

Teaching program

Matériaux

Academic year 2020-2021

Ecole polytechnique de l'université de Nantes

November 25, 2020

# Contents

<b>I Tables of teaching units</b>	<b>2</b>
<b>Semester 5 - unit <i>MAT 3</i></b>	<b>3</b>
Accueil . . . . .	3
Mathematics and applied computing I . . . . .	3
Applied physics I . . . . .	3
Materials chemistry I . . . . .	3
Humanities 5 . . . . .	4
Organization . . . . .	4
Sum of semester . . . . .	4
<b>Semester 6 - unit <i>MAT 3</i></b>	<b>5</b>
Mathematics and applied computing II . . . . .	5
Mechanics and materials I . . . . .	5
Humanities 6 . . . . .	5
Applied physics II . . . . .	5
Materials chemistry 2 . . . . .	6
Sum of semester . . . . .	6
<b>Semester 7 - unit <i>MAT 4</i></b>	<b>7</b>
Engineering sciences . . . . .	7
Characterisation methods . . . . .	7
Materials II . . . . .	7
Physics of materials and applications . . . . .	7
Humanities 7 . . . . .	8
Rheology . . . . .	8
Sum of semester . . . . .	8
<b>Semester 8 - unit <i>MAT 4</i></b>	<b>9</b>
Physic numeric and . . . . .	9
Polymers and composites . . . . .	9
Ceramics, glasses and thin solid films . . . . .	9
Metallic materials . . . . .	9
Humanities 8 . . . . .	10
Internship 4th year . . . . .	10
Sum of semester . . . . .	10
<b>Semester 9 - unit <i>MAPI 5 - Composites CP</i></b>	<b>11</b>
Humanities 9 CP . . . . .	11
[MAPI] Scientific and technical advanced courses . . . . .	11
[MAPI] Industrial project CP . . . . .	11
[MAPI] Cursus Composite materials . . . . .	11
Sum of semester . . . . .	12

<b>Semester 9 - unit <i>MAPI 5 - Composites hors CP</i></b>	<b>13</b>
Humanities 9 . . . . .	13
[MAPI] Scientific and technical advanced courses . . . . .	13
[MAPI] Industrial project hors CP . . . . .	13
[MAPI] Cursus Composite materials . . . . .	13
Sum of semester . . . . .	14
<b>Semester 9 - unit <i>MAPI 5 - Métallurgie CP</i></b>	<b>15</b>
Humanities 9 CP . . . . .	15
[MAPI] Scientific and technical advanced courses . . . . .	15
[MAPI] Industrial project CP . . . . .	15
[MAPI] Cursus Métallurgy : processes . . . . .	15
[MAPI] Cursus Metallurgy : materials . . . . .	16
Sum of semester . . . . .	16
<b>Semester 9 - unit <i>MAPI 5 - Métallurgie hors CP</i></b>	<b>17</b>
Humanities 9 . . . . .	17
[MAPI] Scientific and technical advanced courses . . . . .	17
[MAPI] Industrial project hors CP . . . . .	17
[MAPI] Cursus Métallurgy : processes . . . . .	17
[MAPI] Cursus Metallurgy : materials . . . . .	18
Sum of semester . . . . .	18
<b>Semester 9 - unit <i>MAPI 5 - RD CP</i></b>	<b>19</b>
Humanities 9 CP . . . . .	19
[MAPI] Scientific and technical advanced courses . . . . .	19
[MAPI] Industrial project CP . . . . .	19
[MAPI] Cursus R&D of innovative materials . . . . .	19
Sum of semester . . . . .	20
<b>Semester 9 - unit <i>MAPI 5 - RD hors CP</i></b>	<b>21</b>
Humanities 9 . . . . .	21
[MAPI] Scientific and technical advanced courses . . . . .	21
[MAPI] Industrial project hors CP . . . . .	21
[MAPI] Cursus R&D of innovative materials . . . . .	21
Sum of semester . . . . .	22
<b>Semester 9 - unit <i>Soudage 5 CP</i></b>	<b>23</b>
Humanities 9 CP . . . . .	23
Design and control . . . . .	23
Materials . . . . .	23
Fabrication . . . . .	23
Welding process CP . . . . .	23
Sum of semester . . . . .	24
<b>Semester 9 - unit <i>Soudage 5 hors CP</i></b>	<b>25</b>
Design and control . . . . .	25
Materials . . . . .	25
Fabrication . . . . .	25
Humanities 9 . . . . .	25
Welding process hors CP . . . . .	26
Sum of semester . . . . .	26
<b>Semester 10 - unit <i>S10 CP</i></b>	<b>27</b>
Stage de fin d'études en CP . . . . .	27
Humanities 10 . . . . .	27
Sum of semester . . . . .	27

<b>Semester 10 - unit <i>S10 hors CP</i></b>	<b>28</b>
Stage de fin d'études . . . . .	28
Sum of semester . . . . .	28
<b>II Sheets of courses</b>	<b>29</b>
Adhesion, bonding, interfaces	30
Bibliographic survey	31
Business Simulation 1	32
Business Simulation 2	33
CAD - Thermomechanics	34
Ceramics and glasses	35
Ceramics and inorganic materials - laboratory project	37
Characterisation methods - laboratory	38
Chemical bonding	39
Communicating on the workplace / Intercultural communication	40
Composite materials	41
Computer aided design	42
Computer aided drawing	43
Continuous Assessment (bis)	44
Continuous Assessment(bis)	45
Corrosion and electrochemical coatings	46
Current industrial applications in materials	48
Current industrial applications in processes	49
Design of experiments	50
Design of experiments : advanced course	51
Design of welded components	52
Dielectric materials -Magnetic materials	53
Diffusion in solids	54
Electrical engineering	55
Electrochemistry and generators	57
Electronics for measurement systems - laboratory	58
Experience feedback	59
Fabrication, operation and exploitation of welded components	60

Final internship	61
Fracture-Fatigue-Creep	62
French as a Foreign Language for engineering students	64
French as a Foreign Language for engineering students	65
From elaboration to final product	66
Fundamentals of heat transfer	67
General mechanics	68
General metallurgy	69
Generalized functions, integral transforms and partial differential equations	71
Grammar and professional English 1	73
Grammar, Toeic and professional English 2	74
Industrial metallic alloys	75
Innovation	76
Intercultural explorations	77
Internship 4th year	78
Life cycle of metallic materials	79
Linear algebra and complex analysis	80
MATLAB	82
Managing people	83
Marketing and Business Intelligence	84
Materials Chemistry II	86
Materials and applications (accueil)	88
Mechanical properties of composite materials	89
Mechanics of deformable solid body	90
Meeting management	92
Metallic materials - laboratory project	93
Methodology : Project management 1	94
Methodology : decipher information skills !	95
Microscopies	96
Negotiation	98
Non destructive testing	99
Non destructive testing of welds	100

Numerical algorithms	101
Numerical methods I	102
Numerical methods II	103
Numerical processing of experimental data	104
Opening courses 2	105
Optics and materials	106
Organization : Business Simulation 1	108
Organization : understanding organizations	109
Person : Physical education and sport 1	110
Person : Physical education and sport 2	111
Person : interpersonal skills	112
Person : my relation to others	113
Physical metallurgy	114
Physics (upgrade-refresher training)	116
Physics and chemistry of polymers	118
Physics and materials - laboratory	119
Plasticity of metals and metal forming	121
Polymeric materials - laboratory project	122
Practical training	123
Probabilities and statistics	124
Professional English 3	125
Professional Project 2 : professional project presentation	126
Professional project 3 : skills passport	127
Project	128
Project - case study - meeting management	129
Project management	130
Project management	131
Quality approach and problem solving	132
R&D Project management	133
R&D economy	134
Radiocrystallography	135
Rheology and thermomechanics of polymers	136

Safety Health at Work	138
Second foreign language - Chinese	139
Second foreign language - Chinese	140
Second foreign language - German	141
Second foreign language - German	142
Second foreign language - Japanese	143
Second foreign language - Japanese	144
Second foreign language - Spanish	145
Second foreign language - Spanish	146
Semiconducting materials and devices	147
Sensors, instrumentation and measurements	148
Shaping of composite materials	150
Society : Socio-economic debating	151
Society : history of organizations and epistemology	152
Sociology of innovation	153
Solid state chemistry I	154
Solid state physics	155
Specializes lectures by professionnal lecturers	157
Sport 3	158
Sport 4	159
Surface Analysis	160
Symmetry	161
Thermodynamics of materials	162
Thermodynamics of materials - 2	163
Thermomechanical treatments	164
Thermophysical properties of polymers and composites	165
Thin film materials	166
Training for Toeic	167
Training for Toeic	168
Weld analysis	169
Welding and foundry	170
Welding metallurgy	171

<b>Welding methods</b>	<b>173</b>
<b>Work analysis</b>	<b>175</b>



## Part I

# Tables of teaching units

# Semester 5 - unit *MAT 3*

## Accueil

Manager : *CROSNIER Olivier*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
4 mat { ▷ Chimie organique (accueil) ▷ Physics (upgrade-refresher training) ▷ Mathématiques (accueil) ▷ Materials and applications (accueil)		6					0
		12					0
		18					0
		4.5					0
3 mat { ▷ Computer aided drawing ▷ Materials and applications (accueil) ▷ TP Chimie des matériaux (accueil)	2.5		10.5				0
		4.5					0
			20				0
TOTAL	2.5	45	30.5	0	0	0	

## Mathematics and applied computing I

ECTS : 4

Manager : *CHAUVET Olivier*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Linear algebra and complex analysis		26				15	50
• MATLAB		1	12			6	25
• Numerical processing of experimental data			12			4	25
TOTAL	0	27	24	0	0	25	

## Applied physics I

ECTS : 6

Manager : *TESSIER Pierre-Yves*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Sensors, instrumentation and measurements	12.5	12				13	45
• General mechanics		13.5				6	25
• Optics and materials		18				9	30
TOTAL	12.5	43.5	0	0	0	28	

## Materials chemistry I

ECTS : 6

Manager : *JOUBERT Olivier*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Solid state chemistry I	8.75	9				11	35
• Physics and chemistry of polymers		16.5				20	35
• Thermodynamics of materials		13.5				25	30
TOTAL	8.75	39	0	0	0	56	

## Humanities 5

ECTS : 8

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Grammar and professional English 1		40					35
• Person : Physical education and sport 1		19.5				2	13
• Person : my relation to others		12.5				6	13
• Organization : understanding organizations		15				6	13
• Society : history of organizations and epistemology		15				3	13
• Methodology : decipher information skills !		16.5					13
TOTAL	0	118.5	0	0	0	17	

