1 opt ▷ Entrepreneurship S8				28				*0.75*
1 opt ▷ Great Event S8				28				*0.75*
1 opt ▷ Research S8				28				*0.75*
1 opt ▷ Transitions S8				28				*0.75*
1 opt ▷ Sustainable building instrumented model S8				28				*0.75*
1 opt ▷ Electric assistance intermediate vehicle S8				28				*0.75*
1 opt ▷ Ecodesign of a Data Center S8				28				*0.75*
TOTAL	0	9	0	28	0	0	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	min	82.5	121.5	12	109.5	13	13	133	30
	max	82.5	139.5	12	109.5	13	13	133	
Face-to-face sum		338.5 à 356.5							

Semester 9 - unit *Composites*

Humanities 9 — ECTS : 3

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Supporting change			13.5					3	*35*
• Project management 2		1.5	15					3	*30*
• People management			10.5					6	*30*
• Skills day			8					2	*5*
▷ Achieving TOEIC			18						*0*
TOTAL	min	1.5	47	0	0	0	0	14	
	max	1.5	65	0	0	0	0	14	

Scientific and technical advanced courses — ECTS : 3

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• CAD - Thermomecanics		9					5	*25*
• Computer aided design		9					5	*25*
• Meeting management	2.5	2					3	*20*
• Non destructive testing	9.75					1	6	*30*
TOTAL	12.25	20	0	0	0	1	19	

Internship and industrial project — ECTS : 15

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Project				140			70	*80*
• Bibliographic survey	9			25			13	*20*
TOTAL	9	0	0	165	0	0	83	

Composite materials — ECTS : 9

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Mechanical properties of composite materials	15		12			1.5	15	*30*
• Shaping of composite materials	22	12	24			1.5	30	*50*
• Thermophysical properties of polymers and composites	15					1.5	8	*20*
TOTAL	52	12	36	0	0	4.5	53	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECT$
Sum	min	45.75	89	12	190	0	4	158	30
	max	45.75	107	12	190	0	4	158	
Face-to-face sum		340.75 à 358.75							

Semester 9 - unit *Matériaux pour l'énergie*

Humanities 9 — ECTS : 3

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Supporting change			13.5					3	*35*
• Project management 2		1.5	15					3	*30*
• People management			10.5					6	*30*
• Skills day			8					2	*5*
▷ Achieving TOEIC			18						*0*
TOTAL	min	1.5	47	0	0	0	0	14	
	max	1.5	65	0	0	0	0	14	

Scientific and technical advanced courses — ECTS : 3

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• CAD - Thermomecanics		9					5	*25*
• Computer aided design		9					5	*25*
• Meeting management	2.5	2					3	*20*
• Non destructive testing	9.75					1	6	*30*
TOTAL	12.25	20	0	0	0	1	19	

Internship and industrial project — ECTS : 15

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Project				140			70	*80*
• Bibliographic survey	9			25			13	*20*
TOTAL	9	0	0	165	0	0	83	

[MATNRI] Materials & devices for electrochemical energy storage — ECTS : 5

Manager : LESTRIEZ Bernard

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Lihtium batteries and new battery technologie	11.75	5.5	6			1.5		*40*
• Supercapacitors and hybrid systems	2.58	2.67	6			0.5		*30*
• Hygrogen vector : production, storage and distribution	4.67	2.83	3			0.5		*30*
• Industrial seminars		4.5						*0*
TOTAL	19	15.5	15	0	0	2.5	0	

[MATNRI] Materials for photovoltaic, thermal storage en nuclear energy ECTS : 4

Manager : LESTRIEZ Bernard

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Industrial seminars		4.5						*0*
• Materials for photovoltaic devices	6.25	3	6			1		*45*
• Materials for thermal storage	2.5	3	6			0.5		*35*
• Nuclear fuels	2.5	1.5				0.5		*25*
TOTAL	11.25	12	12	0	0	2	0	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECT$
Sum	min	53	94.5	27	165	0	5.5	116	30
	max	53	112.5	27	165	0	5.5	116	
Face-to-face sum		345 à 363							

Semester 9 - unit *Soudage*

Design and control

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• CAD - Thermomecanics		9					5	*15*
• Computer aided design		9					5	*15*
• Design of welded components	28					1.5	15	*40*
• Non destructive testing	9.75					1	6	*15*
• Non destructive testing of welds	3.5		7				6	*15*
TOTAL	41.25	18	7	0	0	2.5	37	

Materials

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Weld analysis			10					*15*
• Welding metallurgy	57.75					1.5	26	*85*
TOTAL	57.75	0	10	0	0	1.5	26	

Fabrication

ECTS : 7

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Fabrication, operation and exploitation of welded components	24.5					1.5	9	*40*
• Project - case study - meeting management	2.5	2		52.25			29	*60*
TOTAL	27	2	0	52.25	0	1.5	38	

Humanities 9

ECTS : 3

Course		Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Supporting change			13.5					3	*35*
• Project management 2		1.5	15					3	*30*
• People management			10.5					6	*30*
• Skills day			8					2	*5*
▷ Achieving TOEIC			18						*0*
TOTAL	min	1.5	47	0	0	0	0	14	
	max	1.5	65	0	0	0	0	14	

Welding process

ECTS : 8

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Exa	Asst	*Coef*
• Practical training			35					*20*
• Welding methods	56					1.5	29	*80*
TOTAL	56	0	35	0	0	1.5	29	

Sum of semester

		Lect	Tut	PW	Proj	WP	Exa	Asst	ECTS
Sum	min	183.5	67	52	52.25	0	7	144	30
	max	183.5	85	52	52.25	0	7	144	
Face-to-face sum		361.75 à 379.75							

Part II

Sheets of courses

A critical perspective on business

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	9					3

Evaluation

One evaluation : *Rapport Gpe*

Manager : Gwenael THOREL

Achieving TOEIC

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *DS*

Bibliography

Newcombe, H. McDonald Bertail, C. Pass the TOEIC® Test. First Press ELT

Manager : Carole CHAUSSE

Achieving TOEIC

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *DS*

Bibliography

- Grant Trew, Tactics for Toeic , Oxford
- Lin Lougheed,600 essential words, Barron's
- Lin Lougheed, Méthode complète pour le Toeic 6eme edition, Pearson France
- Renald Rilcy, Achieve Toeic, Cengage Learning
- Kaplan Prep Plus 2019-2020 Tests 2 et 3

Manager : Carole CHAUSSE

Adhesion, bonding, interfaces

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
11.25	4.5				1.5	9

Evaluation

One evaluation : *DS*

Outline

- Physics-chemistry of adhesion (bonds, thermodynamic work of adhesion), energy of adherence
  - Evaluation of adherence. Mechanical properties of interfaces. Cantilever beam, shear and peel tests
  - Design of bonded joints (the Volkersen approach)
  - Surface preparation. Laws of wetting and impregnation
  - Welding of polymers
  - Adhesives technology
  - o Non-chemical Adhesives
  - o Chemical adhesives (mechanisms of activation and of polymerization)
  - o Exemples of application
  - Controling bonded joints and conclusion.

Goals

The goals are to be able to handle a bonding problem, from the design to the realization. The students will not be experts, but they will be able to understand all the complexity of bonding problems and to echange with specialists.

Bibliography

SCHINDEL E.H. - Pratique du collage industriel. Lavoisier, Tec & Doc (1992), COUVRAT P. - Le collage structural moderne. Lavoisier, Tec & Doc (1992), COGNARD J. - Science et technologie du collage. Presse polytechniques et universitaires romandes romande (2000). J-J VILLENAVE - Assemblage par collage. Dunod (2005). E. DARQUE-CERETTI, E. FELDER - Adhésion et adhérence. CNRS Editions (2003). GEORGES J.M. Frottement, usure et lubrification Editions Eyrolles et CNRS éditions (2000).

DETERRE R., LESTRIEZ B., Introduction aux matériaux polymères. Lavoisier (2016)

Prerequisites

Polymers rheology, physics-chemistry, synthesis. Basics of mechanics and physics and chemistry of materials.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know designing bonded joints	·	✓	·	·	·
• To know evaluating the mechanical strength of bonded joints	·	✓	·	·	·
• To know preparing and characterizing a surface before bonding	·	✓	·	·	·
• To know using a technical adhesive	·	✓	·	·	·
• To know controling bonded joints	·	✓	·	·	·

Manager : Bernard LESTRIEZ

Algorithmic and programming

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	12	10.5			1.5	13

Evaluation

2 evaluations :

- *DS*
- *Rapport Ind*

Outline

- Algorithms and Modeling
  - Basic actions and algorithmic concepts
  - Structured, alternative, selective, and iterative actions
  - Parameterized actions, functions
  - Data analysis, tables, sorting algorithms

Goals

The algorithms module aims to build a methodology for analyzing a problem and then developing appropriate resolution schemes, based on a finite and structured set of objects and actions. These reasoning processes are essential in an engineering approach to effectively respond to a call for tenders subject to precise specifications.

Prerequisites

No prerequisites.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To control a 'basic' programming (graphic, matrix calculation, polynomial, research of extrema, signal processing)	·	·	✓	·	·
• To control the use of procedures "function" pre-programmed or not	·	·	✓	·	·
• To control the graphic display of data (2D, 3D)	·	·	✓	·	·
• Construct a structured approach providing a solution to an engineering problem using algorithmic techniques	·	✓	·	·	·
• Apply methodologies to the programming of simple algorithms in Matlab language for the realization of different projects	·	✓	·	·	·

Manager : Stéphane CUENOT

Artificial intelligence for materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	12					

Evaluation

3 evaluations :

- *Situation Gpe*
- *Rapport Gpe 1*
- *Rapport Gpe 2*

Outline

- Introduction and overview: What is AI? What are its tools and methods? What applications are there in the field of materials?

- Introductory exercises: coding a single-variable neural network; sensitivity to parametric initialisation and data quality.

- Specific exercises in regression: prediction of mechanical properties of metallic alloys; applicative mini-project on alloy design.

- Specific exercises in pattern recognition: analysis of micrographic images; defect detection; classification of microstructures and defects.

Goals

- Be familiar with the main AI methods applicable to materials issues (excluding generative AI such as LLM, etc.) and the features they offer: regression, classification, clustering, pattern recognition.

- Know how to apply certain methods to simple cases where databases have already been created: regression on properties for material design purposes, pattern recognition in micrographic image analysis.

- Develop a critical eye for data, its structure, its relevance, associated biases, parametric adjustment of models, etc.

Prerequisites

- Fundamentals of materials science and engineering (MAT3).

- Fundamentals of statistics, experimental design, algorithms, programming and numerical methods (MAT3).

Learning outcomes

Learning outcomes	N	A	M	E	O
• Be familiar with the main AI methods applicable to materials issues	✓	·	·	·	·
• Have a critical eye on methods and their limits	✓	·	·	·	·
• Be able to implement basic tools (regression, pattern recognition) to create material-specific models	·	✓	·	·	·
• Be able to exploit models to address material issues	·	·	✓	·	·

Manager : Franck TANCRET

Becoming a professional

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	19					

Evaluation

2 evaluations :

- *Situation Ind*
- *DS*

Bibliography

UNCLOUD => Pedagogie Partagée => Ressources accessibles vacataires => 4eme année => S1 4A => Livret "POLYPRO - Becoming a professional" -

Manager : Carole CHAUSSE

Bibliographic survey

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
9			25			13

Outline

Course section:
- Documentary research techniques
- Sources of information for scientific and technical research
- Questioning techniques
- Information exploitation and bibliographic synthesis

Project section:
Produce a synthesis related to the subject of the ?Project?.

Goals

Know and be able to use the main methods and basic tools for bibliographic research and technology monitoring, and be able to produce a written survey with references.

Bibliography

Net recherche : le guide pratique pour mieux trouver l'information utile - Armelle Thomas - Sci. et tech. de l'information, 2008

Guide de la recherche documentaire - M Gagnon et F Farley-Chevrier - PUM - 2004

Learning outcomes

Learning outcomes	N	A	M	E	O
• Specifying information requirements and writing a research plan	·	✓	·	·	·
• Using a database and exploiting information	·	·	✓	·	·
• Organizing documentation	·	✓	·	·	·
• Writting a bibliographic essay and creating a reference list	·	·	✓	·	·

Manager : Franck TANCRET

Bibliographic survey composite materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			50			25

Evaluation

One evaluation : *Rapport Ind*

Manager : Vincent SOBOTKA

Business communication

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21.5					

Evaluation

2 evaluations :

- *Situation Gpe*
- *DS*

Manager : Pascale SIMON LLOBREGAT

Business knowledge and entrepreneurship

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
1.5	13.5					4

Evaluation

One evaluation : *Situation Ind.*

Bibliography

- Les fonctions de l'entreprise / Pierre Baranger (Vuibert)
  - Management et économie des entreprises / Gilles Dressy (sirey)
  - Structure d'une organisation / xerfi canal https://www.youtube.com/watch?v=twVz2QhRyKw
  - L'orga, l'entreprise et .../ xerfi canal https://www.youtube.com/watch?v=24rY9YfeADU

Manager : Gwenael THOREL

CAD - Thermomecanics

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	9					5

Evaluation

One evaluation : *Rapport Gpe*

Outline

Tackled issues :

- drawing import from Catia to Comsol
- static analysis (2D & 3D), meshing influence with a point load ;
- differential thermal dilatation
- thermomechanics with stationnary conduction
- elasto-plastic analysis

Goals

To solve multiphysic problems with numerical simulation in mechanics and thermomechanics 2D and 3D.

To manage problems of meshing and modeling choices

Used softwares : Comsol and Catia

Prerequisites

Rigid body mechanics ; Mechanics of deformable solids ; vibrations mechanics; Thermal conduction

Learning outcomes

Learning outcomes	N	A	M	E	O
• To solve multiphysic problems by numerical simulation wiyh Comsol	·	·	✓	·	·
• To manage problems of meshing and singularities	·	·	✓	·	·
• To import models from Catia to Comsol	·	·	✓	·	·

Manager : Jérémie RUPIL

Ceramics and glasses

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
12.5	6				2	11

Evaluation

3 evaluations :

- *DS1*
- *DS2*
- *Situation Ind*

Outline

Introduction: similarities and differences with metals, polymers, composites

Synthesis and characterization of powders: solid state route, sol-gel, soft chemistry, other syntheses, characterizations (diffraction, microscopy, surface analysis, particle size ...). Techniques for shaping ceramics: compaction, formulation of slurries, sintering with and without a liquid phase, etc ...

Synthesis and shaping glasses

Binders: synthesis, characterization and use ...

Thermomechanical properties of ceramics (elasticity, fracture toughness, effect of porosity, fracture statistics, thermal shock, heat resistance...)

Examples of current applications of ceramics and glasses

Goals

Knowing the main methods of preparation of and characterization of ceramics and glasses as well as their physical, chemical and thermomechanical properties, being able to choose and / or synthesize a ceramic material or glass with specific properties for a given application, to establish a specifications, to perform failure analysis & recommend solutions

Bibliography

J.M. Haussonne, C. Carry, P. Bowen, J. Barton, "Traité des matériaux", vol. 16, "Céramiques et verres - principes et techniques d'élaboration", PPUR.

W.D. Kingery, H. K. Bowen, D.R. Uhlmann, "Introduction to Ceramics", Wiley

D. Munz, T. Fett, "Ceramics: Mechanical Properties, Failure Behaviour, Materials Selection", Springer

Prerequisites

Solid State Chemistry

crystal symmetry

Phase diagrams

Physics of Solids magnetic and dielectric

Bases in mechanics of materials (elasticity, fracture mechanics)

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main characteristics of ceramics and glasses	·	·	·	✓	·
• Knowledge of methods of preparation of ceramics and glasses and related characterizations	·	·	✓	·	·
• To be able to establish specifications to develop a new material or improve an existing material	·	·	✓	·	·
• To be able to select a material, a powder, a manufacturing method according to an application or environment	·	·	✓	·	·
• To be able to interpret failures and propose remedies for these failures	·	·	✓	·	·

Manager : Thierry BROUSSE

Ceramics and inorganic materials - laboratory project

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			32			16

Evaluation

2 evaluations :

- *Rapport Gpe*
- *SO*

Outline

28 hours of laboratory work. 4 hours for final oral presentations. 2 supervisors for 16 students. Students work in pairs.

Examples of topics :
Synthesis of materials for Lithium-ion and supercapacitors
Fabrication of a Nernst lamp
Synthesis and characterization of materials for Solid Oxide Fuel Cells (SOFC)

Goals

To undertake a small experimental project in near autonomy dealing with ceramic materials

Prerequisites

To know how to synthesize oxide materials (ceramic, hydrothermal routes, or sol gel methods)

To be able to use the characterization equipments (X-ray diffraction, scanning electron microscopy, electrochemistry equipments, furnaces...)

Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to manage and execute a small project (task planning and task distribution) in a limited time, taking account of the limited availability of equipments and staff	·	·	✓	·	·
• Be able to use multi-disciplinary knowledge and apply it to metallic materials	·	·	✓	·	·
• To be able to write a final report and give a talk. To be clear, positive and persuasive	·	·	✓	·	·
• To cast a critical eye on one's own work and others. To compare one's work with others	·	·	✓	·	·
• To be able to analyze the causes of failure and adapt one's approach in light of these failures	·	·	✓	·	·

Manager : Olivier CROSNIER

Characterisation methods - laboratory

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		36				18

Evaluation

2 evaluations :

- *Rapport Gpe*
- *Soutenance*

Outline

Characterization of semi-cristalline polymers using thermal analysis (DSC) - Surface properties of materials

Identification and characterization of polymers using infrared spectroscopy (FTIR) and X-Ray fluorescence (ED-XRF)

Introduction to rheology and viscoelastic behaviors of elastomers and polymers

Characterization of electrochemical generators

Experimental study of materials using X-ray Diffraction (XRD)

Synthesis and forming of ceramics

Powder specific area and grain size determined using the B.E.T. method

Initiation to the usage of a Scanning Electron Microscope (SEM)

Goals

The main objective is to use the main characterization methods used in material science to investigate their properties. These methods will be used by the students in experimental projects, internships, and in their professionnal carrier.

Prerequisites

To know the principles and the basics of the experimental techniques used

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know what kind of information can be obtained from each experimental technique	·	·	✓	·	·
• To know the limits of each technique, and how complementary they can be	·	·	✓	·	·
• To know how to use the different techniques	·	✓	·	·	·
• To be able to write a final report and give an oral presentaion of the obtained results	·	·	✓	·	·

Manager : Laurent COUTURIER

Chemical bonding

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	27				3	15

Evaluation

3 evaluations :

- *DS1*
- *DS2*
- *DS*

Outline

Quantum mechanics postulates, deep well and degeneration.; Hydrogen Atom: spherical harmonics, orbital spin.; Many-electron atoms: Periodic classification, electronegativity.; Molecular orbitals: diatomic molecules, the Hückel method. From molecule to solid : Analogy molecular orbital - Bloch orbital (OB), energy diagram, Brillouin zone concepts, valence bands, conduction and Fermi levels. Construction of the band diagram from the LCAO; Parameters influencing the dispersion bands (E (k)) (orbital overlap, distances ...) Construction of a system for 1D OB (infinite chain of hydrogen); Extension to 2D and 3D systems. Structure-property relationship (relationship between the band structure and electronic properties of materials).

Goals

This course is an introduction to the theoretical determination of the electronic structure of solids. It provides the basis for understanding the relationship stucture - properties exposed in the course of Solid State Chemistry and Physics of the solid.

Prerequisites

Concepts of physics and chemical bonding.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to build the periodic table, knowledge and understanding of the periodic changes in the properties of atoms	·	·	✓	·	·
• To be able to apply the Slater method, Linear Combination of Atomic Orbitals and Hückel	·	·	✓	·	·
• To know how to build and used the Bloch orbitals	·	·	✓	·	·
• To know the tools for analyzing the electronic structure of solids	·	✓	·	·	·
• To understand the relationship between structure at the atomic scale and chemical and physical properties of solids.	✓	·	·	·	·

Manager : Olivier CROSNIER

Circular economy

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
4.5	3					6

Evaluation

One evaluation : *Rapport groupe*

Bibliography

- Thierry Le Moigne, L'économie circulaire, Stratégie pour un monde durable, 2018
- Vincent Aurez, Laurent Georgeault, Economie circulaire : système économique et finitude des ressources, 2019
- Manuel de la grande transition, Collectif FORTES, oct 2020

Manager : Chrystèle GONCALVES

Communication and Professional Relationships

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	12					4.5

Evaluation

One evaluation : *Situation Ind*

Bibliography

- Livret fourni

- DE LASSUS René, L'analyse transactionnelle : une méthode révolutionnaire pour bien se connaître et mieux communiquer, Marabout (Savoir pratique n°3516), 2013, 288 p., ISBN 2501085493

- DE LASSUS René, La communication efficace par la PNL, Marabout (Bien-être - Psy), 2019, 288 p., ISBN 2501089499

- DE LASSUS René, L'ennéagramme : les 9 types de personnalités, Marabout (Poche Psy n°3568), 2019, 288 p., ISBN 2501084950

- DE MONICAULT Frédéric / RAVARD Olivier, 100 questions posées à l'entretien d'embauche, Jeunes Editions (Guides J), 2004 (3e édition), 182 p., ISBN-10 : 2844724221 / ISBN-13 : 978-2844724229

- LEONARD Thomas J., The portable coach, Simon & SCHUSTER, 1999, 336 p., ISBN-10 : 0684850419 / ISBN-13 : 9780684850412

- ROSENBERG Marshall B., Les mots sont des fenêtres (ou bien ce sont des murs) : initiation à la communication non-violente, La Découverte, 2016, 320 p., ISBN 2707188794

- GOLEMAN Daniel, L'intelligence émotionnelle - Intégrale (Analyser et contrôles ses émotions, et ceux des autres), 2014 , 925 p.,Editions J'ai lu

- www.16personalities.com

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Manager : Sylvaine GAUTIER

Composite materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10					1.5	9

Evaluation

One evaluation : *DS*

Outline

PART 1: Composite materials

Reinforcements: glass, carbon, organic fibers

Resins: Thermoplastics, Thermosets

Processing: Contact, Autoclave, Sandwiches, Injection, Compression

PART 2: Mechanic of laminates

- Elastic behavior of a unidirectional composite material
- Behavior of a elastic orthotropic composite . (2D anisotropic behavior, flexibility and stiffness coefficients)
- Composite material outside of its main axes
- Modelling of the mechanical behavior of laminates and sandwiches
- Criteria of breaking classic ; Design Rules

Goals

Having knowledge in the field of reinforced composites, processing and characterization of materials and final product.

Mechanical characterizations : Tests, and modeling, design and examples from the aerospace, naval and automotive.

Prerequisites

Knowledge of polymer chemistry and mechanics of materials

Learning outcomes

Learning outcomes	N	A	M	E	O
• Describe the various components constituting the structural composites	·	·	✓	·	·
• Determine the mechanical tests appropriate for the characterization and modeling	·	·	✓	·	·
• Determine the mechanical properties of a basic structure laminates	·	·	✓	·	·
• Know the failure mechanisms	·	✓	·	·	·
• Determine the rupture limit of laminate material (Tsai-Hill criteria and others)	·	✓	·	·	·

Manager : Bernard LESTRIEZ

Computer aided design

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	9					5

Evaluation

2 evaluations :

- *Rapport Gpe CAO*
- *Rapport Gpe FAO*

Outline

- Introduction to the concepts of manufacturing plan and CAD/CAM.
  - Reminders on how to use CAD software.
  - Instructions for configuring a CAD/CAM protocol (for machining) in the software.
  - Building a CAD/CAM protocol in the software (in mini-project mode).
  - Demonstration of a manufacturing plan on a numerical control machining equipment.

Goals

- Discover the links between the design of objects and the manufacture of their constituent parts, and learn about the concept of manufacturing plan through practical experience. The concepts are illustrated in the case of numerical control machining, for which the sequence of basic operations is configured using computer-aided design (CAD) software in order to define a computer-aided design and manufacturing (CAD/CAM) protocol.

- Understand that these general principles can potentially be applied to material transformation and joining processes.

Prerequisites

Use of CAD software (MAT3)

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the links between the design of objects and the manufacture of their constituent parts (concept of manufacturing plan)	✓	·	·	·	·
• Advance in the use of CAD software for CAD/CAM purposes	·	✓	·	·	·

Manager : Franck TANCRET

Computer aided drawing

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
1.25		7.5				

Outline

Basic rules of technical drawing
Conventional drawings : threads, gears
Perspectives, 3D modelization methods
Practicals : handling of Catia by 3D modelization and 2D drawing of mechanisms

Goals

To understand a technical drawing
To use a drawing software in 3D mode

Bibliography

Memotech-Productique : conception et dessin
par C. Carlier et R. Bourgeois - Editions Casteilla

Learning outcomes

Learning outcomes	N	A	M	E	O
• To understand a technical drawing	·	·	✓	·	·
• To use a drawing software in 3D mode	·	·	✓	·	·

Manager : Jérémie RUPIL

Design of welded components

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
28					1.5	15

Evaluation

One evaluation : *DS*

Outline

Design of joints for welding and brazing
- Principles of welding design
- Behavior of welded structures under different types of load
- Design of welded structures under essentially static
- Behaviour of welded structuresunder cyclic load
- Design of the welded under cyclic load
- Design of welded pressure equipment
- Design of structures in aluminium alloys

Goals

Know to calculate and to design welded structures subjected to different types of solicitation: static or dynamic mechanics, thermal

Bibliography

MANFRED A., Conception des charpentes métalliques, Presses Polytechniques et Universitaires Romandes, 2002

BLONDEAU R., Métallurgie et mécanique du soudage, Lavoisier , Hermès science, 2001

MANFRED A., Construction métallique: notions fondamentales et méthodes de dimensionnement, Presses Polytechniques et Universitaires Romandes, 2001

MOREL J., Guide de calcul des structures métalliques : CM 66 additif 80 - Eurocode 3, Eyrolles, 1997.

Construction métallique et mixte acier-béton : calcul et dimensionnement selon les Eurocodes 3 et 4 - Tome 1, Eyrolles, 1996.

Construction métallique et mixte acier-béton : conception et mise en oeuvre - Tome 2, Eyrolles, 1996

Prerequisites

Course on mechanics of fracture and strength of materials (3rd and 4th year)

Learning outcomes

Learning outcomes	N	A	M	E	O
• To understand the behavior of welded structures under different types of load	·	·	✓	·	·
• To calculate and size welds	·	·	✓	·	·
• To design of welded structures	·	·	✓	·	·

Manager : Pascal PAILLARD

Dielectric materials -Magnetic materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10	3				1.5	8

Evaluation

One evaluation : *DS*

Outline

This course will cover the following topics. Electric polarization and dielectric constant - Dielectric loss - Capacitance - Dielectric breakdown - Piezoelectricity - Pyro and ferroelectricity - Applications of dielectric materials - Magnetostatics - Ferromagnetism - Hard ferromagnets - Soft magnetic materials - Magnetic properties of superconducting materials.

Goals

The aim of the course is to provide students with a general overview of the various properties and of the numerous applications of magnetic or dielectric materials. Manufacturing process are also introduced

Bibliography

"Matériaux de l'électronique - Volume II, P. Robert, Traité d'électricité de l'EPFL, PPR" « Magnétisme - Fondements, Matériaux et Applications », Presses Universitaires de Grenoble - « Matériaux magnétiques en génie électrique », Lavoisier et Hermès science

Prerequisites

Background in electromagnetism and materials sciences (chemistry, physics, process engineering)

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing physical quantities in order to characterize or choose a material	·	·	✓	·	·
• Knowing the possible roles of magnetic or dielectric materials in industrial devices	·	·	✓	·	·
• Evaluating energy losses in a magnetic or dielectric material	·	✓	·	·	·
• Knowing and understanding shape anisotropy and microstructural effects on the properties of magnetic or dielectric materials	·	✓	·	·	·

Manager : Christophe PAYEN

Diffusion in solids

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	6				1	4

Evaluation

One evaluation : *DS*

Outline

Atomic jumps and statistical physics
Fick's equations
Influence of time and temperature on diffusion
Meachanisms and associated diffusion coefficients
- autodiffusion
- vacancies diffusion
- heterodiffusion : in dilute alloy and interdiffusion
Diffusion in ionic solids
Diffusion and cristalline defects
Reactive diffusion

Goals

Get the basics of solid state diffusion : equations that drive the diffusion and the phenomenon mechanisms.

Sensitize the students to the ubiquity of this phenomenon in materials science (often being underlying in more complex phenomena) and then to the fact that they will have to often use it again in the following of their formation.

Bibliography

Phase transformations in Metals and Alloys, Third Edition, D. A. Porter, K. E. Easterling and M. Y. Sherif, CRC Press Taylor & Francis Group

Diffusion in Solids, Field Theory, Solid-State Principles, and Applications, M. E. Glicksman, Wiley Inter-Science

Prerequisites

Mathematics and physics basics

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to use the Fick's equations in order to solve a diffusion problem.	·	✓	·	·	·
• To understand the influence of time and temperature on the diffusion phenomenon.	·	✓	·	·	·
• To understand that diffusion is a phenomenon that governs numerous other more complex phenomena in materials science.	✓	·	·	·	·
• To master the diffusion terminology in order to be able to get from scientific literature the appropriate data to solve a diffusion problem.	·	·	✓	·	·

Manager : Laurent COUTURIER

Durability : corrosion and electrochemical coating deposition

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
8.75	7.5				1.5	9

Evaluation

One evaluation : *DS*

Presentation

A set of lectures, supervised work and industrial presentations covering the mechanisms, thermodynamics and kinetics of corrosion, as well as the ways to fight against it or to avoid it, notably through surface treatments and electrochemically obtained coatings.

Outline

1. Thermodynamics of corrosion:
- Oxidation, electronegativity, Gibbs free energy
- High temperature oxidation (Ellingham)
- Electrochemical potential (Nernst, Pourbaix)
2. Kinetics of aqueous corrosion:
- Kinetics controlled by charge transfer (Butler-Volmer, Tafel, Evans...)
- Kinetics controlled by diffusion
- Passivation and depassivation
3. Industrial case studies and mechanisms:
Uniform, pitting, crevice, galvanic, intergranular, stray current corrosions; stress-corrosion cracking
4. Implementation of surface treatments and coatings:
- Preparation treatments: pickling, degreasing, polishing
- Chemical deposition (displacement deposition, electroless plating), electrolytic deposition and coating by immersion in liquid metals
5. Applications of surface treatments and coatings:
- Protection against corrosion: thickness, undercoats, other physico-chemical properties (hardness, wear resistance...)
- Other uses: MEMS, sensors...

Goals

Provide the future materials engineer with:
- physical and chemical notions leading to the understanding and characterisation of corrosion phenomena;
- an illustration of industrial practice in terms of corrosion control and expertise;
- the scientific and technological knowledge allowing to implement strategies of protection against corrosion, notably involving coating processes by electrochemical routes.

Bibliography

- Dieter Landoldt ; Corrosion et chime de surface des matériaux ; PPUR, 1993
- Mars G. Fontana ; Corrosion Engineering ; Mc Graw-Hill, 1987, www.corrosiondoctors.org/
- MODERN ELECTROPLATING, Fifth Edition, Edited by MORDECHAY SCHLESINGER & MILAN PAUNOVIC, Published by John Wiley & Sons, Inc., Hoboken, New Jersey, 2010, ISBN 978-0-470-16778-6

Prerequisites

Thermodynamics, bases in chemistry and general metallurgy

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing how to apply electrochemical law to corrosion characterisation	·	·	✓	·	·
• Being able to take corrosion into account in engineering design (corrodability, corrosion rate)	·	·	✓	·	·
• Being able to diagnose corrosion damage	·	✓	·	·	·
• Being capable of choosing a surface treatment / a coating to fight against corrosion	·	·	✓	·	·
• Knowing how to implement a surface treatment / a coating	·	·	✓	·	·

Manager : Franck TANCRET

Ecodesign of a Data Center S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Claudia MARINICA

Ecodesign of a Data Center S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Claudia MARINICA

Ecological transition for sustainable development 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	9					

Evaluation

One evaluation : *DS*

Manager : Émilie GADOIN

Economy and controversy mapping

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	27					10

Evaluation

One evaluation : *DS*

Bibliography

- Christine Dollo, Laurent Braquet, Economie, Sirey
- Grégory N. Mankiw, Mark P. Taylor, Principes de l'économie, DeBoeck, 2022.
- Bruno Latour, La science en actions : introduction à la sociologie des sciences, La découverte Poche, 2005.