## Organization

ECTS : 6

Manager : JOUBERT Olivier

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Chemical bonding		33				21.5	50
• Symmetry	15	13.5				22	50
TOTAL	15	46.5	0	0	0	43.5	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	38.75	319.5	54.5	0	0	169.5	30
Face-to-face sum	412.75						

# Semester 6 - unit *MAT 3*

## Mathematics and applied computing II

ECTS : 5

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Numerical algorithms		22.5				12	30
• Generalized functions, integral transforms and partial differential equations	3.75	21.5				15	40
• Probabilities and statistics		19.5				15	30
TOTAL	3.75	63.5	0	0	0	42	

## Mechanics and materials I

ECTS : 8

Manager : BERTRAND Emmanuel

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Mechanics of deformable solid body		34	24			26	50
• General metallurgy	11.25	21.5	24			38	50
TOTAL	11.25	55.5	48	0	0	64	

## Humanities 6

ECTS : 8

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Person : Physical education and sport 2		19.5				2	13
• Person : interpersonal skills		7.5				7.5	13
• Organization : Business Simulation 1		28					13
• Society : Socio-economic debating		12				12	13
• Methodology : Project management 1		8				5	13
• Grammar, ToEIC and professional English 2		39	2				35
TOTAL	0	114	2	0	0	26.5	

## Applied physics II

ECTS : 4

Manager : ANGLERAUD Benoit

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Electronics for measurement systems - laboratory			24			10	30
• Fundamentals of heat transfer	8.75	6				6.5	40
• Physics and materials - laboratory			20			6.5	30
TOTAL	8.75	6	44	0	0	23	

## Materials chemistry 2

ECTS : 5

Manager : PAYEN Christophe

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Materials Chemistry II	17.5	9				10	50
• Thermodynamics of materials - 2		12				25	30
• Diffusion in solids		10.5				10	20
TOTAL	17.5	31.5	0	0	0	45	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	41.25	270.5	94	0	0	200.5	30
Face-to-face sum	405.75						

# Semester 7 - unit *MAT 4*

## Engineering sciences

ECTS : 5

Manager : *ANGLERAUD Benoit*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Electrical engineering		13.5	8			12	35
• Numerical methods I		9	13.5			15	35
• Design of experiments	7.5	6				8	30
TOTAL	7.5	28.5	21.5	0	0	35	

## Characterisation methods

ECTS : 5

Manager : *COUTURIER Laurent*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Microscopies	7.5	2.5				14	30
• Characterisation methods - laboratory			32			16	40
• Radiocrystallography	10	12				8	30
TOTAL	17.5	14.5	32	0	0	38	

## Materials II

ECTS : 4

Manager : *CROSNIER Olivier*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Corrosion and electrochemical coatings	8.75	10.5				10.5	40
• Electrochemistry and generators	12.5	10.5				10	60
TOTAL	21.25	21	0	0	0	20.5	

## Physics of materials and applications

ECTS : 4

Manager : *CHAUVET Olivier*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Dielectric materials -Magnetic materials	11.25	4.5				10	25
• Solid state physics	25	13.5				18	75
TOTAL	36.25	18	0	0	0	28	

## Humanities 7

ECTS : 8

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Professional English 3		19	2				26.25
• Sport 3		19.5				2	15
• Project management		10.5				10.5	10
• Marketing and Business Intelligence	3	10.5				10.5	10
• Safety Health at Work		10.5				5	10
• Business Simulation 1				24		2	20
1 opt { ▷ Continuous Assessment (bis)							8.75
▷ French as a Foreign Language for engineering students		18					8.75
▷ Second foreign language - German		18					8.75
▷ Second foreign language - Chinese		18					8.75
▷ Second foreign language - Spanish		18					8.75
▷ Second foreign language - Japanese		18					8.75
▷ Training for Toeic		18					8.75
<b>TOTAL</b>	<b>3</b>	<b>88</b>	<b>2</b>	<b>24</b>	<b>0</b>	<b>30</b>	

## Rheology

ECTS : 4

Manager : TANCRET Franck

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Rheology and thermomechanics of polymers	13.75	10.5				12	50
• Plasticity of metals and metal forming	6.25	13.5				13	50
<b>TOTAL</b>	<b>20</b>	<b>24</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>25</b>	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	105.5	194	55.5	24	0	176.5	30
Face-to-face sum	379						

# Semester 8 - unit *MAT 4*

## Physic numeric and

ECTS : 3

Manager : *TANCRET Franck*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Fracture-Fatigue-Creep	11.25	13.5				10	65
• Numerical methods II				20		10	35
TOTAL	11.25	13.5	0	20	0	20	

## Polymers and composites

ECTS : 3

Manager : *LESTRIEZ Bernard*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Adhesion, bonding, interfaces	11.25	6				10	35
• Composite materials	5	12				10	35
• Polymeric materials - laboratory project				17.5		8	30
TOTAL	16.25	18	0	17.5	0	28	

## Ceramics, glasses and thin solid films

ECTS : 7

Manager : *BROUSSE Thierry*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Ceramics and glasses	16.25	8				10	25
• Thin film materials	10	6				7	20
• Ceramics and inorganic materials - laboratory project				32		16	25
• Semiconducting materials and devices	13.75	4.5	16			16	30
TOTAL	40	18.5	16	32	0	49	

## Metallic materials

ECTS : 5

Manager : *PAILLARD Pascal*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Metallic materials - laboratory project				32		14	35
• Physical metallurgy		24				10	45
• Welding and foundry	17.5	1.5				9.5	20
TOTAL	17.5	25.5	0	32	0	33.5	



## Humanities 8

ECTS : 7

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Communicating on the workplace / Intercultural communication	3	10.5				5	15
• Quality approach and problem solving		10.5				10.5	10
• Sport 4		19.5				2	15
• Opening courses 2	10.5					10.5	10
• Professional Project 2 : professional project presentation				13.5		2.5	15
• Intercultural explorations		18					17.5
1 opt { ▷ Continuous Assessment(bis)							17.5
▷ French as a Foreign Language for engineering students		18					17.5
▷ Second foreign language - German		18					17.5
▷ Second foreign language - Chinese		18					17.5
▷ Second foreign language - Spanish		18					17.5
▷ Second foreign language - Japanese		18					17.5
▷ Training for Toeic		18					17.5
<b>TOTAL</b>	<b>13.5</b>	<b>76.5</b>	<b>0</b>	<b>13.5</b>	<b>0</b>	<b>30.5</b>	

## Internship 4th year

ECTS : 5

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Internship 4th year					12		0
<b>TOTAL</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>12</b>	<b>0</b>	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	98.5	152	16	115	12	161	30
Face-to-face sum	381.5						

# Semester 9 - unit *MAPI 5 - Composites CP*

## Humanities 9 CP

ECTS : 4

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	35
• Managing people		10.5				10.5	30
• Negotiation		6	4.5			10.5	30
• Sociology of innovation	4.5					4.5	5
TOTAL	4.5	28.5	4.5	0	0	29.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project CP

ECTS : 12

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus Composite materials

ECTS : 10

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Lectures on polymers and composites	8					5	0
• Mechanical properties of composite materials	15	1.5	12				30
• Shaping of composite materials	22	13.5	16				50
• Thermophysical properties of polymers and composites	15	1.5				5	20
TOTAL	60	16.5	28	0	0	10	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	85.75	48	50.5	185	0	184.5	30
Face-to-face sum	369.25						

# Semester 9 - unit *MAPI 5 - Composites hors CP*

## Humanities 9

ECTS : 6

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	22.5
• Managing people		10.5				10.5	17.5
• Negotiation		6	4.5			10.5	17.5
• Professional project 3 : skills passport				12		3	15
• Business Simulation 2	20.5					10	22.5
• Sociology of innovation	4.5					4.5	5
TOTAL	25	28.5	4.5	12	0	42.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project hors CP

ECTS : 10

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus Composite materials

ECTS : 10

Manager : SOBOTKA Vincent

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Lectures on polymers and composites	8					5	0
• Mechanical properties of composite materials	15	1.5	12				30
• Shaping of composite materials	22	13.5	16				50
• Thermophysical properties of polymers and composites	15	1.5				5	20
TOTAL	60	16.5	28	0	0	10	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	106.25	48	50.5	197	0	197.5	30
Face-to-face sum	401.75						

# Semester 9 - unit *MAPI 5 - Métallurgie CP*

## Humanities 9 CP

ECTS : 4

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	35
• Managing people		10.5				10.5	30
• Negotiation		6	4.5			10.5	30
• Sociology of innovation	4.5					4.5	5
TOTAL	4.5	28.5	4.5	0	0	29.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project CP

ECTS : 12

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus Métallurgy : processes

ECTS : 5

Manager : BERTRAND Emmanuel

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• From elaboration to final product	24	1				12	65
• Current industrial applications in processes	8	0.5				8	15
• Thermomechanical treatments	12	0.5				22	20
TOTAL	44	2	0	0	0	42	

**[MAPI] Cursus Metallurgy : materials****ECTS : 5***Manager : COUTURIER Laurent*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Industrial metallic alloys	26	1				13	65
• Life cycle of metallic materials	8	0.5				20	20
• Current industrial applications in materials	8	0.5				8	15
<b>TOTAL</b>	<b>42</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>41</b>	

**Sum of semester**

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	111.75	35.5	22.5	185	0	257.5	30
Face-to-face sum	354.75						

# Semester 9 - unit *MAPI 5 - Métallurgie hors CP*

## Humanities 9

ECTS : 6

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	22.5
• Managing people		10.5				10.5	17.5
• Negotiation		6	4.5			10.5	17.5
• Professional project 3 : skills passport				12		3	15
• Business Simulation 2	20.5					10	22.5
• Sociology of innovation	4.5					4.5	5
TOTAL	25	28.5	4.5	12	0	42.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomecanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project hors CP

ECTS : 10

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus Métallurgy : processes

ECTS : 5

Manager : BERTRAND Emmanuel

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• From elaboration to final product	24	1				12	65
• Current industrial applications in processes	8	0.5				8	15
• Thermomechanical treatments	12	0.5				22	20
TOTAL	44	2	0	0	0	42	



**[MAPI] Cursus Metallurgy : materials****ECTS : 5***Manager : COUTURIER Laurent*

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Industrial metallic alloys	26	1				13	65
• Life cycle of metallic materials	8	0.5				20	20
• Current industrial applications in materials	8	0.5				8	15
<b>TOTAL</b>	<b>42</b>	<b>2</b>	<b>0</b>	<b>0</b>	<b>0</b>	<b>41</b>	