Manager : Chrystèle GONCALVES

Electric assistance intermediate vehicle S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Christophe PAYEN

Electric assistance intermediate vehicle S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Christophe PAYEN

Electrical engineering

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	12	8			1.5	11

Evaluation

2 evaluations :

- *DS*
- *Rapport Gpe*

Presentation

Basis of electrical engineering. The production and the network of electrical energy is presented. The main industrial electrical machines are also described.

Laboratory : practical works and skills concerning electrical engineering ; Pratical performing of electrical circuit using industrial machine (tranformers, motors) ; study of electrical apparatus behaviour. Calculation of electrical powers (DC and RF).

Outline

Course :

Materials being used in electrical engineering regarding their electrical properties

single and three phase networks ; electrical powers ; electrical security ; electrical transformer ; alternator ; Direct current motor ; AC current motor

Laboratory :

single transformer ; no-load and short circuit test ;electrical load measurements ; single phase engine operation ; variable three phase transfomer ; DC current engine operation ; yield measurement ; motor speed control ; characteristics of asynchronous engine

Goals

the aim is to acquire the basis of electrical engineering, of electrical security and also to give the knowleges which allow the choice of material regarding its electrical properties and its potential application in an electrical machine.

Practical basis of electrical engineering ; electrical measurements ; electrical security

Bibliography

titre : Matériaux de l'Electrotechnique
auteurs : P. Robert
éditeur : Presses Polytechniques Romande date : 1998 ISBN: 2-88074-419-9
titre : Les Bases de l'Electrotechniqueauteurs : I. BERKES
éditeur : Vuibert date : 1998 ISBN: 2-7117-8879-2
titre : Electrotechnique Industrielle
auteurs : G. SEGUIER, F. NOBLET
éditeur : Lavoisier date : 2006 ISBN 2-7430-0791-5
titre : Electrotechnique
auteurs : T. WILDI
éditeur : Deboeck, Université date : 2005 ISBN 2-8041-4892-0
titre : Electrotechnique
auteurs : MERAT
éditeur : Nathan date : 1997 ISBN 2-09-177992-7

Prerequisites

Electricity, Magnetism, Electromagnetism

Learning outcomes

Learning outcomes	N	A	M	E	O
• knowing of materials involved in electrical engineering	·	✓	·	·	·
• be able to describe the operating principles of electrical machines	·	✓	·	·	·
• be able to evaluate the different electrical powers and the power factor of an electrical circuit	·	·	✓	·	·
• be able to evaluate and to measure the yield of an electrical system	·	·	✓	·	·
• knowing and be able to follow the bases of electrical safety	·	✓	·	·	·
• be able to choose electrical components to make an electrical circuit and to control an electrical machine	·	✓	·	·	·
• be able to operate different electrical machines	·	·	✓	·	·
• be able to define and use a control and regulation system to operate an electrical machine	·	✓	·	·	·
• be able to make electrical assembly using industrial electrical machines	·	✓	·	·	·

Manager : Benoit ANGLERAUD

Electrochemistry : storage and conversion of decarbonated energy

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
11.25	9				2	11

Evaluation

One evaluation : *DS*

Outline

The first part is devoted to the basics of electrochemistry in liquid medium in particular addressing the concepts of thermodynamic stability of species as a function of potential and pH. The second part deals with the electrochemical generators using the previous bases. Batteries, fuel cells and supercapacitors are detailed.

Goals

Acquire theoretical and practical knowledge on the different systems of electrochemical conversion and storage of energy.

Prerequisites

Basics of general chemistry at final scientific level

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know the basics of electrochemistry	·	·	✓	·	·
• Know the different systems of electrochemical storage and conversion of energy	·	·	✓	·	·
• Know how to draw a voltage-pH diagram	·	·	✓	·	·

Manager : Olivier JOUBERT

Electronics for measurement systems - laboratory

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		24				12

Evaluation

One evaluation : *Rapport Gpe*

Outline

Microproject - Sensors and measurement chain - Experimental study of analog filtering - Sampling, Data acquisition and digital signal processing

Goals

Learn techniques of measurements on electronic systems with analog and digital signal processing. Realize a project of conception and realization of a measurement chain going from the sensor up to the acquisition of datas

Bibliography

Acquisition de données - Du capteur à l'ordinateur - G. Asch - Dunod ; Electronique des systèmes de mesures - Mise en oeuvre des procédés analogiques et numériques - Tran Tien Lang - Masson ; Les capteurs en instrumentation industrielle - G. Asch - Dunod

Prerequisites

Course of "Sensors, Instrumentation and Measurements" in S5

Learning outcomes

Learning outcomes	N	A	M	E	O
• Build a project management with time constraint and with precise technical specifications: organize work and schedule, know how to cooperate, know how to work in a team, manage stress, make choices, adapt oneself to the available facilities.	·	✓	·	·	·
• Conceive, realize and test a measurement chain with a temperature regulation including a sensor, a bridge for signal conditioning, assemblies of operational amplifiers assuring functions of analog signal processing and control of the analog signal and LED for display and alert.	·	✓	·	·	·
• Be able to use a data acquisition system to realize the signal sampling and the calculation of the signal frequency spectrum.	·	·	✓	·	·
• Be able to measure the gain and the phase shift of a linear quadripole. Be able to evaluate the bandwidth.	·	·	✓	·	·

Manager : Jeremy BARBE

English grammar for engineers

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	22.5					

Evaluation

2 evaluations :

- *Situation Gpe*
- *DS*

Manager : Pascale SIMON LLOBREGAT

Entrepreneurship S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

One evaluation : *Situation Ind*

Manager : John KINGSTON

Entrepreneurship S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

One evaluation : *Situation Ind*

Manager : John KINGSTON

Fabrication, operation and exploitation of welded components

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
24.5					1.5	9

Evaluation

One evaluation : *DS*

Outline

Introduction to assurance quality in welded fabrication
- Process quality control
- Deformations and residual stresses
- Means of production, jigs and fixtures
- Hygiene and security
- Defects and acceptance criteria
- Productivity and economic aspects

Goals

Fabrications welded from standardization to implementation in a manufacturing issues

Bibliography

Fumée de soudage : efficacité des différents systèmes de protection du soudeur et de son environnement en soudage, Edition du CETIM, 2005

BLONDEAU R., Procédés et applications industrielles du soudage, Lavoisier , Hermès science, 2001

Prerequisites

Not applicable

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know and to know how to apply the standardisation in the field of welding	·	·	✓	·	·
• To know the impact of welding on health	·	·	✓	·	·
• To know the impact of welding on the quality of the welded construction	·	·	✓	·	·
• To know the overriding settings on increasing productivity in welded construction	·	✓	·	·	·

Manager : Pascal PAILLARD

Fracture-Fatigue-Creep

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10	12				2	12

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Outline

Part I: Fracture mechanics
- Fracture mechanims (brittle, ductile, inter- or transgranular, fractography...)
- Mechanical approach (stress intensity factor, toughness, measurements...)
- Energetic approach (energy balance, G, Gc, measurements, relations with K1c)
- Elasto-plastic fracture (small-scale yielding, J-integral, work of fracture)

Part II: Fatigue of materials
- Initiation of fatigue cracks (mechanisms, triaxial criteria...)
- Propagation of fatigue cracks (mechanisms, Paris' law, fractography)
- S-N curves, fatigue limit, parametric study of fatigue (mean stress, surface state and treatments, residual stresses...)
- Accumulation of damage (Palmgren-Miner, non-linear accumulation...)
- Low cycle fatigue (cyclic loading curves, Coffin-Manson law...)

Part III : Creep of materials
- Deformation mechanisms (dislocation creep, diffusion creep...)
- Models and constitutive laws
- Damage and strengthening mechanisms
- Lifetime extrapolation methods (Monkman-Grant, Rabotnov-Kachanov, Larson-Miller, Wilshire...)

Goals

Provide the future materials engineer with a culture on (thermo)mechanical failure modes of materials (fracture by crack propagation, fatigue, creep), in liaison with their nature and microstructure, as well as knowledge and tools allowing to address the phenomena in terms of experiment (characterisation) and application (mechanical design, durability, control, expertise...).

To be noted that thermal shock is dealt with in another course.

Bibliography

- J. B. Leblond, "Mécanique de la rupture fragile et ductile" (Hermes)
- D. Miannay, "Mécanique de la rupture" (EDP Sciences)
- C. Bathias, A. Pineau, "Fatigue des matériaux et des structures" (Hermes)

Prerequisites

- Basics of continuum mechanics (stresses and strains, elasticity)
- Bases in materials science (microstructures, tensile testing)
- Bases on plasticity criteria (Tresca, von Mises)
- Basics of physical metallurgy (plastic slip in crystals, strain hardening, diffusion)

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the basics of fracture mechanics and the different types of fracture behaviours of materials	·	·	✓	·	·
• To know the behaviour of materials submitted to fatigue and the main damage mechanisms	·	·	✓	·	·
• To be able to apply mechanical design to a structure with the presence of defects and/or submitted to fatigue	·	✓	·	·	·
• To be able to perform a failure analysis from a fracture surface	·	·	✓	·	·
• To know the behaviour of materials during creep and the associated mechanisms	·	·	✓	·	·

Manager : Franck TANCRET

French as a foreign language

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *Situation Ind*

Manager : Carole CHAUSSE

French as a foreign language

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *Situation ind.*

Manager : Carole CHAUSSE

Fundamentals of heat transfer

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
1.25	9				1	6

Evaluation

One evaluation : *DS*

Outline

Introduction (Different forms of energy, Energy conversion, Heat transfer). Conduction (Fourier's law, Heat equation, solution for stationnary regime). Convection (Forced and Natural Convection, Laminar and Turbulent regimes, Correlations). Radiation (Physical aspects, Emission-absorption of opaque surfaces, Radiosity method).

Goals

The objectives of this course is (i) to introduce the fundamentals of this subject, (ii) to establish the relationship of these origins to the behavior of thermal systems. It should develop methodologies which facilitate application of the subject to a broad range of practical problems and it should give necessary tools to perform engineering analysis of a system or process

Bibliography

J.F Sacadura, "Initiation aux transferts thermiques", Editions TEC&DOC, 2000. F.P. Incropera, D.R. De Witt, "Fundamentals of Heat and Mass Transfer", John Wiley and Sons, 1996.

Prerequisites

General Thermodynamics

Learning outcomes

Learning outcomes	N	A	M	E	O
• Basic knowledge of heat transfer modes	·	·	✓	·	·
• Knowing to do an energy balance for a system	·	✓	·	·	·

Manager : Ahmed GUELED

General mechanics

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	10.5				1	6

Evaluation

One evaluation : *DS*

Outline

Mathematical reminders
- Mechanical action modelling
- Mass centre, moments of inertia
- Physical behaviour laws (Newton, Coulomb)
- Study cases

Goals

To position and parametrize a system of rigid bodies
- To modelize mechanical actions
- To solve a static problem (to find efforts and positions)

Bibliography

Mécanique générale par JC. Bône - Editions Dunod
- Engeneering Mechanics par McLean & Nelson - Editions Schaum

Learning outcomes

Learning outcomes	N	A	M	E	O
• To modelize mechanical actions	·	·	✓	·	·
• To determine unknown forces and positions	·	·	✓	·	·

Manager : Jérémie RUPIL

General metallurgy

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
8.75	19.5	26			3.5	27

Evaluation

5 evaluations :

- *DS1*
- *DS2*
- *DS3*
- *Rapport Gpe*
- *Soutenance*

Outline

Mechanical properties of metals
Crystallography of metals
Thermodynamics of metallic systems
Solidification
Diffusional transformations in the solid state
Displacive transformations

Goals

Understand the mechanical behavior of metals and be able to extract mechanical properties from experimental tests

Know the main phenomena involved during solidification, diffusional and displacive transformations, as well as their consequences on microstructure and mechanical properties

Be able to interpret a phase diagram in order to predict a microstructure resulting from cooling from a high temperature

Bibliography

Métallurgie, du minerai au matériau, Jean Philibert, Alain Vignes, Yves Bréchet, Pierre Combrade, Dunod, 2002

Publication : 2002Métallurgie : Élaboration, structures-propriétés, normalisation de Jean Barralis et Gérard Maeder, Afnor-Nathan, 2005

Matériaux : Tome 1, Propriétés, applications et conception de Michael-F Ashby, David-R-H Jones, Yves Bréchet et Joël Courbon, Dunod, 2008

Matériaux : Tome 2, Microstructures, mise en oeuvre et conception de Michael-F Ashby, David R. H. Jones, Joël Courbon et Michel Dupeux, Dunod, 2008

Prerequisites

Thermodynamics, Mechanics of materials, Solid State Chemistry

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the mechanisms of solidification in metallic alloys and the main chemical and microstructural characteristics of alloys solidification	·	·	✓	·	·
• To know the main solid state phase transformations mechanisms in metallic alloys (diffusive, displacive) and microstructures associated with these transformations	·	·	✓	·	·
• To be able to predict the microstructure of a binary alloy using a phase diagram	·	·	✓	·	·
• To be able to predict the microstructure of a steel using a CCT or TTT diagrams	·	·	✓	·	·
• To know the thermodynamical basis of phase diagrams	·	·	✓	·	·
• To know the role of carbon as interticial element in steels	·	·	✓	·	·

Manager : Emmanuel BERTRAND

Generalized functions, integral transforms and partial differential equations

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21				2	12

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Presentation

This EC follows the EC?Linear algebra, complex analysis? of semester 5 and aims to give to the future Materials engineer mathematical tools required for his partice, whether for the description of physical phenomena , their modeling or the modeling of systems, or even the data analysis.

Outline

1. Functional analysis

Dirac distribution, Convolution product , Fourier series, Fourier transformation Laplace transform of functions and distributions

2. Differential analysis

Supplements on differential equations, on partial differential equations (PDE),

Goals

At the end of this EC, the student will be able to implement the basic concepts and elementary calculations based on functional anaylsis (distributions, convolutions, Fourier or Laplace transforms) or differential analysis for applications in materials science in general, in data and signal processing on the other hand.

Bibliography

L. Schwartz ; « Cours d'analyse » ; Hermann

R. Petit ; « L'outil mathématique » ; Dunod

R. Roddier ; « Distributions et transformations de Fourier » ; Ediscience

J. Dixmier ; « Cours de Mathématiques » ; Gauthiers-Villars

G. Gasquet et P. Witomski ; « Analyse de Fourier et applications » ; Masson

Prerequisites

- same as for "linaear algebra, complex analysis"

Learning outcomes

Learning outcomes	N	A	M	E	O
• MAT-1: Apply mathematical tools and statistical methods	·	·	✓	·	·
• MAT-11: Apply analytical, statistical, numerical mathematical tools to solve complex problems already formalized	·	·	✓	·	·
• MAT-10: Explain, model and solve a complex problem, even if it is not fully defined	·	✓	·	·	·

Manager : Hélène PERENNOU

Great Event S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Jérôme BEZIER

Great Event S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Jérôme BEZIER

Heat transfer in processes

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
5	5	12			1.5	12

Evaluation

One evaluation : *Rapport Ind*

Manager : Vincent SOBOTKA

Hygrogen vector : production, storage and distribution

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
4.67	2.83	3			0.5	

Outline

The first part is devoted to a general presentation of the hydrogen sector and introduces the basic concepts concerning electrochemical devices using hydrogen, in particular fuel cells and electrolyzers. Another part covers the main methods of hydrogen storage and some aspects of hydrogen safety.

Goals

The objective of this course is to allow students to become familiar with certain aspects of hydrogen as a chemical molecule and energy carrier. The goal is to learn about the various methods of producing and storing hydrogen, to learn about various aspects related to hydrogen safety and to study certain current and future uses of hydrogen.

Prerequisites

the course "Electrochemistry: storage and conversion of decarbonated energy"

Learning outcomes

Learning outcomes	N	A	M	E	O
• know the different ways of production, storage and conversion of hydrogen	·	·	✓	·	·

Manager : Olivier JOUBERT

Industrial seminars

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	4.5					

Outline

Batteries, supercapacitors, and fuel cells for electric power, renewable energy storage, and other applications. Systems for the production, storage, and distribution of hydrogen.

Goals

Conferences with industrialists in the field of integration of electrochemical systems for energy storage and conversion

Prerequisites

Knowledge of the operating principles, manufacturing, and performance characteristics of batteries, supercapacitors, fuel cells, electrolyzers

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understanding the industrial challenges of electrochemical energy storage and transformation	·	·	✓	·	·

Manager : Bernard LESTRIEZ

Intercultural exploration : understanding differences

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *Situation ind.*

Bibliography

? Polycopié : Intercultural exploration (2025-2026)

? Dignen, B. (2011). Communicating across cultures. Cambridge.

? Meyer, E. (2014). The culture map: Breaking through the invisible boundaries of global business. PublicAffairs.

? Hofstede, G., Hofstede, G. J., & Minkov, M. (2010). Cultures and organizations: Software of the mind - Intercultural cooperation and its importance for survival (3rd ed.). McGraw-Hill.

? Bourrelle, J. S., Elise H. Kollerud (2015). Cracking the Scandinavian code. Mondå Forlag.

? Stringer, D. M., & Cassiday, P. A. (2006). 52 activities for improving cross-cultural communication. Intercultural Press.

Manager : Carole CHAUSSE

Internship 3rd year

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
				8		

Evaluation

One evaluation : *Autoéval*

Manager : Olivier CROSNIER

Internship 4th year

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
				13		

Evaluation

One evaluation : *Autoéval*

Manager : Emmanuel BERTRAND

Introduction to polymer materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
8.75	7.5				1.5	9

Evaluation

One evaluation : *DS*

Outline

THE CHALLENGES OF POLYMERS
Advantages and Problems
PRODUCTION OF POLYMERS
Polymerization Types and Processes. Identification by Infrared Spectrometry. Biopolymers.
ISOMERIZATION: CONFIGURATIONS and CONFORMATIONS
MOLAR WEIGHTS and DISTRIBUTIONS
Definitions and Measurement Techniques
POLYMERS in SOLUTION
Solubility and Conformation. Viscosity of Polymer Solutions.
SHAPING PROCESSES
POLYMERS in the SOLID STATE
Cohesion and Molecular Organization. State Domains and Thermomechanical Behavior.
HOMOGENOUS POLYMER MATERIALS
Amorphous and Crystalline Polymers.
HETEROGENEOUS POLYMER MATERIALS
Fillers and Reinforcements. Polymer Blends. Copolymers.
AGING and END-OF-LIFE RECOVERY
The different causes of aging. Different end-of-life treatments: energy recovery; mechanical/physical/chemical recycling. Biodegradable polymers.

Goals

Understand by simple representations, the macromolecular chemistry.
Know the main characterization tools of polymers.
Anticipate the behavior of polymeric materials by the analysis of their chemical structures and spatial structures
Know the major industrial polymers and their properties
Understand the aging mechanisms of polymer materials and end-of-life recycling methods

Bibliography

DETERRE R., LESTRIEZ B., Introduction aux matériaux polymères. Lavoisier (2016)

Prerequisites

Basic knowledge of organic chemistry

Learning outcomes

Learning outcomes	N	A	M	E	O
• Describe the synthesis routes of polymers	✓	·	·	·	·
• Know the caracterisation tools of polymer materials	·	✓	·	·	·
• Know the different macromolecular structures (homo and copolymers) and their properties	·	·	✓	·	·
• Knowing thermomechanical behavior of different polymers	·	✓	·	·	·
• Describe the key mechanisms of aging and recycling of polymers	·	✓	·	·	·
• To describe the processes for shaping polymers	✓	·	·	·	·

Manager : Bernard LESTRIEZ

Job search strategy and techniques

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
1.5	9					6

Evaluation

One evaluation : *Situation groupe*

Bibliography

? www.16personalities.com
? www.acnv.com

Manager : Sylvaine GAUTIER

Lihtium batteries and new battery technologie

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
11.75	5.5	6			1.5	

Outline

Electrochemical energy storage systems (lithium batteries):
- electrode formulation and shaping techniques
- Introduction to recycling
- Advanced electrochemical characterization techniques (PITT, GITT, power measurements)
- Future technologies: new electrode materials and devices

Practical aspects:
- Assembly and performance evaluation of semi-commercial devices (batteries)

Goals

Understand the relationships between material properties and their technical and economic performance. Understand the manufacturing processes and formulation principles of lithium battery electrodes. Understand the issues, challenges, and recycling processes. Understand the techniques for characterizing and measuring performance. Understand new battery technologies (redox flow, all-solid, sodium ion, sulfur, aqueous zinc). Understand the coupling of storage devices with energy conversion devices (solar, wind) and electric motors.

Bibliography

M. Armand, P. Axmann, D. Bresser, M. Copley, K. Edström, C. Ekberg, D. Guyomard, B. Lestriez, P. Novak, M. Petranikova, W. Porcher, S. Trabesinger, M. Wohlfahrt-Mehrens, H. Zhang, ?Lithium-ion batteries - Current state of the art and anticipated developments?, J. Power Sources, 479, 2020, 228708

Prerequisites

Basic knowledge of electrochemistry and electrochemical generators
- ? The basics of operating principles
- ? The different technological approaches: cell geometry, electrode materials, and electrolytic media
- ? Electrical quantities and characteristic electrical profiles, limiting phenomena

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know how to interact with experts in electrochemical generators or integrators of these technologies.	·	·	✓	·	·
• To know how to formulate and manufacture a battery electrode	·	·	✓	·	·
• Know how to assemble a battery laboratory prototype	·	·	✓	·	·
• Know of to measure the performance of an electrochemical cell	·	·	✓	·	·

Manager : Bernard LESTRIEZ

Linear algebra and complex analysis

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	24				2.5	13

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Presentation

This EC aims to provide the future Materials Science engineer with the mathematical tools essential for the description of physical phenomena, their modeling or the modeling of systems. It is spread over the two semesters of the 1st year of the engineering cycle.

Outline

1) Elements on linear algebra

Algebric structures, linear applications, matrices, determinants and linear systems, eigenvectors eigenvalues and eigen spaces, diagonalisation and tiangularisation

2) Functions of a complex variable

Holomorphic functions, standard functions, integration in the complex plane, analytic functions, method of residues

Goals

At the end of this EC, students will have good skills in basic mathematical techniques such as linear algebra and analysis in the complex plane for applications in materials science.

Bibliography

L. Schwartz ; « Cours d'analyse » ; Hermann
R. Petit ; « L'outil mathématique » ; Dunod
N. Boccara ; « Fonctions analytiques » ; Ellipses
J. Dixmier ; « Cours de Mathématiques » ; Gauthiers-Villars
P. Benoist-Gueutal et M. Courbage ; « Mathématiques pour la physique » ; Eyrolles

Prerequisites

- notions of linear algebra, resolution of linear systems
- notions concerning sequences and series
- master of differential and integral calculus for the functions of the real variable
- master of linear differential equations of 1st and 2nd order with constant coefficients
- notions on functions with several variables, differential, partial derivatives, multiple integrals

Learning outcomes

Learning outcomes	N	A	M	E	O
• MAT-1: Apply mathematical tools and statistical methods	·	·	✓	·	·
• MAT-11:Apply analytical, statistical, numerical mathematical tools to solve complex problems already formalized	·	·	✓	·	·
• MAT-10: Explain, model and solve a complex problem, even if it is not fully defined	·	✓	·	·	·

Manager : Hélène PERENNOU

Materials Chemistry II

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
15	7.5				1.5	12

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Outline

Chapter III - Solid State Chemistry
III.1 Crystal structures
III.2 Ionic bond
III.3 Ionocovalency
III.4 Electronic structure of solids
III.5 Metallic bond
Chapter IV - Defects in solids
IV.1 Types of defects
IV.2 Effect of defetc on optical properties
IV.3 Mobility of defects - Ionic conductivity in solids
Chapter V - Materials Synthesis and Processing
V.1 Modern ceramics overview
V.2 Synthesis routes (powder)
V.3 Introduction to ceramic sintering

Goals

Analyze simple crystal structures.

Describe, in connection with the chemical compositions, crystal structures and properties of materials, the main types of chemical bond (ionic, covalent and metallic) and electronic structures (insulators, semiconductor, metal).

Study the influence of defects on the properties of materials.

Describe the main methods for preparing non-metallic inorganic materials (powder synthesis and ceramic sintering).

Bibliography

Chimie des solides - J.F. Marucco - EDP Sciences
Solid State Chemistry - L. Smart and E. Moore - Chapman et Hall
Chimie Inorganique - Huheey, Ketter et Ketter - De Boeck Université
J. M Haussonne, C. Carry, P. Bowen, and J. Barton. Céramiques et verres: principes et techniques d'élaboration. Presses Polytechniques et Universitaires Romandes

Prerequisites

Courses: "Materials Chemistry I", "Symetry in solids". Level : semester 5

Learning outcomes

Learning outcomes	N	A	M	E	O
• Analyzing simple crystal structures	·	·	✓	·	·
• Predicting the impact of defects on material properties	·	✓	·	·	·
• Relationships between crystal structures, chemical bonds, electronic structure, and material properties.	·	✓	·	·	·
• Synthesis routes for preparing powder of inorganic materials	·	✓	·	·	·

Manager : Christophe PAYEN

Materials and applications (accueil)

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	2.5					

Presentation

This lecture proposes a general description of materials science and engineering (main families and examples of materials, of properties, of processes...), in liaison with the teaching cursus over the three years, the profiles of teachers and the skills necessary for a materials engineer.

Outline

- Materials and Mankind
  - The main families of materials
  - The main categories of properties
  - The main families of processes
  - Case studies
  - Research and innovation
  - The skills of a materials engineer
  - The teaching cursus

Goals

- (Re-)discover materials science and engineering, to give all students a common culture of the domain, whatever is their academic background.

- Being aware of the structure of the cursus (fundamental and engineering sciences => sciences of the materials specialty => industrial practice), which allows to cover globally the domain and the skills of a materials engineer.

- Discover the contribution of the school to the domain through its research.

Prerequisites

Physics and chemistry (beginning of first cycle).

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing and being able to apply materials sciences	✓	·	·	·	·
• Take environmental issues into account	✓	·	·	·	·
• Take society issues into account	✓	·	·	·	·
• Building a realistic and consistent professional and personal project	✓	·	·	·	·

Manager : Franck TANCRET

Materials chemistry - laboratory

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		12				

Evaluation

One evaluation : *Rapport Gpe*

Outline

Four 3-hour laboratory sessions. Work in groups of three.

Topics studied:

1. Synthesis of inorganic materials
2. Determination of metal content in an alloy using spectrophotometry
3. X-ray diffraction studies
4. Study of bio-based polymers: cellulose and its derivatives

Goals

Conduct synthesis and characterization experiments in the field of materials, and prepare a summary report of the results obtained.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to relate experimental observations to chemical models	·	✓	·	·	·
• Use products, equipment, and measuring devices correctly, in accordance with experimental procedures and health and safety rules	·	·	✓	·	·
• Perform accurate dosages, syntheses, or analyses	·	✓	·	·	·
• Collect data and rigorously analyze the results	·	·	✓	·	·
• Present a structured lab report: introduction, protocol, results, critical analysis, conclusion	·	·	✓	·	·

Manager : Olivier CROSNIER

Materials for photovoltaic devices

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6.25	3	6			1	

Evaluation

One evaluation : *DS (100 %)*

Outline

? Introduction to photovoltaics and overview of technologies
- ? Optical and electronic properties of semiconductor materials
- ? Materials used in solar cells: Si, CdTe, CIGS, perovskites, organics
- ? Fabrication techniques
- ? Characterization of photovoltaic devices
- ? Current trends and perspectives (tandem cells, recycling, integration)

Goals

To acquire a thorough understanding of the materials used in photovoltaic devices, their physical properties, and the associated fabrication processes.

To be able to measure and analyze the performance of photovoltaic cells.

Bibliography

Physics of Solar Cells - P. Würfel, Wiley-VCH

Prerequisites

Basic knowledge of solid-state physics: bandgap, charge carriers, doping, light-matter interaction.

Familiarity with thin-film deposition processes and materials characterization techniques.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the fundamental properties of semiconductor materials used in photovoltaics	·	·	✓	·	·
• Identify the advantages and limitations of various photovoltaic technologies	·	·	✓	·	·
• Select and compare suitable fabrication techniques for different types of solar cells	·	·	✓	·	·
• Interpret the results of electrical and optical characterizations of photovoltaic cells	·	·	✓	·	·

Manager : Jeremy BARBE

Materials for thermal storage

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
2.5	3	6			0.5	

Outline

The course is composed of four distinct parts: (1) general concepts, (2) sensible heat storage, (3) latent heat storage, (4) thermochemical storage. Cross-cutting elements (state of the art, transitional applications, materials, LCA, etc.) are developed in each part.

Goals

The objectives of the thermal storage course are: (1) to acquire knowledge of the state of the art specific to thermal storage (sensible, latent, thermochemical), (2) to understand the challenges and expectations of thermal storage in the transition according to applications, (3) to have criteria for choosing between different storage modes including environmental ones (LCA).

Bibliography

Incroperas Principles of Heat and Mass Transfer Global Edition by Lavine & Adrienne S. Mechanical and Aerospace Engineering Department & University of Cal, Theodore L Bergman, Adrienne S Lavine, Frank P Incropera, David P Dewitt.

Thermal Energy Storage: Systems and Applications, Author(s):?brahim Dinçer, Marc A. Rosen

Print ISBN:9781119713159 |Online ISBN:9781119713173 |DOI:10.1002/9781119713173, 2021 John Wiley & Sons Ltd.

Journal of Energy Storage, Elsevier.

Prerequisites

The basic knowledge required to successfully complete the thermal storage course includes: (1) basic concepts of thermodynamics, thermal science and energy, (2) basic concepts of heat transfer, (3) thermal balances in both steady-state and transient conditions.

Learning outcomes

Learning outcomes	N	A	M	E	O
• know how to design a sensible heat storage	·	·	✓	·	·
• know how to design a latent heat storage	·	·	✓	·	·
• know how to select the relevant thermal storage	·	·	✓	·	·
• know how to choose materials based on a multi-criteria approach	·	·	✓	·	·

Manager : Xavier PY

Materials indicators for eco-design

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	4.5					4.5

Evaluation

2 evaluations :

- *DS*
- *Rapport Gpe*

Outline

Introduction
- General information
- Some tools
- An analytical approach
- Definitions of the indicators used by Granta EduPack
- Practice

Goals

Take an overview of the various sources of impacts related to the use of materials, from the extraction of their constituent elements to the end of life of the products they form.

Be able to search for information to quantify these impacts and to understand what lies behind these impact indicators.

Bibliography

Granta Edupack

The materials science behind sustainable metals and alloys, D. Raabe, Chemical Reviews, 2023

Conférences de J.M. Jancovici et A. Stephant

https://fr.statista.com/statistiques/615687/fabrication-de-plastique-dans-le-monde/

https://elements.visualcapitalist.com/

Prerequisites

None

Learning outcomes

Learning outcomes	N	A	M	E	O
• To gain an understanding of the different impacts (nature and ?quantification?) that the production and use of materials by human society can generate.	·	·	✓	·	·
• To understand how indicators used to rationalize the environmental impacts of materials are obtained, and to develop a critical perspective on their use.	·	·	✓	·	·
• To be able to identify relevant indicators that help assess the impacts of a given material, in order to question its appropriate use and consider alternatives if necessary.	·	·	✓	·	·
• To be able to make a material selection based on minimizing various environmental impacts, while still meeting the requirements of a given specification.	·	·	✓	·	·

Manager : Laurent COUTURIER

Mechanical properties of composite materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
15		12			1.5	15

Evaluation

2 evaluations :

- *DS*
- *CR*

Outline

Lectures and supervised work:

1. General information on the effect of mechanical reinforcement with fibers
2. Anisotropic behavior laws in linear elasticity
3. Mechanical behavior of laminated plates: simplified Kirschhoff-Love theory, integrated stiffness matrices
4. Failure mechanisms and design criteria
5. Thermoelasticity and residual stresses in composites
6. Application exercises

Practical work, design of long fiber composite parts using CATIA V5.

1- Design rules for composite parts

2- Definition of virtual stack-up, CATIA ?Composite Design? module

3- Structural calculation, CATIA ?Structural Analysis? module

Goals

Provide basic knowledge of the mechanical effects of fiber reinforcement and the laws of anisotropic behavior in linear elasticity. Understand the effects of ply arrangement for laminated composites, particularly the phenomenon of tension-bending coupling. Be able to design the architecture of a composite laminate for a given load.

Bibliography

Matériaux Composites, J-M Berthelot, Ed. Tec & Doc, Lavoisier, Paris, 2005.

Matériaux Composites, F. Gay, Hermès Science Publications, 2005.