**Sum of semester**

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	132.25	35.5	22.5	197	0	270.5	30
Face-to-face sum	387.25						

# Semester 9 - unit *MAPI 5 - RD CP*

## Humanities 9 CP

ECTS : 4

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	35
• Managing people		10.5				10.5	30
• Negotiation		6	4.5			10.5	30
• Sociology of innovation	4.5					4.5	5
TOTAL	4.5	28.5	4.5	0	0	29.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project CP

ECTS : 12

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus R&D of innovative materials

ECTS : 10

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Surface Analysis	8.75	1.5				4	15
• Specializes lectures by professional lecturers	45						30
• R&D economy	1.5	6					10
• R&D Project management	12						15
• Innovation	9						10
• Project management			14				10
• Design of experiments : advanced course		6				2	10
TOTAL	76.25	13.5	14	0	0	6	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	102	45	36.5	185	0	180.5	30
Face-to-face sum	368.5						

# Semester 9 - unit *MAPI 5 - RD hors CP*

## Humanities 9

ECTS : 6

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	22.5
• Managing people		10.5				10.5	17.5
• Negotiation		6	4.5			10.5	17.5
• Professional project 3 : skills passport				12		3	15
• Business Simulation 2	20.5					10	22.5
• Sociology of innovation	4.5					4.5	5
TOTAL	25	28.5	4.5	12	0	42.5	

## [MAPI] Scientific and technical advanced courses

ECTS : 4

Manager : LOUARN Guy

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	25
• Computer aided design			9			4	25
• Meeting management	2.5	2				2	20
• Non destructive testing	9.75	1				5	30
TOTAL	12.25	3	18	0	0	15	

## [MAPI] Industrial project hors CP

ECTS : 10

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Project				150		100	75
• Bibliographic survey	9			35		30	25
TOTAL	9	0	0	185	0	130	

## [MAPI] Cursus R&D of innovative materials

ECTS : 10

Manager : CUENOT Stéphane

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Surface Analysis	8.75	1.5				4	15
• Specializes lectures by professional lecturers	45						30
• R&D economy	1.5	6					10
• R&D Project management	12						15
• Innovation	9						10
• Project management			14				10
• Design of experiments : advanced course		6				2	10
TOTAL	76.25	13.5	14	0	0	6	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	122.5	45	36.5	197	0	193.5	30
Face-to-face sum	401						

# Semester 9 - unit *Soudage 5 CP*

## Humanities 9 CP

ECTS : 4

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	35
• Managing people		10.5				10.5	30
• Negotiation		6	4.5			10.5	30
• Sociology of innovation	4.5					4.5	5
TOTAL	4.5	28.5	4.5	0	0	29.5	

## Design and control

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	15
• Computer aided design			9			4	15
• Design of welded components	30	2				16	40
• Non destructive testing	9.75	1				5	15
• Non destructive testing of welds	4		8			6	15
TOTAL	43.75	3	26	0	0	35	

## Materials

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Welding metallurgy	49.25	2				25.5	85
• Weld analysis			10				15
TOTAL	49.25	2	10	0	0	25.5	

## Fabrication

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Fabrication, operation and exploitation of welded components	14.5	2				8	70
• Project - case study - meeting management	2.5	2		69.5		38	30
TOTAL	17	4	0	69.5	0	46	

## Welding process CP

ECTS : 8

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Practical training			40				20
• Welding methods	64	2				31.5	80
TOTAL	64	2	40	0	0	31.5	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	178.5	39.5	80.5	69.5	0	167.5	30
Face-to-face sum	368						

# Semester 9 - unit *Soudage 5 hors CP*

## Design and control

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• CAD - Thermomechanics			9			4	15
• Computer aided design			9			4	15
• Design of welded components	30	2				16	40
• Non destructive testing	9.75	1				5	15
• Non destructive testing of welds	4		8			6	15
TOTAL	43.75	3	26	0	0	35	

## Materials

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Welding metallurgy	49.25	2				25.5	85
• Weld analysis			10				15
TOTAL	49.25	2	10	0	0	25.5	

## Fabrication

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Fabrication, operation and exploitation of welded components	14.5	2				8	70
• Project - case study - meeting management	2.5	2		69.5		38	30
TOTAL	17	4	0	69.5	0	46	

## Humanities 9

ECTS : 6

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Work analysis		12				4	22.5
• Managing people		10.5				10.5	17.5
• Negotiation		6	4.5			10.5	17.5
• Professional project 3 : skills passport				12		3	15
• Business Simulation 2	20.5					10	22.5
• Sociology of innovation	4.5					4.5	5
TOTAL	25	28.5	4.5	12	0	42.5	



## Welding process hors CP

ECTS : 6

Manager : PAILLARD Pascal

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Practical training			40				20
• Welding methods	64	2				31.5	80
TOTAL	64	2	40	0	0	31.5	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	199	39.5	80.5	81.5	0	180.5	30
Face-to-face sum	400.5						

# Semester 10 - unit *S10 CP*

## Stage de fin d'études en CP

ECTS : 28

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Final internship					19		100
TOTAL	0	0	0	0	19	0	

## Humanities 10

ECTS : 2

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Experience feedback	24						1
TOTAL	24	0	0	0	0	0	

## Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	24	0	0	0	19	0	30
Face-to-face sum	24						

# Semester 10 - unit *S10 hors CP*

Stage de fin d'études

ECTS : 30

Course	Lect	Tut	PW	Proj	WP	Asst	Coef
• Final internship					19		100
TOTAL	0	0	0	0	19	0	

Sum of semester

	Lect	Tut	PW	Proj	WP	Asst	ECTS
Sum	0	0	0	0	19	0	30
Face-to-face sum							

## Part II

# Sheets of courses

---

# Adhesion, bonding, interfaces

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
11.25	6				10

## 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
  - Controlling 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 exchange 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).

## 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 controlling bonded joints	•	✓	•	•	•

Manager : Bernard LESTRIEZ

---

## Bibliographic survey

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
9			35		30

### Evaluation

One evaluation : *Rapport*

### Outline

The use of documentary research methods - Sources of information in Science and Technology - Query methods - Information exploitation and bibliographic synthesis

### Goals

The aim of this course is to equip students with the skills required to utilise databases and search engines suited to research and development.

### 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 : Stéphane CUENOT*

---

# Business Simulation 1

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
			24		2

## Evaluation

One evaluation : *Soutenance + CC*

## Goals

Put into practice teachings " HES " in a global approach of the company by integrating its various economic, commercial, financial, human dimensions.

Understand the link between these dimensions.

Understand the enterprise by using a concrete case.

## Prerequisites

accounting and economics

## Learning outcomes

Learning outcomes	N	A	M	E	O
• to implement the theoretical concepts Economics and management which were taught in the 3rd year	.	✓	.	.	.
• managing a virtual enterprise by integrating the different dimensions of the company, in a team and in a limited time	✓	.	.	.	.

*Manager : Chrystèle GONCALVES*

---

## Business Simulation 2

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
20.5					10

### Evaluation

One evaluation : *Contrôle continu*

### Outline

Management of a virtual company in competitive environment. Taking of decisions, from the production organisation until the marketing.

Realization of specific works at the same time as the decisions of management :

- Strategic presentation of the company
- Dashboards
- Negotiation...

### Goals

Synthesize and put into practice teachings " HES " in a global approach of the company in international environment by integrating its various economic, commercial, financial, human and societal dimensions, into a perspective of sustainable development. Use on a concrete case tools and methods such as project management, dashboards, negotiation ...

### Bibliography

Celles des cours précédents.

### Prerequisites

All the courses HES of 3rd and 4th year, in particular the simulation of the business management of 4th year.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Report its work under an appropriate shape.	•	•	✓	•	•
• Manage projects in team in an allotted time.	•	•	✓	•	•
• Manage a virtual company by integrating all the dimensions into a perspective of sustainable development.	•	✓	•	•	•
• Know how to set up simple dashboards.	•	✓	•	•	•
• Know how to practise a commercial negotiation.	•	✓	•	•	•

*Manager : Jacques MOREAU*



---

## CAD - Thermomechanics

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		9			4

### Evaluation

One evaluation : *CR*

### Outline

Tackled issues :

- drawing import from Catia to Comsol
- static analysis (2D & 3D), meshing influence with a point load ;
- differential thermal dilatation
- thermomechanics with stationary 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 with 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	Asst
16.25	8				10

## Evaluation

3 evaluations :

- *DS1*
- *DS2*
- *Projet*

## 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	Asst
			32		16

### Evaluation

2 evaluations :

- *CR*
- *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	Asst
		32			16

### Evaluation

2 evaluations :

- *CR*
- *SO*

### 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 professional 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	Asst
	33				21.5

## Evaluation

3 evaluations :

- *CC*
- *DS1*
- *DS2*

## 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 structure - 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*

---

# Communicating on the workplace / Intercultural communication

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
3	10.5				5

## Evaluation

One evaluation : *Contrôle continu*

## Outline

The sessions will alternate lectures, practical exercises, simulations, collective debriefing.

10,5 hours in groups will be dedicated to Communication at work, and 2,5 hours of lecture to Intercultural communication.

## Goals

To discover the various facets of business communication.

To learn how to observe interpersonal or group communication situations, to analyse them and to adjust one's communication style.

To be able to express oneself in public.

To present the challenges and the major principles of the intercultural communication.

## Bibliography

La communication en entreprise, J-P. Lehnisch, PUF, coll. Que sais-je ?, 2011

Comment leur dire... La process communication, G. Collignon, Inter-Editions, 2010

## Prerequisites

Minimal knowledge on companies.

## Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to distinguish the different forms of communication in business	✓	·	·	·	·
• To be able to observe and analyze a communication situation	·	✓	·	·	·
• To be able to understand the effect of one's communication style and to adjust it	·	✓	·	·	·
• To be able to express oneself in public	·	✓	·	·	·
• To understand the stakes connected to the intercultural communication	✓	·	·	·	·
• To know the main theories, the models and the tools of analysis of the interculturalism	✓	·	·	·	·

Manager : Anouk GREVIN

---

# Composite materials

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
5	12				10

## 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 : Guy LOUARN



---

## Computer aided design

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		9			4

### Evaluation

One evaluation : *Travail à rendre*

*Manager : Guy LOUARN*

---

# Computer aided drawing

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
2.5		10.5			

## 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*

---

## Continuous Assessment (bis)

---

### Hours

Lect Tut PW Proj WP Asst

### Evaluation

One evaluation : *CC*

---

## Continuous Assessment(bis)

---

### Hours

Lect Tut PW Proj WP Asst

### Evaluation

One evaluation : *CC*

---

# Corrosion and electrochemical coatings

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
8.75	10.5				10.5

## 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 chimie de surface des matériaux ; PPUR, 1993
- Mars G. Fontana ; Corrosion Engineering ; Mc Graw-Hill, 1987, [www.corrosiondoctors.org/](http://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*

---

## Current industrial applications in materials

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
8	0.5				8

### Evaluation

One evaluation : *CR*

### Outline

A program of conferences animated by engineers currently working in the mettalic materials industry (topics will depend on the speakers)

### Goals

To get an experience of the development of innovative and/or complex metallic alloys based on the development of the technicity of metallic parts through some examples steaming from the current industry

### Prerequisites

industrial metallic alloys

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To know some examples of the development of innovative and/or complex metallic materials	✓	·	·	·	·
• Be able to extract the important information from an oral presentation and sum them up in a written report	·	·	✓	·	·

*Manager : Emmanuel BERTRAND*

---

## Current industrial applications in processes

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
8	0.5				8

### Evaluation

One evaluation : *CR*

### Outline

A program of conferences animated by engineers currently working in the mettalic materials industry (topics will depend on the speakers)

### Goals

To get an experience in the innovative and/or complex processes developped based on the technicity of mettalic parts through some examples used in the current industry.

### Prerequisites

processes of elaboration, forming and joining

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To know some examples of recent and/or complex process development	✓	·	·	·	·
• To be able to extract important information from an oral presentation to sum them up in a written report	·	·	✓	·	·

*Manager : Laurent COUTURIER*



---

# Design of experiments

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
7.5	6				8

## Evaluation

One evaluation : *DS*

## Outline

Introduction: experimental strategies, winning strategy

Factorial designs 2p with factors p and two levels

Fractional designs 2k-p

Data analysis

Accuracy

Notions about other types of design of experiments: Tagushi, central composite designs

## Goals

To know how to design fractional factorial design of experiments 2p and 2k-p.

## Bibliography

« La méthode des plans d'expériences », J.Goupy, Dunod, Paris 1988.

« Introduction à la méthode des plans d'expériences par la méthode Tagushi », M.Pillet, Les éditions d'organisation université, 1991.

« Plans d'expériences pour surfaces de réponse », J. Goupy, Dunod, Paris 1999

## Prerequisites

matrix calculations

Basic Statistics

## Learning outcomes

Learning outcomes	N	A	M	E	O
• To know how to design a design of experiments 2p, how to perform it and how to solve it	·	·	✓	·	·
• To know how to design a fractional design of experiments 2k-p, how to perform it and how to solve it	·	·	✓	·	·

Manager : *Thierry BROUSSE*

---

## Design of experiments : advanced course

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	6				2

### Evaluation

One evaluation : *CC*

### Outline

Multilinear regression, quality evaluation models

Analysis of variance

Transmission of errors, accuracy in the predicted responses

Optimality criterion

Study on the model of second degree

Canonical analyzes R and RT

Different types of experimental designs

### Goals

To know the analysis of variance and canonical analysis practice.

To know the different types of experimental designs and their characteristics

### Bibliography

« Plans d'expériences pour surfaces de réponse », J. Goupy, Dunod, Paris 1999

### Prerequisites

Advanced notions on complete and fractional factorial designs.

Matrix calculations.

Statistics

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the principles of analysis of variance	·	✓	·	·	·
• To practice canonical analysis R and RT	·	✓	·	·	·

*Manager : Thierry BROUSSE*

---

# Design of welded components

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
30	2				16

## Evaluation

2 evaluations :

- *CC*
- *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 structures under 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	Asst
11.25	4.5				10

### 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	Asst
	10.5				10

## Evaluation

One evaluation : *DS*

## Outline

Atomic jumps and statistical physics

Fick's equations

Influence of time and temperature on diffusion

Mechanisms and associated diffusion coefficients

- autodiffusion

- vacancies diffusion

- heterodiffusion : in dilute alloy and interdiffusion

Diffusion in ionic solids

Diffusion and crystalline 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*

---

# Electrical engineering

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	13.5	8			12

## Evaluation

2 evaluations :

- *DS*
- *CR*

## 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 and generators

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
12.5	10.5				10

### Evaluation

2 evaluations :

- *CC*
- *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

Concepts of general chemistry

### 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	.	.	✓	.	.

*Manager : Olivier JOUBERT*



---

## Electronics for measurement systems - laboratory

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		24			10

### Evaluation

One evaluation : *CR*

### 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 : Pierre-Yves TESSIER*

---

## Experience feedback

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
24					

### Evaluation

One evaluation : *Validé / non validé*

*Manager : Maud BEAUTRAIS SATTLER*

---

# Fabrication, operation and exploitation of welded components

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
14.5	2				8

## Evaluation

2 evaluations :

- *CC*
- *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*

---

## Final internship

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
				19	

### Evaluation

One evaluation : *Rapport+soutenance+é*

### Outline

This is an internship (training period / placement), of at least 19 weeks and 6 months maximum, followed by a supervisor in the host organisation and by a teacher in the school, during which the student must get deeply involved in an industrial issue, with functions as close as possible to those of a materials engineer in industry and covering, beyond scientific and/or technical issues, aspects related to organisation and project management, a contribution to decision taking, and aspects related to the analysis and synthesis of the work as well as written and oral communication (cf. literature references).

### Goals

To get trained, through practice, to the profession and functions of a materials engineer, within an actual industrial context.

### Bibliography

- Commission des Titres d'Ingénieur (2012) :  
"Références et Orientations Tome 1 - T1.B.1.1 : L'ingénieur et ses missions"  
- Règlement des stages de Polytech Nantes

### Prerequisites

All of the teaching and training completed before the internship.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to deal autonomously with a complex problem in one of the scientific and/or technical domains of the specialty.	·	·	·	✓	·
• To be able to enrich the technical analysis of a complex problem with knowledge coming from other domains.	·	·	✓	·	·
• To be able to take into account industrial, economical, social, regulatory, environmental issues...	·	✓	·	·	·
• To be able to contribute to the organisation and management of a project with an industrial objective.	·	✓	·	·	·
• To be able to contribute to decision taking, and become aware of responsibility taking.	✓	·	·	·	·

---

# Fracture-Fatigue-Creep

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
11.25	13.5				10

## Evaluation

2 evaluations :

- *DS1*
- *DS2*

## Outline

Part I: Fracture mechanics

- Fracture mechanics (brittle, ductile, inter- or transgranular, fractography...)
- Mechanical approach (stress intensity factor, toughness, measurements...)
- Energetic approach (energy balance,  $G$ ,  $G_c$ , measurements, relations with  $K_{Ic}$ )
- 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
- 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 for engineering students

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## French as a Foreign Language for engineering students

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*



---

## From elaboration to final product

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
24	1				12

### Evaluation

One evaluation : *Oral*

### Outline

Extractive metallurgy  
Semi-wrought products processes  
Finished products processes  
Assembly processes

### Goals

To know how metallic materials are produced, from ore to material.  
To know how metallic materials are shaped into half-wrought material or finished product.  
To know which properties can be reached.

*Manager : Laurent COUTURIER*

---

# Fundamentals of heat transfer

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
8.75	6				6.5

## Evaluation

One evaluation : *DS*

## Outline

Introduction (Different forms of energy, Energy conversion, Heat transfer). Conduction (Fourier's law, Heat equation, solution for stationary 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	Asst
	13.5				6

## Evaluation

2 evaluations :

- *DS*
- *CR*

## 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 position and parametrize rigid bodies	.	.	✓	.	.
• To modelize mechanical actions	.	.	✓	.	.
• To determine unknown forces and positions	.	.	✓	.	.

Manager : Jérémie RUPIL

---

# General metallurgy

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
11.25	21.5	24			38

## Evaluation

3 evaluations :

- *CC*
- *DS*
- *TP*

## Outline

Introduction

Mechanical properties of metals (Tensile curves, effect of physical parameters (temperature, crystal structure...), practical realization of a tensile test, hardness and Charpy impact tests)

Thermodynamic of metallic systems (Relationship between Gibbs free energy and phase diagrams)

Phase of metallic alloys (Crystal structures, solid solutions)

Solidification (homogeneous and heterogeneous nucleation, growth, cellular and dendritic microstructure, segregation, ingot solidification)

Solid state transformation (Energy barrier, nucleation and growth in diffusive transformations)

## Goals

To be able to interpret a phase diagram and predict solidification microstructure

To know the main transformations in the liquid and solid state and in metallic materials

To know how to characterize the mechanical properties of a metallic material

To understand the mechanisms of solidification of an alloy

## Bibliography

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

Publication : 2002 Métallurgie : 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, Strength 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 interstitial element in steels	•	•	✓	•	•

*Manager : Emmanuel BERTRAND*

---

# Generalized functions, integral transforms and partial differential equations

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
3.75	21.5				15

## 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 : Olivier CHAUVET*

---

## Grammar and professional English 1

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	40				

### Evaluation

2 evaluations :

- *CC*
- *DS*



---

## Grammar, Toeic and professional English 2

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	39	2			

### Evaluation

3 evaluations :

- *CC*
- *Tutorat*
- *Toeic*

---

# Industrial metallic alloys

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
26	1				13

## Evaluation

One evaluation : *Oral*

## Outline

- I/ Iron based alloys
  - I.1/ Iron-carbon based alloys : steels and cast irons
  - I.2/ Stainless steels
- II/ Light alloys
  - II.1/ Precipitation hardening aluminum alloys
  - II.2/ Non-precipitation hardening aluminum alloys
  - II.3/ Magnesium based alloys
- III/ Titanium based alloys (and Zr)
- IV/ Nickel based alloys (and Co)
- V/ Copper based alloys

## Goals

To know the different families of metallic alloys currently used in industry, their properties ranges and their principal use.

To learn how one may design the alloys microstructure to adapt their properties to a specific use.

## Prerequisites

general metallurgy, physical metallurgy, metallic materials microprojects, thermodynamics, corrosion, plasticity, mechanics

## Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the principal families of industrial metallic materials, their main properties and their main applications	✓	.	.	.	.
• To know and to know how to use the designations of the different metallic alloys used in industry	.	.	✓	.	.
• To understand the link between the microstructures and the properties of these metallic alloys	.	.	.	✓	.
• Be able to suggest thermomechanical treatments to adapt the properties of a metallic material to a specific use	.	.	✓	.	.

*Manager : Emmanuel BERTRAND*

---

# Innovation

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
9					

## Evaluation

One evaluation : *Soutenances projets*

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Connaitre les étapes du processus d'innovation et leurs acteurs	✓	.	.	.	.