Généralités sur les matériaux composites, L. Gornet, Ecole Centrale de Nantes, 2008

Prerequisites

Basic knowledge of continuum mechanics and materials mechanics (stresses, strains, mechanical behavior laws)

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understanding the main principles of fiber reinforcement	·	·	✓	·	·
• Mastering the concepts of anisotropic elasticity and the consequences of material symmetries on macroscopic behavior	·	·	✓	·	·
• Understand the principles of the thoery of plates	·	✓	·	·	·
• Knowing how to design and dimension a laminated composite for a given mechanical condition	·	✓	·	·	·

Manager : Vincent SOBOTKA

Mechanics of deformable solid body

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	28.5	18			3	25

Evaluation

4 evaluations :

- *TP-Rapport Gpe*
- *TP-Soutenance*
- *2DS*
- *CAO Rapport Gpe*

Presentation

This course makes the link between the mechanical properties of materials at the local scale and the mechanical behavior (deformation, stress) at the global scale of a part or structure.

Outline

Lectures and supervised work:
I. General introduction
II. Basic concepts and concepts in Mechanics
Material continuity concept, concept of REV (Representative Elementary Volume)
Kinematics of the deformable solid
Deformation
Stress concept
1D elasticity material behavior
Characterization of materials: tensile, bending, twisting tests
Generalization to the 3D case
III. Introduction to beam theory
Fundamental assumptions
Simplifications in beam theory
IV. Practical method of solving a problem with beam theory
From external mechanical loading to internal stresses
Dimensioning in tension / compression
Determining the characteristics of a section
Simple bending
V. Resolution approached by the finite element method
Basic principle of the method
Digital applications in CATIA V5
VI. Theory of beams: Torsion, shear and combined stresses
Shear-Twist
Combined loadings
VII. Basic relations for solving a 3D problem
Local equilibrium equation
Behavioral relation
Yield strength criteria
Practicals:
- Strain gauges, digital image correlation, stress concentration, elastic properties of materials.
- Role of moment of inertia in simple plane bending; profiles and sandwich structures; section optimisation.

- Truss systems; influence of material (metals, polymers, composites, natural materials) on stiffness and environmental footprint (Ansys Granta EduPack software); introduction to Ashby's method of material selection.

- Isostatic and hyperstatic beam-based structures; strain gauges; numerical simulation (RDM7 software).

- Secondary torsion of a thin-walled profile subjected to bending; rosette measurements; stress states; von Mises equivalent stress.

Goals

Introduce the notions of displacement, stress state and deformation (tensors) in a material.

Be able to measure displacements and strains (dial gauge, strain gauge, digital image correlation).

Knowledge of the fundamental relations of the mechanics of deformable solids: linear elasticity, local equilibrium assumption, deformation/displacement relation.

Discover orders of magnitude of the main characteristics (mechanical : elasticity, plasticity, fracture ; environmental : carbon footprint, embodied energy...) of materials (metals, polymers, composites, sandwich structures, natural materials...).

Knowledge of Mohr's graphical analysis of stress and strain states in elasticity theory.

Know how to analytically solve a problem for a structure formed of "beam" type solids: calculation of internal loadings, stresses, deformations and displacements.

Be aware of the main differences in the behaviour of isostatic and hyperstatic structures.

Mechanical dimensioning through the use of strength criterions.

Bibliography

S. TIMOSHENKO & J. GOODIER, Théorie de l'élasticité, éd. Béranger, 1961

P. GERMAIN, Cours de Mécanique des Milieux Continus, éd. Masson, 1973

J. DUC & D. BELLET, Mécanique des solides réels - Elasticité, Cepadues , 1977

Résistance des matériaux par Giet & Géminard - Editions Dunod

Résistance des matériaux par Kerguignas & Caignaert - Editions Dunod

Résistance des Matériaux par A. Bazergui - Editions Polytech. Montréal

Prerequisites

Deformable solid mechanics

Notions of tensor algebra

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know the concepts of state of deformation and stress state expressed by their respective tensors and their respective properties	·	·	✓	·	·
• Know graphical analyzis of elastic strains measurments (strain gage, strain rosette) to determine components of strain and stress tensors	·	✓	·	·	·
• Calculate and measure stresses, deformations and displacements in a structure. To size through the use of strength criterions	·	·	✓	·	·
• Know the orders of magnitude of the mechanical characteristics of materials	·	·	✓	·	·

Manager : Jérémie RUPIL

Meeting management

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
2.5	2					3

Evaluation

One evaluation : *Rapport Ind*

Outline

To organize a meeting: material aspects, objectives, communication
Methodology of problem solving in groups.
Tools for group problem solving: tools for sorting, selection, analysis, presentation, etc ...

Goals

To know the principles of the organizing a meeting, conducting meetings and solving problems in groups using appropriate methodology and related tools.

Prerequisites

Communication.
Negotiation.
Group work.
Mathematical tools and basic statistics.

Learning outcomes

Learning outcomes	N	A	M	E	O
• To organize a meeting	·	✓	·	·	·
• To lead a meeting	·	✓	·	·	·
• To solve problems in group	·	✓	·	·	·

Manager : Thierry BROUSSE

Metallic materials - laboratory project

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			32			14

Evaluation

2 evaluations :

- *Rapport Gpe*
- *Soutenance*

Outline

28 hours of laboratory work. 4 hours for final oral presentations. 2 supervisors for 16 students. Students work in pairs.

Examples of topics:
TRIP effect in 304L stainless steel
Intergranular corrosion in cemented 304L stainless steel
Inoculation during wire-arc additive manufacturing of an aluminum alloy
Effect of grain size in on martensitic transfomation in a low alloyed steel
Heterogeneous welding of stainless steels

Goals

To undertake a small experimental project in near autonomy dealing with metallic materials

Prerequisites

Use of standard metallurgy laboratory equipment (heat and/or mechanical treatments, metallography, optical microscopy, X-ray diffraction, mechanical testing) and interpretation of results

General Metallurgy and Physical Metallurgy course

Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to manage and execute a small project (task planning and task distribution) in a limited time, taking account of the limited availability of equipments and staff.	·	·	✓	·	·
• Be able to use multi-disciplinary knowledge and apply it to metallic materials	·	·	✓	·	·
• To be able to write a final report and give a talk. To be clear, positive and persuasive.	·	·	✓	·	·
• To cast a critical eye on one's own work and others'. To compare one's work with others'.	·	·	✓	·	·
• To be able to analyse the causes of failure and adapt one's approach in light of these failures	·	·	✓	·	·

Manager : Emmanuel BERTRAND

Microscopies and spectroscopies

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
8.75	1.5				1	6

Evaluation

One evaluation : *DS*

Outline

Image analysis 101
- Optical microscopy
- Electron microscopy
- Electron-matter interactions
- Microscopes technology
- SEM specificity
- TEM specificity
- Diffractions and crystal orientations identification (EBSD, ACOM)
- Spectroscopies
- Spectroscopies 101
- Vibrational spectroscopies (UV-vis, IR, Raman)
- X-Rays spectroscopy techniques (EDS/WDS, XRF, XAS, XPS)
- Electron spectroscopy techniques (EELS, Auger)

Goals

To provide the basics of optical microscopy, electron microscopy (scanning and transmission) and associated techniques (spectroscopies and diffractions), applied to materials science. To present and understand the capabilities and the limits of each technique.

Bibliography

Scanning Electron Microscopy and X-ray Microanalysis, J.I. Goldstein, C.E. Lyman, D.E. Newbury, E. Lifshin, P. Echlin, L. Sawyer, D.C. Joy, J.R. Michael, Spinger, 2003.

Caractérisation microstructurale des matériaux, Analyse par les rayonnements X et électroniques, C. Esnouf, Presses polytechniques et universitaires romandes, 2011.

Articles des techniques de l'ingénieur (https://www.techniques-ingenieur.fr/) :

Théorie des spectres atomiques, P 2655, A. Petit

Théorie des spectres moléculaires, P 2656, A. Petit

Spectroscopie Raman, P 2865, J. Barbillant, D. Bougeard, G. Buntinx, M. Delhaye, P. Dhamelincourt, F. Fillaux

Spectroscopie d'absorption dans l'infrarouge, P 2850, B. Humbert, J.-Y. Mevellec, J. Grausem, M. Dossot, C. Carteret

Analyse non destructive des objets d'art par méthodes spectroscopiques portables, RE 217, P. Colomban

Prerequisites

light reflection, refraction and diffraction; optical lenses; Gaussian optics; electrons; photons; X-rays; thermoelectric effect; magnetic and electric fields; structure of matter; microstructure of materials; crystal diffraction; periodic table; atom model; energy levels of electron shells

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main characteristics of microscopy techniques: resolution, depth of field and contrast	·	·	✓	·	·
• To know the principle of optical and electron (scanning and transmission) microscopy. To know the main characteristics associated with these techniques, as well as the specimen preparations needed	·	·	·	✓	·
• To know the advantages and limitations of the different observation modes in electron microscopy	·	·	✓	·	·
• To be able to chose one of the presented techniques depending on the nature of what you want to observe or measure within the material you are studying	·	·	✓	·	·
• To know the basics of the physical principle of the presented spectroscopy techniques and the main characteristics of each of them	·	·	✓	·	·
• To know how an electron microscope is working from the gun to the sample	·	✓	·	·	·
• To know how it is possible to determine the cyrstallographic structure of a grain and its orientation using electron microscopy	✓	·	·	·	·

Manager : Laurent COUTURIER

Modern language 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *Situation Ind*

Manager : Carole CHAUSSE

Modern language 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *Situation ind.*

Manager : Carole CHAUSSE

Negotiation

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
3	7.5					2

Evaluation

One evaluation : *Situation Ind*

Bibliography

- Salzer, J. et Stimec, A. (2019). Outil 63. Les qualités d'un bon accord. La boîte à outils de la Gestion des conflits (p. 182-183). Dunod. https://shs.cairn.info/la-boite-a-outils-de-la-gestion-des-conflits–9782100791415-page-182?lang=fr.

- https://web.archive.org/web/20140427011407/http://www.commerciaux.fr/profession/methode_soncas.php

Manager : John KINGSTON

Non destructive testing

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
9.75					1	6

Evaluation

One evaluation : *DS*

Outline

Organization and use of non-destructive testing and non destructive analysis in a company, relationship with quality assurance system.

Non-destructive testing, description of the main techniques and their application fields: visual checks (including interference holography, radar imaging , etc. ..), penetrant testing, Foucault current testing, magnetic measurements, radiography, ultrasonic and acoustic emissions, infrared thermography.

Goals

To know the main methods of non-destructive testing for metals and alloys, ceramics, glasses, polymers and composites, and being able to advocate on a given part.

To know the different ways of organizing controls within a company.

Bibliography

Techniques de l'ingénieur

Non-Destructive Testing, B. HULL, Springer-Verlag, New-York, 1988

Prerequisites

Solid state chemistry, solid state physics

Materials characterization techniques

Design and use of polymers and composites

Design and use of metals and alloys

Design and use of céramqiues and glasses

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main methods of non-destructive testing	·	·	✓	·	·
• To know the main methods for organizing NDT in companies	✓	·	·	·	·
• To advocate NDT methods on a given part	·	·	✓	·	·

Manager : Thierry BROUSSE

Non destructive testing of welds

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
3.5		7				6

Evaluation

One evaluation : *Rapport Gpe*

Outline

Overview of the NDT applied to welding
- Penetrant testing
- Magnetic particle testing
- Eddy current
- Ultrasound (classic, TOFD, Phased Arrays)
- X-ray and Gamma Graphy

Goals

Knowledge of non-destructive controls applied to the weld

Bibliography

ALTHOUSE A.D., BRAMAT M., MAYER, VILLENEUVE M., Technologie des métaux, contrôles et essais des soudures, De Boeck Edition 2008

Caractérisation ultrasonore par TOFD de défauts de soudures, Publication du CETIM, 2004

Prerequisites

Physics courses

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the various technics of controls and their application in the field of welding	·	·	✓	·	·
• To know the limits of the different technics	·	·	✓	·	·
• How to use the technics of conventional controls	·	✓	·	·	·

Manager : Pascal PAILLARD

Nuclear fuels

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
2.5	1.5				0.5	

Evaluation

One evaluation : *DS*

Outline

Review of the concepts of nuclear fission
- Conventional fuels based on enriched uranium
- MOX fuels
- Nuclear fuel manufacturing
- Use in nuclear reactors
- Fuel cycle and reprocessing

Goals

Acquire basic knowledge of materials for nuclear fuels, manufacturing processes, their use in reactors, and their reprocessing.

Prerequisites

Concept of nuclear physics, different types of radioactivity, nuclear reactions

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know the nuclear fuel cycle	·	✓	·	·	·
• To know the different types of nuclear fuels and how they are manufactured.	·	✓	·	·	·

Manager : Thierry BROUSSE

Numerical methods 1

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21				1.5	12

Evaluation

2 evaluations :

- *DS*
- *Rapport Ind*

Outline

Systems of linear equation (Gauss Pivot, iterative methods: Jacobi, Gauss-Seidel), Polynomial interpolation (Lagrange polynomial, Hermite polynomial), Numerical Integration (Trapeze formula, Simpson formula), Numerical derivation (Taylor development, progressive, regressive, centered differentiations), differential equations (Euler's method, predictor-corrector scheme, Runge-Kutta method) All chapters are followed by simple exercises allowing to learn how to calculate the various numerical methods. Corresponding TP sessions allow to learn how to program and to use these numerical methods.

Goals

To control the calculation of the various numerical methods. To know how to program and to use the numerical methods (Matlab)

Prerequisites

Mathematics, Programming with Matlab

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to calculate the various numerical methods	·	·	✓	·	·
• To know how to use the various numerical methods (programming with Matlab)	·	✓	·	·	·
• To manage the concepts of convergence and stability of a numerical method	·	·	✓	·	·

Manager : Stéphane CUENOT

Numerical methods 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		20				10

Evaluation

One evaluation : *Rapport Ind*

Outline

2D and 3D modeling of a physical problem (Drawing), Create and manage a 2D meshing, Optimize the meshing for a given structure, Taking into account the boundary conditions of a problem, Post-processing and visualization, Convergence of a numerical solution in function of meshing, Relationship meshing-time of calculation, Modeling of multi-physic problems

Goals

To know how to use a modeling software of finite element methods. Modeling a (multi)physical problem. To manage the convergence relationship of the numerical solution in function of meshing. To manage the relationship meshing-time of calculation

Prerequisites

To know the numerical methods, Matlab programming concept

Learning outcomes

Learning outcomes	N	A	M	E	O
• To manage the steps of modeling of a simple problem (drawing, boundary conditions, physical properties, meshing, resolution)	·	·	✓	·	·
• To control the convergence of a numerical solution (meshing, calculation time)	·	·	✓	·	·
• To know the different steps of modeling of a multi-physic problem	·	✓	·	·	·

Manager : Stéphane CUENOT

Numerical processing of experimental data

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		7.5				4

Evaluation

One evaluation : *Rapport Ind*

Outline

Excel: presentation of graphic tools, tables of number and data treatment, import of raw data, solver
Matlab: presentation of graphic tools

Goals

To know how to use Excel and Matlab for graphic display and simple data analysis

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to present Excel and Origin data	·	·	✓	·	·
• To control data processing (curves analysis) with Excel	·	·	✓	·	·
• To know how to adjust experimental data with theoretical curves (parameters optimization)	·	✓	·	·	·

Manager : Laurent COUTURIER

Optics and materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	15				1.5	9

Evaluation

One evaluation : *DS*

Presentation

Interaction between light and matter with optical applications.

Outline

propagating waves ; phase and group velocity, dispersion relation, index number ; propagation of electromagnetism waves ; polarization ; refractive index ; transmission, reflection and absorption factors ; electromagnetism energy ; photon concept, radiating pressure ; guided waves ; metallic wave guides ; introduction to optical fibers ; ligh propagation in anisotropic materials ; birefringence ; materials for optics ; optical filters ; laser and applicartions

Goals

This course is dealing with the basis of the interaction between matter and light. Particularly, the phenomena involved betwwen matter and the visible light are presented : the reflection, absorption and transmission factors are calculated. The understanding of the mecanisms involved in the the polarization of the light by birefringent materials and in the light propagation through optical fibers is also studied. The different concepts developed lead to the choice of materials for optics.

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titre : Manuel d'Optique
auteurs : G. Chartier
éditeur : Hermès date : 1997 ISBN 2 86 601634 3
titre : Optique
auteurs : J.P. Pérez
éditeur : Dunod date : 2000 ISBN 2 10 004890 2
titre : Fibres optiques Théories et applications
auteurs : S. Ungar
éditeur : Bordas-Dunod date : 1989 ISBN 2 04 018763 4
titre : Ondes élastiques dans les solides ; Tome 1 : Propagation libre et guidée ; Tome 2 : Génération, Interaction acousto-optique, Applications
auteurs : D. Royer
éditeur : Masson date : 1996 - 1999 ISBN 2 2258 5422 X et 2 2258 34415
titre : Electromagnétisme
auteurs : J.P. Pérez
éditeur : Dunod date : 2002 ISBN 2 10 005574 7
auteurs : E. Hecht
titre : Optique
éditeur : Série Schaum - Mac Graw Hilldate date : 1985 ISBN 2 7042 1021 7
titre : Lasers
auteurs : P.W. Milonni
éditeur : Wiley-Interscience date : 1988 ISBN 0 47 162731 3

Prerequisites

Electricity, Magnetism, Electromagnetism, wave physics, geometric optics

Learning outcomes

Learning outcomes	N	A	M	E	O
• be able to choose a material for optics regarding its properties	·	·	✓	·	·
• be able to calculate the absorption, reflection and transmission factors of light for a chosen material	·	·	✓	·	·
• be able to describe and understand the effect of a electromagnetic wave in a material	·	·	✓	·	·
• knowing the basis of matter-wave interaction	·	✓	·	·	·
• Knowing of light propagation and guiding	·	✓	·	·	·

Manager : Benoit ANGLERAUD

Organizational analysis

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
4.5	6					3

Evaluation

One evaluation : *DS*

Bibliography

Droits et devoirs du salarié :
- la pyramide des normes https://www.youtube.com/watch?v=xpWzj66Lxk0
- la négociation collective https://www.youtube.com/watch?v=giwvtotJjws
- Légifrance ingénieurs https://www.legifrance.gouv.fr/conv_coll/id/KALICONT000005635173

Théorie des organisations :
- Théorie des organisations / j m plane (dunod)
- Théorie des orga et écosystèmes / maclouf https://www.youtube.com/watch?v=fn-4ZxWRjNE

Manager : Gwenael THOREL

People management

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	10.5					6

Evaluation

One evaluation : *DS*

Manager : John KINGSTON

Pharmacy Preparation S6

Hours

Lect Tut PW Proj WP Exa Asst

Evaluation

One evaluation : *Eval ext*

Manager : Luc MARCHAL

Pharmacy Preparation S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst

Evaluation

One evaluation : *Eval ext*

Manager : Luc MARCHAL

Pharmacy Preparation S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst

Evaluation

One evaluation : *Eval ext*

Manager : Luc MARCHAL

Physical education and sport 1

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21					2

Evaluation

One evaluation : *Situation ind.*

Manager : Jérôme BEZIER

Physical education and sport 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21					2

Evaluation

One evaluation : *Situation ind.*

Manager : Jérôme BEZIER

Physical education and sport 3

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	21					2

Evaluation

One evaluation : *Situation Ind*

Manager : Jérôme BEZIER

Physical education and sport 4

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	19.5					2

Evaluation

One evaluation : *Situation ind.*

Manager : Jérôme BEZIER

Physical metallurgy

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	16.5				1.5	9

Evaluation

One evaluation : *DS*

Outline

Slip systems and dislocations
Hardening mechanisms
Point defects and introduction to thermal activation
Recovery and recrystallization
Grain boundaries
Dynamic recovery and recrystallization

Goals

Understand the main defects present in metals, classified by dimensionality, and their primary effects on material properties

Use dislocation theory to identify the strengthening mechanisms of metals

Identify the metallurgical phenomena involved during cold deformation, heat treatment, and subsequent thermomechanical processing

Quantify microstructure-property relationships during cold deformation and heat treatment (particularly through the concept of thermal activation)

Bibliography

Métallurgie, du minerai au matériau. J. Philibert, A. Vignes, Y. Bréchet, P. Combrade. Masson Editeur. 1998.

Les défauts ponctuels dans les métaux. Y. Quéré. Masson Editeur. 1967.

La diffusion dans le solides. J. Philibert. Les éditions de physique. 1985.

Eléments de métallurgie physique. Y. Adda, J.M. Dupouy, J. Philibert, Y. Quéré. La documentation française. 6 tomes. 1987-1991.

Physical Metallurgy Principles. R. Abbaschian, L. Abbaschian, R. E. Reed-Hill. Cencage Learning. 2009.

Prerequisites

General Metallurgy Course (3rd Year); Metal Transformation Processes

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main types of defect in crystalline materials : vacancies, dislocations, subsitutional solute, interstitial solute, grain boundaries	·	·	✓	·	·
• To know the principle of diffusion at the atomic scale (diffusion mechanisms)	·	·	✓	·	·
• To know the mechanisms of deformation and hardening (including work-hardening) associated with the dislocation theory	·	·	✓	·	·
• To know the mechanisms of twinning, recrystallization and recovery in deformed materials	·	·	✓	·	·
• To understand phenomena occuring in a metallic alloy during thermal treatments, cold or hot working	·	·	✓	·	·

Manager : Emmanuel BERTRAND

Physics (upgrade-refresher training)

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	3					

Presentation

General physics upgrade to prepare the courses of S5

Outline

unit system
- uncertainty calculation
- Mathematics tools
- Electrostatics (Coulomb law, Poisson and Laplace Law, Gauss therorem)
- Magnetostatics (Biot and Savart, Laplace, Lorentz laws, Ampere theorem)
- Electrical current effects (Joule and Ohm laws)
- basis of Electromagnetism (Maxwell laws, propagation equations of electrical and magnetical fields)
- electrical analogue signal (DC and rf signals, periodical signals, sinusoidal signals)
- Electricity networks, Kirchhoff laws, linear dipoles, general theorems (Norton Thevenin, Millman...)
- Transfer functions (Bode diagramm)

Goals

refresher training of the basis of general physics (electricty, optics, electronics) in order to homogenize the knowledges of students ocming from different schooling.

Bibliography

titre : Electromagnétisme
- auteurs J.P. Pérez
- éditeur : Dunod date : 2002 ISBN 2-1000-5574-7
- titre : Electronique linéaire
- auteurs Blot
- éditeur Dunod date 1993 ISBN 2-1000-1777-5
- titre : Physique 1ère année Cours et exercices corrigés
- auteurs : M.N. Sanz, A.E. Badel, F. Clausset
- éditeur : Dunod date 2002 ISBN 2 10 005373 6

Prerequisites

Basis of Physics : Optics, electronics, electricity.

Learning outcomes

Learning outcomes	N	A	M	E	O
• be able to to present numerical results in the right format	·	·	✓	·	·
• be able to make uncertainty calculation	·	·	✓	·	·
• be able to to apply the laws and equations of general electricity	·	·	✓	·	·
• knowing the main electrical properties of materials	·	·	✓	·	·
• knowing of electrical current effects on materials	·	✓	·	·	·
• be able to determine electrical transfer function of a linear quadripole	·	·	✓	·	·
• be able to calculate the electrical complex impedance of a linear dipole made of resistors, self inductance and capacitors	·	·	✓	·	·
• be able to draw and interprate the bode diagramm of a first order electrical circuit	·	·	✓	·	·
• be able to use the electrical laws : Kirchhoff, voltage and current divider bridges, Millman	·	·	✓	·	·

Manager : Benoit ANGLERAUD

Physics and materials - laboratory

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		24				12

Evaluation

One evaluation : *Rapport Gpe*

Presentation

Practical works of physics

Outline

Study of glass dispersion ; determination of glass optical index ; Study of laser light ; HeNe laser tuning ; study of a laser diode ; Study of light polarization ; Retardation plates ; temperature measurement ; study of different temperature sensors ; ultrasonic inspection of materials

Goals

The aim of these practical courses is to to teach the basis of measurement methods in physics : measure of light power, measure of optical index, use of heat sensors, caracterisation of birefringence materials.

Bibliography

titre : Manuel d'Optique
auteurs : G. Chartier
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titre : Optique
auteurs : J.P. Pérez
éditeur : Dunod date : 2000 ISBN 2 10 004890 2
titre : Fibres optiques Théories et applications
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auteurs : D. Royer
éditeur : Masson date : 1996 - 1999 ISBN 2 2258 5422 X et 2 2258 34415
titre : Electromagnétisme
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auteurs : E. Hecht
titre : Optique
éditeur : Série Schaum - Mac Graw Hilldate date : 1985 ISBN 2 7042 1021 7
titre : Lasers
auteurs : P.W. Milonni
éditeur : Wiley-Interscience date : 1988 ISBN 0 47 162731 3

Prerequisites

Electricity, Magnetism, Electromagnetism, wave physics, geometric optics

Learning outcomes

Learning outcomes	N	A	M	E	O
• be able to determine the mechanical properties of a material using ultrasonic waves	·	·	✓	·	·
• be able to make ultrasonic material inspection	·	✓	·	·	·
• be able to choose, use and calibrate temperature sensors	·	·	✓	·	·
• be able to describe and put in light the effects of an anisotropic material on light polarization	·	✓	·	·	·
• be able to determine and to measure laser light properties	·	✓	·	·	·

Manager : Benoit ANGLERAUD

Plasticity of metals and metal forming

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
3.75	12				1.5	9

Evaluation

One evaluation : *DS*

Presentation

A set of lectures and supervised work allowing to cover plasticity of metals and alloys from the point of view of mechanics (plasticity criteria, flow rule...), materials (constitutive laws...) and forming processes by plastic deformation. To be noted that creep is detailed in another course.

Outline

Part I: Mechanical aspects of plasticity
- Continuum mechanics (reminders, invariants, deviator, generalised variables)
- Plastic flow rule, plasticity criteria (Tresca, von Mises, Hill)
- Constitutive laws for metals at low and high temperatures

Part II: Technological aspects of plasticity: forming processes
- Chapters: Rolling, forging, extrusion, wire drawing, sheet drawing...

Goals

Provide the future materials engineer a set of basic skills and knowledge allowing to understand the plastic behaviour of metals and alloys, the mechanical design of structures and the implementation of forming processes by plastic deformation.

Bibliography

G.E. Dieter, "Mechanical metallurgy" (McGraw-Hill)

B. Jaoul, J. Friedel, C. Crussard, "Etude de la plasticité et application aux métaux" (Presses Mines ParisTech)

Prerequisites

Bases in continuum mechanics (stress and strain tensors, principal stresses, Mohr's circle, elasticity...)

Bases of general metallurgy (microstructure of polycristalline materials)

Learning outcomes

Learning outcomes	N	A	M	E	O
• Being able to perform simple continuum mechanics calculations applied to plasticity (plasticity criteria, plastic flow rule, plastic constitutive laws)	·	·	✓	·	·
• To know the main families of forming processes by plastic deformation as well as their principal characteristics	·	·	✓	·	·
• Be able to choose a process for a given part	✓	·	·	·	·

Manager : Franck TANCRET

Polymeric materials - laboratory project

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			17.5			9

Evaluation

2 evaluations :

- *Rapport Gpe*
- *Soutenance*

Outline

1) Formulation, characterization, and application of a physically applied adhesive
- Characterization of the adhesive by DSC, IR spectrometry, and rheology
- Adhesive application
- Mechanical characterization of the assembly bonded with this adhesive (effect of application conditions and assembly geometry)

2) Development and characterization of a glass-epoxy composite material
- Polymerization monitoring by DSC and IR spectrometry
- Manual wet application
- Thermal analysis and loss on ignition tests
- Flexural tests

Goals

The objectives are
- to know how to formulate, characterize, and apply a pressure-sensitive adhesive such as a tape or hot-melt adhesive.
- to know how to manually manufacture a composite material, characterize the resin and its polymerization, define the appropriate curing cycle, and characterize the mechanical properties of the resulting composite.

Bibliography

DETERRE R., LESTRIEZ B., Introduction aux matériaux polymères. Lavoisier (2016)

Prerequisites

An introduction to polymers and composite materials and to adhesion science

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know monitoring the curing of a thermoset	·	·	✓	·	·
• To know determining the curing cycle of a thermoset	·	✓	·	·	·
• To know characterizing the physico-chemical and mechanical properties of an adhesive	·	·	✓	·	·
• Know how to characterize the mechanical resistance of a glued assembly in overlap mode	·	·	✓	·	·
• To know characterizing the adhesion properties of pressure-sensitive adhesives	·	·	✓	·	·

Manager : Bernard LESTRIEZ

Practical training

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		35				

Evaluation

One evaluation : *Rapport Ind*

Outline

Oxy-fuel welding
- Welding with covered electrode
- GMA welding
- GTA welding

Goals

Practice of different welding processes

Bibliography

RAS

Prerequisites

Theoretical course on welding processes of the 4th and 5th years

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know practice of different welding processes	·	✓	·	·	·
• To understand the influence of welding parameters	·	✓	·	·	·

Manager : Pascal PAILLARD

Preparing the TOEIC

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	19.5					

Evaluation

One evaluation : *DS*

Manager : Carole CHAUSSE

Preparing the TOEIC

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	18					

Evaluation

One evaluation : *DS*

Bibliography

Newcombe, H. McDonald Bertail, C. Pass the TOEIC® Test. First Press ELT

Manager : Carole CHAUSSE

Presenting and debating

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	19.5					

Evaluation

One evaluation : *Situation Gpe*

Bibliography

- Matchan, L. (2015). Schools seek balance for cellphones in class. The Boston Globe.
- Wilson, J. (2013). Cool things DNA testing can do. CNN.
- Gascoigne, A. (2023). Silicon Valley's huge diversity problem holds tech back. The Los Angeles Tmes.

Manager : Pascale SIMON LLOBREGAT

Project

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			140			70

Evaluation

3 evaluations :

- *Situation Gpe*
- *Rapport Ind*
- *Soutenance*

Outline

- Contacting stakeholders to discover the subject.
- (Technological and bibliographic survey on the project subject is included in the course ?bibliographic survey?).
- Defining specifications, a schedule, deliverables, etc.
- Scientific and technical execution of the project.
- Co-management of the project with stakeholders.
- Production and dispatch of deliverables to stakeholders.
- Production of a written report and presentation of a defense.

Goals

Carry out an applicative project in the field of composite materials or functional materials for energy:
- Participate in project management in interaction with stakeholders (company, laboratory, etc.).
- Execute the project from a scientific and technical point of view.
- Report the results and conclusions.

Prerequisites

All 3rd and 4th year courses, including humanities.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Implement scientific and technical knowledge to produce a response to a materials problem prposed by a company or a laboratory	·	·	·	✓	·
• Analyse and formalise the materials issues linked to an industrial application	·	·	✓	·	·
• Design and manage a team project	·	✓	·	·	·
• Report the results of a project (deliverables, written report, oral presentation)	·	·	·	✓	·

Manager : Franck TANCRET

Project - case study - meeting management

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
2.5	2		52.25			29

Evaluation

2 evaluations :

- *Rapport Gpe*
- *Rapport Ind*

Outline

Shipbuilding case studies
Offshore construction case studies
Energy case studies
Organisation of a meeting
Group problem-solving methodology and tools

Goals

The aim is to provide examples in the form of case studies of practical industrial applications related to the manufacturing of welded structures. The studies are conducted in project mode, for which skills are provided on the organization and conduct of meetings, as well as on the methods and tools for group problem solving.

Prerequisites

All courses in welding processes, welding metallurgy, design and manufacturing

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the choices of welding processes for a given application	·	·	✓	·	·
• Know how to choose a material for a given application	·	·	✓	·	·
• Choose designs for a given application	·	·	✓	·	·
• Understand and implement manufacturing for a given application	·	·	✓	·	·
• Organize and conduct a meeting	·	✓	·	·	·
• Knowing how to lead group problem solving	·	✓	·	·	·

Manager : Pascal PAILLARD

Project management 1

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
4.5	7.5					2

Evaluation

One evaluation : *Situation Gpe*

Manager : Sylvaine GAUTIER

Project management 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
1.5	15					3

Evaluation

One evaluation : *DS*

Manager : Sylvaine GAUTIER

Radiocrystallography

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
8.75	10.5				2	11

Evaluation

2 evaluations :

- *DS2*
- *DS1*

Outline

The first part deals with general information on radiation such as x-ray production and collection of diffraction data. The second part concerns the laws of diffraction and a third on the methods of diffraction by single crystal and powders.

Goals

The study of diffraction (X-rays, neutrons or electrons) and highlighting the relationship between the directions of diffraction and the lattice, and between the diffracted intensity and pattern. Applications.