*Manager : Emmanuel CHENE*

---

## Intercultural explorations

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Internship 4th year

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
				12	

### Evaluation

One evaluation : *Rapport écrit*

*Manager : Bernard LESTRIEZ*

---

## Life cycle of metallic materials

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
8	0.5				20

### Evaluation

One evaluation : *SO*

### Outline

Deterioration phenomena and how to avoid them

Microstructures aging and associated properties drop

Corrosion mechanisms and means to avoid them / limit their effects

Wear phenomena

Metallic alloys recycling

### Goals

Be able to understand and anticipate the properties evolution of in use materials.

To know the requirements due to metals recycling and be able to take them into account in the developpement of new materials and/or processes.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to use materials that may deteriorate during use and plan counteractions	.	.	✓	.	.
• Be able to anticipate metallic alloys recycling by imposing a well though use and management of these materials during their whole life cycle	.	.	✓	.	.
• Do a literature review and make of speech of it	.	.	.	✓	.

*Manager : Emmanuel BERTRAND*

---

# Linear algebra and complex analysis

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	26				15

## 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

Algebraic structures, linear applications, matrices, determinants and linear systems, eigenvectors eigenvalues and eigen spaces, diagonalisation and triangularisation

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 : Olivier CHAUVET*



---

# MATLAB

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	1	12			6

## Evaluation

One evaluation : *TP*

## 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)	.	.	✓	.	.

*Manager : Stéphane CUENOT*

---

# Managing people

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	10.5				10.5

## Evaluation

One evaluation : *Examen*

## Outline

The sessions will alternate lectures, practical exercises, simulations, collective debriefing.

## Goals

To understand the role of a manager and the paradoxes of management, main management issues, individual and organisational behavior.

To prepare oneself to leadership positions.

## Bibliography

Management, l'essentiel des concepts et des pratiques, S. Robbins, D. DeCenzo, M. Coulter, Ed. Pearson.

Manager, les meilleures pratiques du management, M. Barabel, O. Meier, Dunod.

Management et leadership, C. Dejoux, Dunod, coll. Les topos.

## Prerequisites

Minimal knowledge on companies.

Team working experience in a professional context.

## Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to analyze human or managerial issues and to draw conclusions for action	·	✓	·	·	·
• To be able to identify the management style adapted to a situation	✓	·	·	·	·
• To know the main theoretical currents in organization theory	✓	·	·	·	·

*Manager : Anouk GREVIN*

---

# Marketing and Business Intelligence

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
3	10.5				10.5

## Evaluation

One evaluation : *Examen*

## Outline

- 1 - The Marketing approach
  - From needs to proposals
  - Place of the Marketing in a company
  - Evolutions of the Marketing, value creation, ICTS, CRM, one to one ...
- 2 - The Strategic Marketing
  - Corporate strategies, strategic diagnostics (swot, Porter, life cycle, BCG ...)
  - Marketing strategies, segmentation, targeting, positioning, innovation...
  - MIS, techniques of studies, market study: demand, offers, environment
3. The operational marketing
  - Marketing Mix, Product, Place, Promotion, Price
4. Conference Economic Intelligence : stakes and main functions of the economic intelligence and methodology of the watch

## Goals

Present the approach marketing, heart of the activity of the company, which concerns all the functions of the company, in term of value creation and satisfaction of the needs for the customer. Present the stakes, the strategic aspects and the main operational levers.

Introduction to business intelligence.

## Bibliography

G. Armstrong, P Kotler ; « Principes de Marketing » ; Pearson Education - Mercator; "Mercator"; Dunod. Dernières éditions.

Audigier M., Coulon G., Rassat P. : « L'intelligence économique » - Economica

## Prerequisites

General knowledge of the company and its functions. Introduction in the economy and the management.

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the role and the place of the approach and the function Marketing within the firm.	✓	.	.	.	.
• Join the role, the stakes and the methodologies of the marketing initiative into a professional approach.	✓	.	.	.	.
• Know the main generic strategies of a company allowing it to build a concurrentiel long-lasting advantage.	✓	.	.	.	.
• Know the techniques of studies and be able to validate an initiative of simple study.	✓	.	.	.	.
• Know the main operational levers Product, Place, Promotion, Price, in term of means of action, stakes and role.	✓	.	.	.	.

*Manager : Luc OILI*

---

# Materials Chemistry II

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
17.5	9				10

## Evaluation

2 evaluations :

- *CC*
- *DS*

## 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 defect 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	.	.	✓	.	.
• traduire	.	✓	.	.	.
• traduire	✓	.	.	.	.
• traduire	✓	.	.	.	.

*Manager : Christophe PAYEN*

---

## Materials and applications (accueil)

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	4.5				

### 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*

---

# Mechanical properties of composite materials

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
15	1.5	12			

## Evaluation

2 evaluations :

- *DS*
- *CR*

## 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

## Learning outcomes

Learning outcomes	N	A	M	E	O
• -	.	.	✓	.	.
• -	.	.	✓	.	.
• -	.	✓	.	.	.
• -	.	✓	.	.	.

*Manager : Vincent SOBOTKA*



---

# Mechanics of deformable solid body

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	34	24			26

## Evaluation

2 evaluations :

- *Cours-TD (2DS+CR)*
- *TP (CR+SO)*

## Outline

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

## Goals

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

Introduce the deformation measurement by strain gauge.

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

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.

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 analysis of elastic strains measurements (strain gage, strain rosette) to determine components of strain and stress tensors	.	✓	.	.	.
• To determine stresses, deformations and displacements in a structure. To size through the use of strength criterions	.	.	✓	.	.

---

# Meeting management

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
2.5	2				2

## Evaluation

One evaluation : *CC*

## 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. To know the principles of the organizing a meeting, conducting meetings and solving problems in groups.

## 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	Asst
			32		14

### Evaluation

2 evaluations :

- *CR*
- *S0*

### 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 transformation 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

To be able to use the laboratory equipments (tensile apparatus, optical microscope, hardness tester, scanning electron microscope, X-ray diffractometer, 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 analyse the causes of failure and adapt one's approach in light of these failures	.	.	✓	.	.

Manager : Emmanuel BERTRAND

---

## Methodology : Project management 1

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	8				5

### Evaluation

One evaluation : *DS*

### Bibliography

- HEAGNEY, Joseph. Fundamentals of project management. Amacom, 2016
- BOURGEOIS, Jean-Paul. Gestion de projet. Ed. Techniques Ingénieur, 1997

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-2	✓	.	.	.	.
• TPN-4	.	✓	.	.	.
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-15	✓	.	.	.	.
• TPN-16	✓	.	.	.	.

*Manager : John KINGSTON*

---

## Methodology : decipher information skills !

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	16.5				

### Evaluation

One evaluation :  $DS + CC$

### Bibliography

- François-Bernard Huyghe, Fake News, VA press, « Influence et conflits », 2019

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	.	✓	.	.	.
• TPN-2	.	✓	.	.	.
• TPN-3	.	✓	.	.	.
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-13	✓	.	.	.	.
• TPN-21	.	✓	.	.	.

Manager : Cédric LAIR

---

# Microscopies

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
7.5	2.5				14

## Evaluation

One evaluation : *Examen*

## Outline

Image analysis 101

Optical microscopy

Electron microscopy

Electron-matter interactions

Microscopes technology

SEM specificity

TEM specificity

Associated characterization techniques

X-Rays : production and matter interaction

X-Rays spectroscopy techniques (EDS/WDS, XRF, XAS, XPS)

Electron spectroscopy techniques (EELS, Auger)

Crystalline orientations identification (EBSD, ACOM)

## 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.

## 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*



---

# Negotiation

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	6	4.5			10.5

## Evaluation

One evaluation : *DS + vidéo*

## Outline

- 1 - Argumentation
- 2 - Negotiation and management of conflicts
  - 2.1 - Introduction to the system negotiation
  - 2.2 - Strategies of negotiation
  - 2.3 - Technical and tactical of negotiation
  - 2.4 - Main theoretical currents

## Goals

Make sensitive the pupils in theories, techniques and stakes in the contemporary management in resituant in a historical perspective. Give them the theoretical and practical bases of the negotiation with various partners of the engineer to advance projects, take out of situations of blocking or manage conflicts.

## Bibliography

Stimec A. ; « La négociation » ; Dunod  
Fisher, Ury ; « Comment réussir une négociation » ; Seuil

## Prerequisites

General knowledge of companies.  
Interpersonal communication in companies

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Know the theories, the strategies, the tactics and the techniques of negotiation, in particular the reasoned negotiation.	·	✓	·	·	·
• Be able to analyze and prepare a situation of negotiation.	·	✓	·	·	·

*Manager : Jacques MOREAU*

---

# Non destructive testing

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
9.75	1				5

## 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 céramiques 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	Asst
4		8			6

### Evaluation

One evaluation : *CR*

### 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*

---

# Numerical algorithms

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	22.5				12

## Evaluation

One evaluation : *DS*

## Outline

Notions of Algorithms and Modelling

- Information representation and numerical errors
- Elements of Information, simple Objects and Structured Objects
- Elementary actions & notion of algorithm
- Structured actions, alternatives. Selective iterative
- Down analysis,
- Actions set, Functions, Procedures
- Data structure, File Pile, Tree and Graph
- Development & Evaluation of algorithms

## Goals

The teaching Algorithmic module aims to build a methodology to analyze a problem and develop appropriate resolution schemes based on a finite set of structured objects and actions. These reasoning processes are essential in a engineering approach to efficiently respond to offers subject to precise specifications

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Build a rational and structured methodology to provide solutions to engineering problems using algorithmic techniques	.	.	✓	.	.
• Modeling, and formulation a concrete problem : from the mathematical representation to the resolution in computer sciences	.	✓	.	.	.
• Apply methodologies to program simple algorithms in Matlab language,needed to achieve digital projects in subsequent semesters	.	.	✓	.	.

*Manager : Stéphane CUENOT*

---

# Numerical methods I

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	9	13.5			15

## Evaluation

2 evaluations :

- *DS*
- *CR*

## 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 II

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
			20		10

### Evaluation

One evaluation : *CR*

### 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	Asst
		12			4

## Evaluation

One evaluation : *CR*

## 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*

---

## Opening courses 2

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
10.5					10.5

### Evaluation

One evaluation : *Contrôle continu*

*Manager : Chrystèle GONCALVES*



---

# Optics and materials

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	18				9

## Evaluation

One evaluation : 1 DS

## Presentation

Interaction between light and matter with optical applications.

## Outline

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

## Goals

This course is dealing with the basis of the interaction between matter and light. Particularly, the phenomena involved between matter and the visible light are presented : the reflection, absorption and transmission factors are calculated. The understanding of the mechanisms involved in 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.