Bibliography

"Cristallographie géométrique et radiocristallographie", J.J. Rousseau, Ed. MASON 1995, ISBN 2 225 84990 0

Prerequisites

Courses of symmetry

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know how to extract information from the X-ray, neutron and electron diffraction data	·	✓	·	·	·
• Know the expression of the intensity of a diffraction peak, of the structure factor and know how to determine the reflection condictions	·	·	✓	·	·
• To be able to give the diffraction conditions in the direct and reciprocal spaces	·	·	✓	·	·

Manager : Olivier JOUBERT

Recruitment Pitch

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	15					5

Evaluation

One evaluation : *Situation ind.*

Bibliography

- Fiches métier France Travail - https://www.francetravail.fr/employeur/vos-recrutements/le-rome-et-les-fiches-metiers.html
- MétierScope France Travail - https://candidat.francetravail.fr/metierscope/
- APEC - https://www.apec.fr/

Manager : Sylvaine GAUTIER

Research S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

One evaluation : *Situation Ind*

Manager : Antoine GOULLET

Research S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

One evaluation : *Situation Ind*

Manager : Antoine GOULLET

Responsible management 1

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	4.5					3

Evaluation

One evaluation : *Rapport groupe*

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- Lettre d'information de l'INRS - Publications et outils?INRS. (n.d.). Retrieved 25 August 2025, from https://www.inrs.fr/publications/lettre-information.html

Manager : Dominique BARBELIVIEN

Responsible management 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	3					1

Evaluation

One evaluation : *Rapport Gpe*

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Manager : Dominique BARBELIVIEN

Rheology and thermomechanics of polymers

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10	12				2	12

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Outline

1. Rheology of Complex Fluids (Measurement and Behaviors)
   2. Rheology of Molten Polymers (Measurement and Behaviors)
   3. Viscoelasticity
   - Creep-Recovery and Relaxation Tests
   - Phenomenological Models of Viscoelastic Fluids and Solids
   - Harmonic/dynamic Measurements
   4. Molecular Origin of Polymer Viscoelasticity
   5. Time (Frequency)-Temperature Equivalence - WLF Law
   6. Structure-Property Relationship of Polymer Materials in the Solid State

Goals

It is an introduction to the rheological behaviours of complex fluids and visco-elastic materials in their day-to-day life and processing situation; it is also a more exhaustive study of polymers and the influence of their composition and external factors (time and temperature).

Bibliography

Mc GRUM N.G., BUCKLEY C.P., BUCKNALL C.B. - Principles of polymer engineering 2nd ed. Oxford University Press (1997).

Les techniques de l'ingénieur :

CARROT C., GUILLET J. -Viscoélasticité linéaires des polymères fondus (AM 3 620) et Viscoélasticité non linéaires des polymères fondus (AM 3630).

KRAWCZAK P., - Essais mécaniques des plastiques (AM 3 510) (AM 3 511) (AM 3 512).

CHATAIN M., - Comportement physique et thermomécanique des plastiques (A 3 110).

DETERRE R., LESTRIEZ B., Introduction aux matériaux polymères. Lavoisier (2016)

Prerequisites

An introduction to polymers

An introduction to mechanics

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the thermomechanical behaviour of polymers in general, in the solid and melt states	·	·	✓	·	·
• To know the effect of the chemical nature of a polymer on its thermomechanical behaviour	·	·	✓	·	·
• To know how to measure the thermomechanical behaviour of a polymer depending on its usage and processing method	·	·	✓	·	·
• To know how to chose a polymer for an application of a processing method	·	✓	·	·	·
• To know how to use viscoelastic models to predict the behaviour of a viscoelastic material in certain conditions	·	·	✓	·	·
• To know the rheological behavior of complex fluid	·	·	✓	·	·
• To know of to measure the rheological behavior of a complex fluid	·	·	✓	·	·

Manager : Bernard LESTRIEZ

Semiconducting materials and devices

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
13.75	3	12			1.5	16

Evaluation

2 evaluations :

- *DS*
- *Rapport Gpe*

Outline

? Electronic properties of semiconductors
  ? Junction diodes
  ? Bipolar transistors
  ? Field-effect transistors
  ? Basics of integrated circuit fabrication processes
  ? Future of the microelectronics industry

Goals

Understand the physical properties of semiconductors and the operating principles of key electronic devices: diodes, bipolar transistors, and field-effect transistors.

Develop a comprehensive view of microelectronics, from materials physics to technological fabrication processes.

Be able to build circuits using diodes and transistors and analyze their electrical characteristics.

Bibliography

Physics of Semiconductor Devices - S. M. Sze, Wiley

Prerequisites

Basic solid-state physics: bandgap, density of states, doping.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the fundamental electronic properties of semiconductors and their dependence on temperature and doping	·	·	✓	·	·
• Explain the operation of p-n junction and heterojunction devices	·	·	✓	·	·
• Analyze the electrical behavior of bipolar and field-effect transistors	·	·	✓	·	·
• Analyze the electrical behavior of bipolar and field-effect transistors	·	·	✓	·	·
• Understand the prospects and challenges related to new materials and emerging architectures in microelectronics	·	·	✓	·	·
• Build circuits using diodes and transistors and analyze their electrical characteristics	·	·	✓	·	·

Manager : Jeremy BARBE

Sensors, instrumentation and measurements

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10	9				1.5	11

Evaluation

One evaluation : *1 DS*

Outline

Continuous and discrete signals, Continuous and discrete systems - sampling, Signal processing, amplification, filtering, control and conversion - A/D converter. Semiconductor devices : diodes and transistors. Measurement chain - sensors - conditioning systems - amplifier for instrumentation - Examples

Goals

Describe different principles of the transduction of sensors related to the physical properties of materials. Describe the signal conditioning of sensors. Give the basic knowledge onto the structure and the functioning of a measurement chain and acquisition of data. Give basic notions of continuous and digital signal processing.

Bibliography

Acquisition de données - Du capteur à l'ordinateur - G. Asch - Dunod ; Electronique des systèmes de mesures - Mise en oeuvre des procédés analogiques et numériques - Tran Tien Lang - Masson ; Les capteurs en instrumentation industrielle - G. Asch - Dunod

Prerequisites

Calculation of a function of transfer of a quadripole in sinusoidal regime - Diagram of Bode - Calculation of a gain and a phase shift - Theorems and basic techniques of calculation on circuits in linear regime : Kirchoff, Thévenin, Norton, voltage dividing bridge, Millman, Equivalent Impedance

Learning outcomes

Learning outcomes	N	A	M	E	O
• Conceive the elements of a measurement chain and acquisition of datas including the sensors and their integration in bridges, conditioning systems, the amplification systems and analog filtering, the analog multiplexers, sampling and the digital-analog conversion	·	✓	·	·	·
• Know the basic principles leading to a specific function of transduction in a sensor related to material properties and/or to geometrical effects.	·	✓	·	·	·
• Set the conditions of sampling of a continuous signal of time: sampling frequency (Shannon criterion) and number of samples and know tools allowing to estimate the frequency spectrum of a continuous signal or a discrete signal.	·	·	✓	·	·
• Know the basic features about operational amplifier used for processing and the control of the analog signals (amplifier, comparator, trigger, converter).	·	·	✓	·	·
• Know the electric basic characteristics of junction diodes (recovery, switching, LED, photodiodes) and know how to evaluate the behavior of an electrical assembly with ideal diodes.	·	·	✓	·	·

Manager : Jeremy BARBE

Serious game

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	10.5	12				10

Evaluation

One evaluation : *Soutenance*

Bibliography

- Pierre Vernimmen, Pascal Quiry et Yann Le Fur, Finance d'entreprise, Dalloz, 2025
- Philippe Thomas, Principes de finance d'entreprise, RBédition
- Anna Shapiro-Niel, Denis Fasse, Marketing & Communication : le mix gagnant, Dunod

Manager : Chrystèle GONCALVES

Shaping of composite materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
22	12	24			1.5	30

Evaluation

2 evaluations :

- *CR1*
- *CR2*

Outline

1. Lectures
   - General information
   - Composite components (matrices, reinforcements)
   - Main forming processes
   - Common constraints for all processes
   - The Resin Transfer Molding process
   - Darcy's Law
   - Heat transfer during curing
   - Heat transfer in tools

   2. Supervised work
   - Presentation of PAM-Rtm® software.
   - Simulation of composite filling and curing.
   - Study of the influence of physical and numerical parameters.

   3. Practical work

Production of a composite test piece on the PVTa mold: Study and analysis of the dimensional changes in the part during a forming cycle with the coupling between heat transfer and chemical transformation. Determination of thermal expansion and chemical shrinkage coefficients

Goals

The objective is to understand the processes involved in shaping composites using liquids, particularly the Resin Transfer Molding (RTM) process. The various coupled physical phenomena inherent to this process are presented and modelled. Technological and scientific barriers are highlighted. The process control parameters that enable the production of high-quality parts are studied. Students are trained in RTM process simulation (PAMRTM software) and in the experimental production of a composite test piece.

Bibliography

J.-P. Pascault, H. Sautereau, J. Verdu, R.J.J. Williams ; « Thermosetting polymers» ; Marcel Dekker Inc., ISBN 0-8247-0670-6.

Heat Transfers in Polymer Composite Materials: Forming Processes, ISTE Ltd.(nov. 2015), ISBN-13: 978-1848217614.

« Pam Rtm : Users Guide » ; ESI-Group, http ://www.esi-group.com

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understanding the processes involved in implementing thermosetting composites	·	✓	·	·	·
• Analyzing thermal phenomena in thermosetting resin-based composite material forming processes	·	·	✓	·	·
• Use the RTM process simulation software (PAM RTM)	·	·	✓	·	·
• Performing and analyzing the forming of a composite test specimen under industrial conditions	·	✓	·	·	·

Manager : Vincent SOBOTKA

Skills day

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	8					2

Evaluation

One evaluation : *AutoévaL*

Manager : Sylvaine GAUTIER

Solid state chemistry I

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
7.5	7.5				1.5	9

Evaluation

One evaluation : *DS*

Outline

Chapter I - Atoms
A: Chemical elements - Periiodic Table
B: Orbitals
C: Interactions - Chemical bond
a: electronegativity,
b: oxidation state,
c: Diffeernt types of chemical bond
Chapter II - Coordination chemistry
A- Structural descrption, ligands and coordination
B - Molecular orbital theory : octahedral complexes, sigma interactions, pi interactions
C - Crystal field theory
a: Crystal field splitting
b - Jahn Teller effect

Goals

Firmly establish the background of solid state chemistry. Precisely know the orbitals and their occupancy. Acquire important basic knowledges: electronegativity, oxidation state, different types of chemical bond. Establish energy diagramms for orbitals in a complex.

Bibliography

Chimie des solides - J.F. Marucco - EDP Sciences
Solid State Chemistry - L. Smart and E. Moore - Chapman et Hall
Chimie Inorganique - Huheey, Ketter et Ketter - De Boeck Université

Prerequisites

Basic knowledge in chemistry - Content of previous courses in semester 5 : Chemical Bond and Symmetry

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know chemical elements, their classification and their main characteristics	·	·	✓	·	·
• To know basic knowledge in solid state chemistry : electronegativity, oxidation states, the types of chemical bond	·	·	✓	·	·
• To know the different types of chemical bond	·	·	✓	·	·
• Draw an orbital diagramm in coordination chemistry	·	·	✓	·	·

Manager : Olivier JOUBERT

Solid state physics 1

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6.25	3				1.5	6

Evaluation

One evaluation : *DS*

Presentation

This course is the first part of the Solid State Physics course. Its objective is to provide the elements necessary for understanding and possibly predicting a significant part of the physical properties of materials. In this first part, we will focus on the physical properties of conductors in relation to their composition and structure.

Outline

1- Introduction
2- Crystal structure, reciprocal lattice
3- The classical free electron gas: Drude theory
4- The quantum free electron gas: The Drude-Sommerfeld model

Goals

At the end of this course:
- You will be able to relate the crystalline structure of a material to its physicochemical parameters such as density, mass density, etc.;
- You will be able to relate the electronic configuration of an atom to the physical properties of the associated solid;
- You will master the concepts associated with the quantum gas of free electrons;
- You will understand the orders of magnitude of the physical properties of metals.

Bibliography

C. Kittel: Introduction à la physique du solide, Dunod, Paris
M. Gerl, JP. Issy, Traité des matériaux: physique des matériaux, tome 8, Presses Polytechniques et Universitaires Romandes, Lausanne
N.W. Ashcroft, N.D. Mermin, Solid State Physics, Saunders, Philadelphie

Prerequisites

Basic Quantum Mechanics
Basic Quantum Chemistry and Chemical Bonds
Structure of Solids, Elements of Crystallography

Learning outcomes

Learning outcomes	N	A	M	E	O
• MAT-3: describe and solve a physics problem	·	·	✓	·	·
• MAT-6: Being able to apply physics and / or chemistry in the field of material science	·	·	✓	·	·
• MAT-8:Make the link between the different scientific fields, Take into account their interactions, and be able to synthesize them on complex cases of material science	·	✓	·	·	·

Manager : Olivier CHAUVET

Solid state physics 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
15	9				1.5	13

Evaluation

2 evaluations :

- *1 DS*
- *Autoéval*

Presentation

This course is the second part of the Solid State Physics course. Its objective is to provide the elements necessary for understanding and possibly predicting a significant part of the physical properties of materials.

In this second part, we will focus on the physical properties of insulators, vibrational and thermal properties, electrical transport properties and magnetic properties.

Outline

Reminder about the free electron gas and the physical properties of metals
The quasi free electrons- conductors and insulators
Phonons and thermal properties
Electronic transport properties of solids
Magnectif properties of solids
Elements on magnetic spectroscopies

Goals

At the end of this course, the future engineer will be able to:

? Understand the origin of physical properties and the link between them for the major classes of materials, in connection with their microscopic structure

? Know the order of magnitude of the physical properties of the different classes of materials

? Being able to choose a material for a given application

Bibliography

C. Kittel: Introduction à la physique du solide, Dunod, Paris

M. Gerl, JP. Issy, Traité des matériaux: physique des matériaux, tome 8, Presses Polytechniques et Universitaires Romandes, Lausanne

N.W. Ashcroft, N.D. Mermin, Solid State Physics, Saunders, Philadelphie

Prerequisites

Basis of quantum mechanics
Basis of quantum chemistry
Structure of solids

Learning outcomes

Learning outcomes	N	A	M	E	O
• MAT-3: describe and solve a physics problem	·	·	✓	·	·
• MAT-6: Being able to apply physics and / or chemistry in the field of material science	·	·	✓	·	·
• MAT-8:Make the link between the different scientific fields, Take into account their interactions, and be able to synthesize them on complex cases of material science	·	✓	·	·	·
• MAT-13: Choose and use the materials characterizations; interpret, analyze and use the results	✓	·	·	·	·

Manager : Olivier CHAUVET

Statistical data analysis and design of experiments

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6.25	10.5				2	

Evaluation

One evaluation : *DS*

Outline

Statistics Review: Mean, Standard Deviation, Within-Class Standard Deviation
- Different Population Types
- Statistical Tests
- Comparison of Means
- Introduction to Experimental Design: Principles and Applications
- Two-Level Full and Fractional Factorial Designs of experiments
- Error Estimation
- Centered Composite Designs of experiments
- Response Modeling
- Canonical Analysis
- Analysis of Variance
- Other Experimental Designs of experiments

Goals

The objective of this course is to master statistical data processing for decision-making purposes. Statistical sampling techniques are presented, as well as parameter estimation from samples. The most commonly used hypothesis tests are described. The second part of the course focuses on the use of experimental designs, with an emphasis on full and fractional factorial designs with two levels, centered composite designs, and related analysis methods: canonical analysis, analysis of variance, response prediction, etc.

Bibliography

Jacques Goupy
Plans d'expériences pour surfaces de réponse
Dunod, Industries Techniques, Paris , 1999
ISBN 2-10-003993-8

Prerequisites

Probability Concepts
Mathematical Tools for Engineers

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to determine the important parameters of a data series using statistical tools	·	·	✓	·	·
• To know how to implement complete or fractional two-level factorial designs	·	·	✓	·	·
• To know how to implement centered composite plans and perform canonical analysis	·	·	✓	·	·

Manager : Thierry BROUSSE

Storage and decarbonization

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6	14					10

Evaluation

One evaluation : *DS*

Manager : Xavier PY

Supercapacitors and hybrid systems

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
2.58	2.67	6			0.5	

Evaluation

One evaluation : *DS*

Outline

- Comparison between the performance of dielectric capacitors and supercapacitors
  - Application of supercapacitors
  - Manufacturing: from material to device
  - Pseudocapacitive materials
  - Hybrid systems
  - Recycling processes
  - Practical work on assembling a supercapacitor and evaluating its performance

Goals

Understand how supercapacitors work, their design, and the major differences from batteries. Understand their current applications and how to use them for new applications. Lithium-ion capacitor hybrid systems will also be presented, as well as their differences from supercapacitors. A practical exercise will allow students to build a supercapacitor and evaluate its performance.