## Bibliography

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 Hill 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*

---

## Organization : Business Simulation 1

---

### Hours

Lect Tut PW Proj WP Asst  
28

### Evaluation

One evaluation : *Soutenance + CC*

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	.	✓	.	.	.
• TPN-2	.	✓	.	.	.
• TPN-4	.	✓	.	.	.
• TPN-5	.	✓	.	.	.
• TPN-7	.	✓	.	.	.
• TPN-12	.	✓	.	.	.
• TPN-13	.	✓	.	.	.
• TPN-14	.	✓	.	.	.

*Manager : Chrystèle GONCALVES*

---

## Organization : understanding organizations

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	15				6

### Evaluation

One evaluation : *DS + étude de cas*

### Bibliography

- A. de Baynast, J. Lendrevie, J. Levy - Mercator ; tout le marketing à l'ère digitale ! (Dunod. Dernières éditions)
- F. Canard - Management de la qualité ; vers un management durable (Gualino LExtenso Editions)
- H. Mintzberg - Structure et dynamique des organisations (Éd. d'Organisation)
- M. Crozier - A quoi sert la sociologie des organisations ? (Éd. Seli Arslan)
- S. Robbins, D. DeCenzo, M. Coulter - Management, l'essentiel des concepts et des pratiques (9ème édition) (Ed. Pearson)

### Learning outcomes

Learning outcomes	N	A	M	E	O
• CTI-07	✓	.	.	.	.
• TPN-4	✓	.	.	.	.
• TPN-5	✓	.	.	.	.

*Manager : Luc OILI*

---

## Person : Physical education and sport 1

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				2

### Evaluation

One evaluation : *CC*

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	✓	.	.	.	.
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-19	✓	.	.	.	.

*Manager : Jérôme BEZIER*

---

## Person : Physical education and sport 2

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				2

### Evaluation

One evaluation :  $DS + CC$

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-3	✓	.	.	.	.
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-19	✓	.	.	.	.

Manager : Jérôme BEZIER

---

## Person : interpersonal skills

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	7.5				7.5

### Evaluation

One evaluation :  $DS + CC$

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-5	✓	.	.	.	.
• TPN-6	✓	.	.	.	.
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-13	✓	.	.	.	.
• TPN-20	✓	.	.	.	.
• TPN-21	✓	.	.	.	.

*Manager : Anouk GREVIN*

---

## Person : my relation to others

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	12.5				6

### Evaluation

One evaluation :  $DS + CR$

### Bibliography

Ces contenus empruntent beaucoup de notions de base à des approches comme l'analyse transactionnelle (AT), la communication non-violente (CNV), le life coaching, la programmation neuro-linguistique (PNL).

Pour aller plus loin, on pourra consulter avec profit :

- DE LASSUS René, L'analyse transactionnelle : une méthode révolutionnaire pour bien se connaître et mieux communiquer, Marabout (Savoir pratique n3516), 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 n3568), 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
- [www.16personalities.com](http://www.16personalities.com)
- [www.acnv.com](http://www.acnv.com)

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-7	✓	.	.	.	.
• TPN-12	✓	.	.	.	.
• TPN-13	✓	.	.	.	.
• TPN-19	✓	.	.	.	.
• TPN-20	✓	.	.	.	.
• TPN-21	✓	.	.	.	.

Manager : Maud BEAUTRAIS SATTLER



---

# Physical metallurgy

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	24				10

## Evaluation

2 evaluations :

- *DS sur table*
- *DS partie numérique*

## Outline

Introduction

Dislocations (dislocation theory, slide plane and directions, Frank-Read source, Schmid factor)

Hardening mechanisms (strain hardening, solid solution hardening, precipitation hardening, grain size hardening)

Punctual defects (voids, self-interstitials, thermal activation)

Restoration and recrystallization (cold-work, restauration, recrystallization, grain coarsening)

Grain boundaries (Classification, nucleation, embitterment)

Diffusion (origin of diffusion coefficient in metals, Kirkendall effect)

Diffusion-plasticity interactions (PLC effect, dynamic recrystallization)

## Goals

To understand phenomena occuring during thermal treatments, cold or hot forming in metallic alloys.

Know dislocation theory, hardening mechanisms, diffusion at microscopic scale, restauration and recrystallization.

To be able to address the problems of deformation in metals and thermomechanical treatments, considered at the microstructure scale and at the atomic scale. This lecture comes after the General Metallurgy lecture given in the 3rd year.

## 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. Cengage Learning. 2009.

## Prerequisites

structure of matter; crystallography; stress; strain; microstructure of materials; basics of statistical thermodynamics; potential barrier; concentration; chemical potential; mathematics of 1st year level

## Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main types of defect in crystalline materials : vacancies, dislocations, substitutional 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 occurring in a metallic alloy during thermal treatments, cold or hot working	•	•	✓	•	•

*Manager : Emmanuel BERTRAND*

---

## Physics (upgrade-refresher training)

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	12				

### 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 theorem)

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 (electricity, optics, electronics) in order to homogenize the knowledges of students coming 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 chemistry of polymers

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	16.5				20

## Evaluation

2 evaluations :

- *DS*
- *DM*

## Outline

### 1. MACROMOLECULAR CHEMISTRY

chain polymerisation, Copolymerisations; Step-growth polymerisation

### 2. PHYSICO-CHEMISTRY OF POLYMERS IN SOLUTION

Configuration and chain conformation, molar mass distribution ; Experimental characterisation techniques

### 3. CONDENSED STATE PHYSICS OF POLYMERS

Amorphous polymers, semicrystalline polymers, rubbery state; Mechanical properties in the solid state.

## 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

## Prerequisites

Basic knowledge of organic chemistry

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Describe the synthesis routes of polymers	✓	.	.	.	.
• Know the characterisation 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	✓	.	.	.	.

Manager : Guy LOUARN

---

## Physics and materials - laboratory

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		20			6.5

### Evaluation

One evaluation : *CR*

### 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 teach the basis of measurement methods in physics : measure of light power, measure of optical index, use of heat sensors, characterisation of birefringence materials.

### Bibliography

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 Hill 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	Asst
6.25	13.5				13

## 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 polycrystalline 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 ; to be able to choose a process for a given part	·	✓	·	·	·

*Manager : Franck TANCRET*



---

# Polymeric materials - laboratory project

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
			17.5		8

## Evaluation

2 evaluations :

- *Rapport*
- *SO*

## Outline

- 1) Thermomechanical properties of thermoplastics
  - Elaboration and creep behaviour of the pressure sensitive adhesive
  - Rheological study of complex fluids
  - Tensile tests - Role of the temperature - Relaxation test
  - Charpy (impact) test - Role of the temperature
  - Reverse engineering: thermoforming
- 2) Elaboration and characterization of an epoxy-glass composite material
  - Monitoring the curing reaction by scanning differential calorimetry
  - Monitoring the curing reaction by infra-red spectroscopy
  - Fabrication of the epoxy-glass composite
  - Thermal analysis
  - Flexion test

## Goals

The objectives are to know characterizing the rheological and mechanical properties of polymer materials, looking at the influence of their composition and external factors (time, temperature). The objectives are also to be able to process manually an epoxy-glass fiber composite material, knowing monitoring its curing reaction and designing its curing cycle.

## Prerequisites

An introduction to polymers and composite materials

## 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 rheological properties of a complex (non-newtonian) fluid	.	.	✓	.	.
• To know characterizing the thermomechanical properties of polymer and polymer-based composite materials	.	.	✓	.	.
• To know characterizing the adhesion properties of pressure-sensitive adhesives	.	.	✓	.	.

*Manager : Bernard LESTRIEZ*

---

## Practical training

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		40			

### Evaluation

One evaluation : *CC*

### 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*

---

## Probabilities and statistics

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				15

### Evaluation

2 evaluations :

- *DS*
- *DM*

### Outline

Introduction: probability and statistics for engineers

Single variable descriptive statistics

Discrete probabilities: definitions, Bayes formula

Random variables, discrete distributions, continuous distributions

Inferential statistics: estimates, confidence intervals

Inferential statistics: statistical tests, chi-2 test, parametric tests

Linear regression: simple regression, multiple regression

Multivariable statistics: principal component analysis, factorial analysis

### Bibliography

A. Mansour: Probabilités et statistiques pour les ingénieurs, Hermes, Lavoisier, 2007

G. Saporta: Probabilités, analyse de données et statistiques, Technip, Eyrolles, 2006

G. Demengel; Probabilités, statistique inférentielle, fiabilité, outils pour les ingénieurs, Ellipses, 1997

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To be able to use simple statistical tools to describe and analyze data	.	.	✓	.	.
• To give estimates and confidence intervals	.	.	✓	.	.
• To perform simple statistical tests of adjustments and parametric tests	.	✓	.	.	.
• To implement multivariable analysis (PCA, FAC) and extracting the information	✓	.	.	.	.
• To use probability and statistical tools to solve a problem of engineering	.	✓	.	.	.

Manager : Guy LOUARN

---

## Professional English 3

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19	2			

### Evaluation

3 evaluations :

- *CC*
- *Tutorat*
- *DS*

---

## Professional Project 2 : professional project presentation

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
			13.5		2.5

### Evaluation

One evaluation : *Contrôle continu*

### Outline

Path : 4 sessions of 3h TD

1 / Portfolio "Exploration Project Professional" : my "professionnel journey" those last years - changes - choices - motivations...

2 / My professional project : what I intended, the way to go, anticipate steps (especially the choice of option at the end of the fourth year)

3 and 4 / I introduce myself, my skills, my project : simulations and role plays

### Goals

Clarify the professional project and be able to present it orally in different circumstances (professional network meetings, hiring individual or collective interview , student lounge, video resume, ..)

### Bibliography

"Le Carnet de Route universitaire et professionnel" - SUIO de l'Université de Nantes - 2008

### Prerequisites

Professional project 1 (S5)

Discovery of firms and professions (S6)

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Formalize and build their own professional project	.	.	✓	.	.
• Present themselves professionally : introduction, skills, project	.	✓	.	.	.
• Updated Resume	.	✓	.	.	.

*Manager : Maud BEAUTRAIS SATTLER*

---

## Professional project 3 : skills passport

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
			12		3

### Evaluation

One evaluation : *Examen*

### Outline

1 / Day skills (7.5 h TD)

Course within six thematic workshops (12 to 15 students maximum) in connection with the assessment of skills and seeking their first job.

Production of a paper on key competencies.

2 / Job interview simulation platform (3h TD)

Job Interviews for the last training (speed dating) with business partners Polytech'Nantes

### Goals

Achieve an end-of course student appraisal to help the student:

- To find an internship study linked with his professional project
- To stand in front of a future recruiter with realism about his skills.