Bibliography

Conway B.E., Electrochemical Capacitors: Scientific Fundamentals and Technology Applications, Kluwer Academic/Plenum Publishers, 1999.

Prerequisites

Course on Electrochemical Energy Storage devices

Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the design and operation of a supercapacitor	·	·	·	✓	·
• Understand the design and operation of a hybrid device	·	·	✓	·	·
• To know how to implement a supercapacitor for a given application	·	·	✓	·	·

Manager : Thierry BROUSSE

Supporting change

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	13.5					3

Evaluation

One evaluation : *DS*

Bibliography

- Autissier D (2024), Néo change
  - Detchessahar M (2019), L'entreprise délibérée
  - Gomez PY (2013), Le travail invisible
  - Grevin A & Préchoux V (2025), Reconnaître le don au travail
  - Masclef O, Glaisner J & Gallon F (2025), L'entreprise du travail vivant
  - Morin E (2005), Introduction à la pensée complexe
  - Taskin L & Dietrich A (2024), Le management humain

Manager : Anouk GREVIN

Sustainability issues

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10.5	7.5	1.5				

Evaluation

One evaluation : *DS*

Manager : Nicolas VERRE

Sustainability tools S6

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6	9					

Evaluation

One evaluation : *Devoir surveillé*

Manager : Nicolas VERRE

Sustainable building instrumented model S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Dominique TARLET

Sustainable building instrumented model S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Dominique TARLET

Symmetry

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
13.75	12				2.5	14

Evaluation

2 evaluations :

- *DS1*
- *DS2*

Outline

I INTRODIUCTION -THE MOLECULAR SYMMETRY - THE CRYSTALLOGRAPHY
II ORIENTATION SYMMETRY
III GROUP THEORY
IV SPACE GROUP SYMMETRY - THE CRYSTALLOGRAPHY

Goals

Introduce the principles of group theory and the base of geometrical crystallography from the study of symmetry operations, enumeration and construction of point groups, calculations in different spaces, and the construction of space groups.

Bibliography

"La théorie des groupes en physique et chimie quantiques", J. HLADIK, Ed. MASSON 1995, ISBN : 2 225 84752 3.

"Cristallographie géométrique et radiocristallographie", J.J. Rousseau, Ed. MASON 1995, ISBN 2 225 84990 0

Prerequisites

Mathematics, Level equivalent to a second academic year

Learning outcomes

Learning outcomes	N	A	M	E	O
• Know how to recognize and count the symmetry operations of a molecule, an object or a crystal.	·	·	✓	·	·
• Know how to determine a point group of a molecule	·	·	✓	·	·
• Know how to build a character table	·	·	✓	·	·
• Know how to represent direct and reciprocal lattices and solving some calculations	·	·	✓	·	·
• Recognize the elements of symmetry of a space group and place them in a unit cell	·	·	✓	·	·

Manager : Olivier JOUBERT

Thermodynamics of materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	10.5				1	6

Evaluation

One evaluation : *1 DS*

Outline

Work, heat, thermal capacities - First law - Entropy, second and third laws. Free Gibbs energy - Chemical potentials - Phase transition of matter, allotropic transformations - Variations of enthalpy, entropy and free Gibbs energy for a chemical reaction - Thermodynamic tables - Interfacial tension - Lattice energy - Oxidation of metals in air or oxygen gas.

Goals

This course will consider classical thermodynamics and its practical application in the field of material science and engineering

Bibliography

"Thermodynamique des matériaux", Gérard Lesoult, Traité des matériaux vol. 5, Presses polytechniques et universitaires Romandes - "Thermodynamique des matériaux" : équilibres de phases et métastabilité", P. Desré, F. Hodaj, EDP Sciences

Prerequisites

Introductory thermodynamics
Mathematics

Learning outcomes

Learning outcomes	N	A	M	E	O
• Calculating thermodynamic quantities for physical transformations or chemical reactions	·	·	✓	·	·
• Calculating heat and temperature changes	·	·	✓	·	·
• Using Free Gibbs energy	·	·	✓	·	·
• Using interfacial tension	·	✓	·	·	·

Manager : Christophe PAYEN

Thermodynamics of materials - 2

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
	10.5				1	6

Evaluation

One evaluation : *DS*

Outline

Chemical equilibrium (equilibrium constant, activity, phase rule and degrees of freedom, van't Hoff equation, Le Chatelier's principle) - Ellingham diagrams - Reactive atmospheres - Reducing or oxidizing agents - Introduction to electrochemical devices (free Gibbs enthalpy and emf, Nernst equation).

Goals

This course will consider classical thermodynamics and its practical application in the field of material sciences and engineering.

Bibliography

"Thermodynamique des matériaux", Gérard Lesoult, Traité des matériaux vol. 5, Presses polytechniques et universitaires Romandes - "Thermodynamique des matériaux" : équilibres de phases et métastabilité", P. Desré, F. Hodaj, EDP Sciences

Prerequisites

Course : "Thermodynamics of materials - 1" - Level : Semester 5

Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing the factor which allow to control a reaction	·	·	✓	·	·
• Knowing the factor which allow to control a reaction	·	·	✓	·	·
• Using Nernst equation	·	·	✓	·	·
• Using Ellingham diagrams	·	·	✓	·	·

Manager : Christophe PAYEN

Thermomechanical CAD

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
6	12					5

Evaluation

One evaluation : *Rapport Gpe*

Presentation

See the description of "CAD for thermomechanics" in TEM5. This course is common to MAT5/TEM5.

Manager : Jérémie RUPIL

Thermophysical properties of polymers and composites

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
15					1.5	8

Evaluation

One evaluation : *DS*

Outline

1. Thermophysical properties of polymers by calorimetry (DSC): Technical description of the device, thermal analysis, definition and measurement of glass transition, specific heat at constant pressure, reaction/transformation enthalpy, effect of device parameters (heating rate, calibration, sample mass, etc.) on measurements. Critical analysis of curves based on observable signals and extraction of qualitative and quantitative information for use in simulation.

2. Crystallization of semi-crystalline thermoplastic polymers and crystallization kinetics: Review of thermoplastics and the specific characteristics of amorphous and semi-crystalline polymers in terms of microstructure. Coupling between heat transfer and crystallization in shaping processes. Physics of crystallization: nucleation, growth, degree of supercooling, thermodynamic melting point. Nucleation and growth models. Kinetic models: global approach, Avrami equation (isothermal crystallization), Ozawa and Nakamura model (anisothermal crystallization); microscopic approach (Schneider and Haudin-Chenot models). Effect of flow and pressure. Transcrystallization phenomenon and its impact on kinetics.

3. Specific volume of thermoplastic polymers: Measurement techniques, PvT diagram of amorphous and semi-crystalline polymers, practical aspects for calculating heat transfer. Effect of pressure, measurement protocols, cooling rate. Tait model. Qualitative and quantitative analysis of PvT diagrams.

4. Thermal conductivity of polymers and composites: Measurement techniques (hot plate, laser flash, impact probe, hot plate), in-plane and transverse conductivity, temperature dependence, models for predicting the conductivity of composites.

Goals

The thermophysical properties of thermoplastic polymers are essential data for the numerical simulation of forming processes. Engineers must be able to evaluate and analyze the results obtained from the characterization of these materials. This course covers the basics and methods of critical analysis of the properties of polymers used for forming, with the aim of ensuring their correct use in simulation codes.

Bibliography

D.W. Van Krevelen ; « Properties of polymers » ; Elsevier, Third completely revised edition

Learning outcomes

Learning outcomes	N	A	M	E	O
• Using and analyzing PVT diagrams	·	·	✓	·	·
• Evaluate and analyze the results of characterizing the thermophysical properties of polymers	·	·	✓	·	·
• Use crystallization models and identify parameters	·	·	✓	·	·

Manager : Vincent SOBOTKA

Thin film materials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
10	4.5				1.5	8

Evaluation

One evaluation : *DS*

Outline

1- Panorama of the applications 2- Process overview 3-Notion of physics of surfaces 4- Kinetic theory of gases 5- Thermal Evaporation 6-Laser ablation 7-Ion sputtering 8-Examples

Goals

Give the fields of thin film applications and give a knowledge about the panorama of the techniques of thin film synthesis.

Bibliography

Thin films - R.A. Powell, S.M. Rossnagel - Academic Press

Prerequisites

Notions of thermodynamics: Maxwell-Boltzman distribution, Clapeyron law - Saturation vapor pressure - Notion of crystallography: Crystalline Bravais lattice

Learning outcomes

Learning outcomes	N	A	M	E	O
• Have a knowledge of the main fields of application of thin films and have a knowledge of the panorama of the techniques of thin film deposition	·	·	✓	·	·
• Have a knowledge of the surface mechanisms leading to the growth of a thin film	·	·	✓	·	·
• Be able to choose a technique of thin film deposition according to a given application.	·	✓	·	·	·
• Know the principle of the cathodic sputtering, the thermal evaporation, the plasma laser deposition and of the chemical vapor deposition	·	·	✓	·	·
• Able to evaluate the evaporated or sputtered flux of atoms and able to estimate the deposition rate and the rate of contamination by residual gas.	·	·	✓	·	·

Manager : Jeremy BARBE

Transitions S7

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			36			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Bruno AUVITY

Transitions S8

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
			28			

Evaluation

2 evaluations :

- *Situation Gpe*
- *Situation Ind*

Manager : Bruno AUVITY

Tutorials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		2				

Evaluation

One evaluation : *Situation Gpe*

Bibliography

- Booklet TD 1 du S6 pour les 3A et le booklet S7 pour les 4A
- Rebecca Hughes, 2010, Teaching and researching Speaking, Second Edition
- Jo Sudden, teachinenglish.org website : Role Play article : https://www.teachingenglish.org.uk/professional-development/teachers/planning-lessons-and-courses/articles/role-play

Manager : John KINGSTON

Tutorials

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		2				

Evaluation

One evaluation : *Situation Gpe*

Bibliography

- Booklet TD 1 du S6 pour les 3A et le booklet S7 pour les 4A
- Rebecca Hughes, 2010, Teaching and researching Speaking, Second Edition
- Jo Sudden, teachinenglish.org website : Role Play article : https://www.teachingenglish.org.uk/professional-development/teachers/planning-lessons-and-courses/articles/role-play

Manager : Carole CHAUSSE

VIP : english and french as a foreign language

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		15				

Bibliography

? Murphy, R. 2015. Essential Grammar in Use. Elementary. Cambridge
? TOEIC le guide officiel du test, ETS Global
? https://community-courses.memrise.com/community/course/430131/3a-s2-toeic-vocabulary/10/
? https://community-courses.memrise.com/community/course/2233959/3a-s1-polytech-nantes-irregular-verbs-meetings/

Manager : John KINGSTON

VIP : english and french as a foreign language

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		15				

Bibliography

? Murphy, R. 2015. Essential Grammar in Use. Elementary. Cambridge
? TOEIC le guide officiel du test, ETS Global
? https://community-courses.memrise.com/community/course/430131/3a-s2-toeic-vocabulary/10/
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Manager : John KINGSTON

Weld analysis

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
		10				

Evaluation

One evaluation : *Rapport Gpe*

Outline

It is a mini project in the laboratory comprising macrographic and micrographic observations of weld seams and mechanical characterizations (shock, tensile tests, bends).

Goals

This involves carrying out the expertise of weld seams in order to validate the welding parameters. It is a question of characterizing the quality of cords

Prerequisites

The courses in metallurgy, characterization of materials and behavior of materials during welding must be acquired.

Learning outcomes

Learning outcomes	N	A	M	E	O
• Weld characterization	·	·	✓	·	·
• Interpret the presence of faults	·	·	✓	·	·
• Give solutions in case of faults	·	·	✓	·	·

Manager : Pascal PAILLARD

Welding and foundry

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
15	1.5				1.5	9

Evaluation

One evaluation : *DS*

Outline

Foundry and Economics
- History of the Foundry
- Foundry processes
- Metallurgical changes
- Foundry defects
- Casting alloys
- Welding processes
- The electric arc
- Welding deformation
- Health and security
- Welding metallurgy

Goals

Panorama of processes foundry and the methods of jointing by welding
- Behaviour of metallic materials during forming

Bibliography

DOUR G., Aide mémoire Fonderie, DUNOD, 2004
- MURRY G., Aide mémoire Métallurgie, DUNOD, 2004
- WEMAN K., Aide mémoire Procédés de soudage, DUNOD, 2004

Prerequisites

Courses of Metallurgy and Phisical Metallurgy in 3rd and 4th years

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the foundry processes	·	·	✓	·	·
• To know the welding processes	·	·	✓	·	·
• To understand the effect of forming process (foundru and welding) on metallic materials	·	·	✓	·	·

Manager : Pascal PAILLARD

Welding metallurgy

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
57.75					1.5	26

Evaluation

One evaluation : *DS*

Outline

Behavior of steels during fusion welding
- Cracking in welded joints
- Heat treatment of welded joints
- Structural steels (non-alloy)
- High strength steels
- Applications of construction and high strength steels
- Creep and creep-resisting steels
- Steels for cryogenic applications
- Stainless and refractory steel
- Fonts and cast steels
- Copper and copper alloys
- Nickel and nickel alloys
- Aluminium and aluminium alloys
- Titanium and titanium alloys

Goals

Acquire the basic principles of the metallurgy of welding of all types of structural steels, stainless steels, aluminum alloys, titanium alloys, copper alloys ...

Bibliography

KOU S., Welding Metallurgy, John Wiley, 2005

BOUCHER C., L'aluminium et ses alliages, Publications du soudage et de ses applications, 2000

GRANJON H., Bases métallurgiques du soudage, Publications du soudage et de ses applications, 1995

GRANJON H., Bases métallurgiques du soudage, Soudure Autogène, 1989

ALTHOUSE A.D., BRAMAT M., MAYER, VILLENEUVE M., Technologie des métaux, contrôles et essais des soudures, De Boeck Edition 2008

Prerequisites

Courses of Metallurgy and Physical Mettalurgy en 3rd ant 4th years

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the influence of welding on the metallurgical modifications of alloys	·	·	✓	·	·
• To choose a welding process based on the alloy to weld	·	·	✓	·	·
• To understand damages of materials likely to appear during the welding operation and to propose remedies	·	·	✓	·	·
• To choose a metallic material for a given application	·	·	✓	·	·

Manager : Pascal PAILLARD

Welding methods

Hours

Lect	Tut	PW	Proj	WP	Exa	Asst
56					1.5	29

Evaluation

One evaluation : *DS*

Outline

Oxyfuel processes

Current sources

Processes with electric arc without gas protection (Metal arc welding with covered electrode, submerged arc welding,...)

Methods for gas shielded arc (GTAW, GMAW, Plasma,...)

High density of energy (Laser, electron beam) processes

Electric resistance welding processes

Other welding processes: aluminothermy, diffusion, explosion,...

Cutting and preparation of the edges

Brazing

Mechanization and automation of welding

Goals

Understand in detail the developments in all welding processes, including terminology, standards, accepted abbreviations, equipment, applications, procedures and common problems

Bibliography

ALTHOUSE A.D, PAQUET C., BRAMAT M., VILLENEUVE M., Coupage et procédés oxygaz, De Boeck Edition 2008.

PAQUET C., BRAMAT M., VILLENEUVE M., Procédés spéciaux de soudage et coupage, De Boeck Edition 2008.

ALTHOUSE A.D., BRAMAT M., MAYER, VILLENEUVE M., Technologie des métaux, contrôles et essais des soudures, De Boeck Edition 2008.

PAQUET C., LEVESQUE L., BRAMAT M., Procédés de soudage à l'arc, De Boeck Edition 2008.

JORION A., THIEBAULT A., La soudure à l'arc, Edition SAEP, 2007.

CRETIN S., JUBIN L., MACQUET P., Soudage robotisé en construction mécanique : technologies de production, Publication du CETIM, 2005

Prerequisites

Course of Welding and Cast Process of 4th year

Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the different welding processes	·	·	✓	·	·
• To know the possible applications with different welding processes	·	·	✓	·	·
• To choose a welding process based on a given application	·	·	✓	·	·

Manager : Pascal PAILLARD