### Bibliography

"Le Carnet de Route universitaire et professionnel" - SUIO de l'Université de Nantes - 2008

### Prerequisites

Professionnal Project 2 : Professional project presentation

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Produce a skill assessment	·	✓	·	·	·
• Present themselves professionally: introduction, skills, project	·	·	✓	·	·

*Manager : Maud BEAUTRAIS SATTLER*

---

# Project

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
			150		100

## Evaluation

One evaluation : *Rapports + so*

## Outline

From September to January, students conduct a mentored advanced project. To this end, they can use all equipment available in the department of materials science and engineering. Projects are funded by private companies, and they have to be aligned with the corporate strategic plan. Students have to organize working meetings, to present the final results to the project's leadership, and to complete a post-project review report.

## Goals

Students will actively engage in funded research projects. They will have to demonstrate initiative in shaping the project at each stage.

## Bibliography

Pas de bibliographie

## Prerequisites

All 3rd and 4th year courses

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Using scientific and technical skills to fix a technological problem.	•	•	•	✓	•
• Defining and analyzing the needs associated with a particular industrial problem.	•	•	✓	•	•
• Designing novel materials or process	•	•	✓	•	•
• Shaping and conducting a project. Conducting workshops and presenting results	•	•	•	✓	•
• Organizing a project schedule and a work plan.	•	•	✓	•	•

*Manager : Stéphane CUENOT*

---

## Project - case study - meeting management

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
2.5	2		69.5		38

### Evaluation

One evaluation : *CC*

### Outline

Shipbuilding case studies  
Offshore construction case studies  
Energy case studies

### Goals

Here it is a question of having examples in the form of case studies of practical applications related to welded fabrication. Interventions are given by industrialists in the sector.

### 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	.	.	✓	.	.

*Manager : Pascal PAILLARD*



---

## Project management

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		14			

### Evaluation

One evaluation : *CC*

*Manager : Stéphane CUENOT*

---

# Project management

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
	10.5				10.5

## Evaluation

One evaluation : *Examen*

## Outline

1 / Introduction:

Project Definition - Project Management - Specifications of a project - Project Types

2 / Stakeholders:

Instances of project, categories of actors, roles and borders - gouvernance project - the project leader missions

3 / The project life cycle

The phasing of the project and its steps (the emergence - set up - implementation - evaluation )

For each phase: objectives, operations, deliverables, tools

4 / Methods and tools of project management (with exercises)

Block diagram, work and responsibilities - Project Planning and Resource Management - Project Dashboard - Risk Management (FMEA)

5 / Communication and changes management (Basic)

Communication Plan - Impact analysis and changes management sheet

## Goals

Provide basic knowledge of project management allowing students to understand the different types of projects, stakeholders and bodies, project methodology (phasing, decisions, methods and tools) in order to prepare them to take responsibility in a simple project or to contribute to the creation of a more complex project (internship and / or transversal project and / or student project)

## Bibliography

Le dictionnaire de management de projet - AFITEP (5e édition), AFNOR ,Paris, impr 2010

La conduite de projet, Hugues Marchat, Editions d'Organisation, Paris, juillet 2008

Le Kit du Chef de projet, Hugues Marchat, Livres outils - Editions d'organisation, Paris, 2010

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Know and apply the methods and tools of traditional project management, understand their context of use, their advantages and limitations	.	✓	.	.	.
• Plan a mission according to project method : distinguish purpose / objectives / means, plan action, anticipate major risks, evaluate the outputs.	.	✓	.	.	.
• Identify stakeholders in a project and understand their respective roles towards the project.	.	✓	.	.	.
• Pilot a project = know the responsibilities of a project leader	✓	.	.	.	.

*Manager : John KINGSTON*

---

## Quality approach and problem solving

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	10.5				10.5

### Evaluation

One evaluation : *Contrôle continu*

### Outline

1 / Origins and forms of quality management:

Product quality - Quality system - quality project - management systems - ISO 9001 - process approach - opening trades on standards

2 / Principles of organization based on the process approach:

Typology of processes - Mapping - Organizational Interfaces

3 / approach and tools useful to the engineer:

QQQQCP - 5M - Flowchart - Methods of analysis and problem solving

4 / What is he an engineer involved in a quality approach?

Decollaboration direct objects with a quality manager - topics that relate directly to the engineer

### Goals

- Open to students issues, forms and tools of quality management
  - Know the "commun" tools quality approach
  - Encourage collaboration among future engineers and quality managers who hire enterprises

### Bibliography

"Maîtriser les processus de l'entreprise - Guide opérationnel" - Michel CATTAN, Nathalie IDRISSE, Patrick KNOCKAERT, 3 édition, Editions d'Organisation

"Méthodes et outils pour résoudre un problème" 45 outils pour améliorer la performance de votre organisation - Alain-Michel CHAUVET, 3 édition, DUNOD

### Prerequisites

- Discover the world of entreprise through an internship and / or project
  - Ability to project in the engineering profession  
(see Module Discovery trades and entreprise 3rd year)

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Understand the organization of a company in a point of view "process"	✓	·	·	·	·
• Handle "commun" tools quality through analysis and problem solving	·	✓	·	·	·
• Know the principles of continuous improvement	✓	·	·	·	·

Manager : Cédric LAIR

---

# R&D Project management

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
12					

## Evaluation

One evaluation : *Projet+exposés*

## Outline

Introduction to innovation projects. Possible fundings. Industrial property protection strategies. How to effectively plan and execute a project ? Risk analysis. Communication in project management.

## Goals

This course is designed to provide a broad introduction to project management and to intellectual property.

## Bibliography

Manager par projets. [ Valentine CHAPUS-GILBERT NATHAN / Les échos.fr]

L'Auto qui n'existait pas - Management des projets et transformation de l'entreprise. [ Christophe MIDLER DUNOD]

La méthode APTE (Analyse fonctionnelle). [ Bertrand DE LA BRETESCHE PETRELLE]

Pratique de l'AMDEC. [ Jean FAUCHER DUNOD / L'usine Nouvelle]

## Prerequisites

Pre-professional work experience (internship)

## Learning outcomes

Learning outcomes	N	A	M	E	O
• Knowing about industrial property protection strategies and about the principal funding opportunities for research and innovation in France and in EU.	✓	·	·	·	·
• Conducting a simple needs assessment	·	✓	·	·	·
• Planning and organizing a simple project	·	✓	·	·	·
• Understanding the role of a project leader and anticipating project risks	✓	·	·	·	·

*Manager : Emmanuel CHENE*

---

## R&D economy

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
1.5	6				

### Evaluation

One evaluation : *Etude de cas*

### Outline

CHAPTER 1 : Innovation: engine of the economic growth

CHAPTER 2 : The modes of evaluation and financing of the innovation

### Goals

Understand the relations and interaction between economy and innovation

### Bibliography

GUELLEC D, "Economie de l'innovation", Repères La Découverte

LACHMANN J., "le finacement des stratégies de l'innovation", Paris, Economica

BETBEZE J.P (2005), "Financer la R&D", Conseil d'analyse économique

### Prerequisites

The basic concepts in economy

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Know the links between economy and innovation	✓	·	·	·	·
• Know the economic problems of the economy of the innovation following countries and periods	·	✓	·	·	·

*Manager : Emmanuel CHENE*

---

# Radiocrystallography

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
10	12				8

## Evaluation

2 evaluations :

- *CC*
- *DS*

## 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.

## 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 conditions	.	.	✓	.	.
• To be able to give the diffraction conditions in the direct and reciprocal spaces	.	.	✓	.	.

*Manager : Olivier JOUBERT*

---

# Rheology and thermomechanics of polymers

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
13.75	10.5				12

## Evaluation

One evaluation : *DS*

## Outline

A - Viscoelasticity

- Creep-Recovery and relaxation tests
- Maxwell and Kelvin-Voigt models
- Dynamic mechanical measurements

B - Rheology of complex fluid : typical behaviours

C - Polymers rheology

- Time - Temperature Superposition (WLF law)
- Thermomechanical behaviour of polymer in the solid state
  - o Mechanical spectroscopy (structure-property relationships)
  - o Determination of long-term mechanical properties (cycle life)
  - o Determination of short-term properties (quality check)
- Thermomechanical behaviour of polymers in the liquid state

## Goals

It is an introduction to the rheological behaviours of 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).

## Prerequisites

An introduction to polymers

## 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	•	✓	•	•	•

*Manager : Bernard LESTRIEZ*



---

## Safety Health at Work

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	10.5				5

### Evaluation

One evaluation : *Contrôle continu*

### Outline

General information on occupational risks (defined AT / MP / risks / hazards, pricing, direct and indirect costs, statistics, internal and external actors)

Regulatory framework Law 1991 - prevention principles, guidelines, laws, decrees,

Penal and civil responsibility: roles and responsibilities of an engineer in the prevention of occupational risks, delegation of power

Different hazards and their sources in company

Evaluation of occupational hazards applied to a work situation, risks document

Definition and implementation of preventive and / or corrective actions

Work accident : mechanisms, analysis

### Bibliography

[www.inrs.fr](http://www.inrs.fr)

sites des carsat

[www.legifrance.gouv.fr](http://www.legifrance.gouv.fr)

code permanent hygiène et sécurité

<http://www.travailler-mieux.gouv.fr/>

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Know their rights and obligations under the internship and future employment	·	✓	·	·	·
• Identify the risks of infringement with the health on a workstation and propose adapted prevention measures	·	✓	·	·	·
• Know the regulations relative to the hygiene and the safety at work	✓	·	·	·	·
• Prepare the student to think of an issue of health and safety at work to apprehend in its future projects	·	✓	·	·	·

Manager : Cédric LAIR

---

## Second foreign language - Chinese

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - Chinese

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - German

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - German

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - Japanese

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - Japanese

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Second foreign language - Spanish

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*



---

## Second foreign language - Spanish

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Semiconducting materials and devices

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
13.75	4.5	16			16

### Evaluation

2 evaluations :

- *DS*
- *TP*

*Manager : Pierre-Yves TESSIER*

---

## Sensors, instrumentation and measurements

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
12.5	12				13

### 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
<ul style="list-style-type: none"> <li>• 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</li> </ul>	•	✓	•	•	•
<ul style="list-style-type: none"> <li>• Know the basic principles leading to a specific function of transduction in a sensor related to material properties and/or to geometrical effects.</li> </ul>	•	✓	•	•	•
<ul style="list-style-type: none"> <li>• 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.</li> </ul>	•	•	✓	•	•
<ul style="list-style-type: none"> <li>• Know the basic features about operational amplifier used for processing and the control of the analog signals (amplifier, comparator, trigger, converter).</li> </ul>	•	•	✓	•	•
<ul style="list-style-type: none"> <li>• 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.</li> </ul>	•	•	✓	•	•

*Manager : Pierre-Yves TESSIER*

---

## Shaping of composite materials

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
22	13.5	16			

### Evaluation

3 evaluations :

- *CR1*
- *CR2*
- *TP*

### 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
• -	.	✓	.	.	.
• -	.	.	✓	.	.
• -	.	.	✓	.	.
• -	.	✓	.	.	.

*Manager : Vincent SOBOTKA*

---

## Society : Socio-economic debating

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	12				12

### Evaluation

One evaluation : *DS + exposé débat*

### Bibliography

- BRAQUET Laurent et MOUREY David, Comprendre les fondamentaux de l'économie, De Boeck, 2015, 475 p., ISBN 978-2-8041-9021-7
- BIASUTTI Jean-Pierre et BRAQUET Laurent, Les débats économiques d'aujourd'hui, Ellipses, 2019, 278p, ISBN 9782340-031210
- DESCAMPS Christian, L'analyse économique en questions, Vuibert, 2005, ISBN 2-71117-7413-9
- SINAÏ Agnès, Penser la décroissance, Sciences Po Les presses, 2018, 210 p, ISBN 9782724613001
- SINAÏ Agnès, Economie de l'après-croissance, Sciences Po Les presses, 2018, ISBN 9782724617559
- PIKETTY Thomas, Capital et idéologie, Seuil, 2019, ISBN 978-2-02-133804-1
- COHEN Daniel, Le monde est clos et le désir infini, Albin Michel, 2015, ISBN 978-2226240293

### Learning outcomes

Learning outcomes	N	A	M	E	O
• TPN-1	.	✓	.	.	.
• TPN-2	.	✓	.	.	.
• TPN-3	.	✓	.	.	.
• TPN-8	✓	.	.	.	.
• TPN-9	✓	.	.	.	.
• TPN-10	.	✓	.	.	.
• TPN-11	✓	.	.	.	.

Manager : Chrystèle GONCALVES

---

## Society : history of organizations and epistemology

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	15				3

### Evaluation

One evaluation : *DS + CR*

### Bibliography

- Henry Mintzberg, 1982, Structure et dynamique des organisations (Éd. D'Organisation)
  - Jean-Charles Asselain, 2007, Histoire des entreprises et approches globales. Quelles convergences ? Dans Revue économique 2007/1 (Vol. 58), pages 153 à 172
  - Thomas Piketty, 2013, Le Capital au XXIe siècle, Le Seuil, coll. « Les Livres du nouveau monde », 5 septembre 2013, 976 p.
  - Marlyse Pouchol, 2006, La pensée de l'économie chez Galbraith, Innovations, (n23), pp 9 à 30.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• CTI-07	✓	.	.	.	.
• TPN-5	✓	.	.	.	.
• CTI-10	✓	.	.	.	.
• TPN-10	✓	.	.	.	.

*Manager : Marc BIDAN*

---

## Sociology of innovation

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
4.5					4.5

### Evaluation

One evaluation : *CR écrit*

### Outline

Innovation (organization, development, industrial property, project's driving (steering)).

### Goals

Global definition "Innovation". Acquire knowledges : the innovation global process. Create a project (non-existent product) (team)

### Bibliography

Créativité et Innovation Tayeb Louafa et Francis-Luc Perret (éditions presse polytechniques et universitaires romandes).

La boîte à outils de l'innovation de Géraldine Benoit-Vervantes (éditions Dunod).

### Prerequisites

None

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Being able to organise and lead an innovation global process	✓	·	·	·	·

*Manager : Dominique PECAUD*



---

# Solid state chemistry I

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
8.75	9				11

## Evaluation

2 evaluations :

- *CC*
- *DS*

## Outline

Chapter I - Atoms A: Chemical elements - Periodic Table

B: Orbitals

C: Interactions - Chemical bond a: electronegativity, b: oxidation state, c: Different types of chemical bond

Chapter II - Coordination chemistry

A- Structural description, ligands and coordination

B - Molecular orbital theory : octahedral complexes, s interactions, p interactions

C - Crystal field theory - 1: Crystal field splitting 2 - 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 diagrams 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, Keiter et Keiter - 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 diagram in coordination chemistry	•	•	✓	•	•

*Manager : Olivier JOUBERT*

---

# Solid state physics

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
25	13.5				18

## Evaluation

2 evaluations :

- *CC (quizz+DM)*
- *Examen final*

## Presentation

This EC aims to give the future engineer the keys to understand, model and evaluate the physical properties of functional materials according to the environment, excluding mechanical properties. Emphasis is placed on the link between the microscopic / crystalline structure and the physical properties (electronic, thermal, magnetic, optical). Some applications associated with these properties are described but the technological systems are not treated.

## Outline

Introduction

- The classical free electron gas: Drude's model- metals
- The quantum free electrons: the Drude Sommerfeld model- metals
- The quasi free electrons- conductors and insulators
- Phonons and thermal properties
- Electronic transport properties of solids
- Magnetic properties of solids
- Elements on magnetic spectroscopies

## Goals

At the end of this EC, 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
- ? Have some notions of magnetic spectroscopies

## 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*

---

Specializes lectures by professional lecturers

---

**Hours**

Lect	Tut	PW	Proj	WP	Asst
45					

**Evaluation**

One evaluation : *DS*

*Manager : Stéphane CUENOT*

---

## Sport 3

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				2

### Evaluation

One evaluation : *Contrôle continu*

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Capacité à prendre des initiatives, mise en action, adaptation à un contexte et/ou consigne (dans un contexte nouveau)	.	.	✓	.	.
• Favoriser l'équilibre physique et psychique des élèves	.	.	✓	.	.
• Etre capable de travailler en équipe, de communiquer et d'établir des relations de confiance et d'entraide	.	✓	.	.	.
• Résister au stress et évacuer les tensions liées aux études	.	.	✓	.	.

Manager : Jérôme BEZIER

---

## Sport 4

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	19.5				2

### Evaluation

One evaluation : *Contrôle continu*

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Capacité à prendre des initiatives, mise en action, adaptation à un contexte et/ou consigne (dans un contexte nouveau)	.	.	✓	.	.
• Favoriser l'équilibre physique et psychique des élèves	.	.	✓	.	.
• Etre capable de travailler en équipe, de communiquer et d'établir des relations de confiance et d'entraide	.	✓	.	.	.
• Résister au stress et évacuer les tensions liées aux études	.	.	✓	.	.

Manager : Jérôme BEZIER

---

## Surface Analysis

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
8.75	1.5				4

### Evaluation

One evaluation : *DS*

### Outline

- 1) Introduction on the need for specific techniques of surface characterization from examples in the field of physics and the chemistry of materials
- 2) Electron Spectroscopy - XPS / ESCA, AES
- 3) Rutherford Backscattering Spectrometry - RBS
- 4) Secondary Ions Mass Spectrometry - SIMS
- 5) Comparison of techniques - Strategies of analysis approach

### Goals

Overview of surface analysis techniques, their principles and their main characteristics and specifications. Know how to choose a surface analysis technique based on a specific problem.

### Bibliography

Analyse structurale et chimique des matériaux - J.P. Eberhart (Dunod) ; Surfaces, interfaces et films minces - B. Agius, M. Froment et co-auteurs (Dunod) ; Semiconductor material and device characterization - Dieter K. Schroder (John Wiley and Sons)

### Prerequisites

General knowledge of the different categories of materials: glasses, ceramic, polymers, metals, semiconductors. Electron orbital in atoms. Solid-state physics and chemistry.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• Be able to choose a technique of surface analysis of a material according to a specific problem	·	✓	·	·	·
• Be able to interpret spectra of XPS, AES, RBS, SIMS analysis	·	✓	·	·	·

*Manager : Pierre-Yves TESSIER*

---

# Symmetry

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
15	13.5				22

## Evaluation

2 evaluations :

- *CC*
- *DS*

## Outline

- I INTRODUCTION -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	Asst
	13.5				25

## 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	Asst
	12				25

### 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 treatments

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
12	0.5				22

### Evaluation

One evaluation : *SO*

### Goals

To know thermal, mechanical or thermomechanical treatments employed in industry to modify properties of metallic parts and understand how these treatments modify microstructures and properties of metallic alloys.

### Learning outcomes

Learning outcomes	N	A	M	E	O
• To know the main thermal treatments employed on metals and their consequences	·	·	✓	·	·
• To understand the consequences of thermal treatments on microstructures of metals	·	·	·	✓	·

*Manager : Laurent COUTURIER*

---

# Thermophysical properties of polymers and composites

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
15	1.5				5

## Evaluation

One evaluation : *DS*

## Bibliography

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

## Learning outcomes

Learning outcomes	N	A	M	E	O
• -	·	·	✓	·	·
• -	·	·	✓	·	·
• -	·	·	✓	·	·

*Manager : Vincent SOBOTKA*

---

# Thin film materials

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
10	6				7

## 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 : Pierre-Yves TESSIER

---

## Training for Toeic

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Training for Toeic

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	18				

### Evaluation

One evaluation : *CC*

---

## Weld analysis

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
		10			

### Evaluation

One evaluation : *CC*

### 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	Asst
17.5	1.5				9.5

### 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 Physical 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 (foundry and welding) on metallic materials	·	·	✓	·	·

Manager : Pascal PAILLARD

---

# Welding metallurgy

---

## Hours

Lect	Tut	PW	Proj	WP	Asst
49.25	2				25.5

## Evaluation

2 evaluations :

- *CC*
- *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 Metallurgy en 3rd and 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	Asst
64	2				31.5

### Evaluation

2 evaluations :

- *CC*
- *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*

---

## Work analysis

---

### Hours

Lect	Tut	PW	Proj	WP	Asst
	12				4

### Evaluation

One evaluation : *Contrôle continu*

### Bibliography

Cf liste des ressources mises à disposition des étudiants pour répondre aux questions, entre autre :

- J'ai très mal au travail - Christophe Desjours - Octobre 2011 (Interviews Youtube)
- Management Humain, Taskin L. et Dietrich A., De Boeck Supérieur, 2016
- L'évaluation du travail à l'épreuve du réel : critique des fondements de l'évaluation, 1995
- L'acteur et le système, Michel Crozier, Erhard Friedberg, Points (dernière édition 2014)

### Learning outcomes

	N	A	M	E	O
• 1	.	✓	.	.	.
• 2	.	✓	.	.	.

*Manager : Anouk GREVIN*