ÉCOLE NATIONALE D'AÉROTECHNIQUE

UNE ÉCOLE AFFILIÉE AU CÉGEP ÉDOUARD-MONTPETIT

280-2C5-EM

Winter 2023

Département de Techniques de génie aérospatial

COURSE OUTLINE

COURSE : **Strength of Materials Used in the Aircraft Industry**

PROGRAM : 280.C0 Aircraft Maintenance

DISCIPLINE : 280 Aeronautics

WEIGHTING : *Theory :* 3 *Practical Work :* 2 *Personal Study :* 2

Teacher	**Office**	**☎ Ext.**	**✉ Email**
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Office Hours

	MONDAY	**TUESDAY**	**WEDNESDAY**	**THURSDAY**	**FRIDAY**
Morning					
Afternoon					
Evening					

Coordinators	**Office**	**☎ Ext.**	**✉ Email**
Dominique Gonthier	A-183	4671	dominique.gonthier@cegepmontpetit.ca
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1 CONTEXT OF THIS COURSE IN THE PROGRAM

This course is offered during the second session of the program. By the end of the course, students will have developed the ability to:

- Recognize materials and the manufacturing processes of aircraft components as well as their heat treatment and anticorrosion methods.
- Interpret the results obtained from different mechanical tests and establish the mechanical properties of materials.

This course is a co-requisite with 280-2B5-EM. Students must keep this course outline for the duration of their studies as it will be useful for the comprehensive assessment at the end of the program.

Transport Canada: This course outline meets the requirements of Training Organisation Certification Manual (MCF) of Transport Canada. The Department applies Transport Canada standard which allows a maximum absence of 5% for the course (theory and laboratory). The department compiles absences of all students enrolled in Aircraft Maintenance (280.C0) and Avionics (280.D0) according to Transport Canada requirements. The application of Transport Canada policies regarding absences is available on the college website and in the student agenda under the heading « Privilèges accordés par Transports Canada ».

2 COMPETENCE OF PORTRAIT OF GRADUATE

To master the scientific bases and those of the work function.

3 MINISTERIAL OBJECTIVE(S) AND COMPETENCIES

025W	To perform activities related to the strength of materials used in the aircraft industry.

4 FINAL COURSE OBJECTIVE

To perform activities related to the resistance of materials used in aerospace.

5 TEACHING AND LEARNING STRATEGIES

Theory

Teaching Methods:

- Discussions and questions.
- Formal lecture.

Learning Activities:

- Exercises.
- Work based on self study.

Practical Work

Teaching Methods:

- Short presentations of the theoretical concepts.
- Demonstrations.

Learning Activities:

- Demonstration on heat treatment and mechanical tests.
- Demonstration on different forming and fabrication processes.
- Welding exercises.
- Practical work.

Students can enhance their understanding of the material with reference books available at the library as well as specific websites.

6 COURSE PLAN - THEORY

LEARNING OBJECTIVES

1. To identify the main materials used in aircraft construction
2. To describe the characteristics of the main materials used in aircraft construction
3. To describe the influence of treatment on the performance of aircraft components
4. To describe the main types of heat treatment for aluminum and steel
5. To describe the influence of the manufacturing processes on the characteristics of aircraft components.
6. To describe the main types of corrosion and appropriate ways to prevent it.
7. Distinction between force, couple and moment
8. To determine the centroid and the centre of gravity of mechanical parts
9. To explain the equilibrium of simple mechanical parts and aircraft components
10. To calculate the stress and/or strain that is applied to aircraft components
11. Calculation of the moment of inertia of simple and composite surfaces

WEEK	LEARNING OBJECTIVE	CONTENT	LEARNING MODE	DOCUMENTS
1	1	1.1 Physical identification by standards: steel, aluminum alloys, copper alloys, ceramics, polymers, nickel and cobalt superalloys, wood, composite materials.	- Lecture course. - Exercices.	Study : Module 1 and reference books.
2 and 3	2	2.1 Physical, chemical and mechanical properties. 2.2 Interpretation of tables and diagrams. 2.3 Tensile, hardness, impact and shear tests. 2.4 Standardization. 2.5 Health and Safety.	- Lecture course. - Exercices.	Study : Module 1 and reference books.
4	3	3.1 Structural hardening, stress-relief annealing, recrystallization annealing, etc. 3.2 Datasheets, technical documentation. 3.3 Designation of aluminum alloys. 3.4 Improvement of mechanical strength and ductility. 3.5 Residual stress, deformation, oxidation.	- Lecture course. - Exercices.	Study : Module 2 and reference books.
5	4	4.1 Tempering, cooling, stress-relieving annealing, carburizing, etc. 4.2 Datasheets, technical documentation. 4.3 Designation of steels. 4.4 Improvement of mechanical strength and ductility. 4.5 Residual stress, deformation, oxidation.	- Lecture course. - Exercices.	Study : Module 3 and reference books.

6	5	5.1 Welding, forging, chemical milling, etc. 5.2 Deformations and residual stresses of components. 5.3 Chemical, physical and mechanical alterations of materials. 5.4 Mechanical abuse (scratches, nicks, etc.), heat abuse, machining abuse.	- Lecture course. - Exercices.	Study : Module 4 and reference books.
6	6	6.1 General corrosion, pitting, from high temperatures, etc. 6.2 Anodising, painting, metal coating, etc.	- Lecture course. - Exercices.	Study : Module 3 and reference books.

WEEK 7 : MIDTERM EXAM

WEEK	LEARNING OBJECTIVE	CONTENT	LEARNING MODE	DOCUMENTS
7 and 8	7	7.1 Forces and vectors : definitions and characteristics. 7.2 Resultant force. 7.3 Moment of a force. 7.4 Couple. 7.5 Pulleys.	- Lecture course. - Exercices.	Study : Module 5 and reference books.
9	8	8.1 Difference between the centroid and the centre of gravity. 8.2 Location of the centroid and centre of gravity.	- Lecture course. - Exercices.	Study : Module 5 and reference books.
10 and 11	9	9.1 Equilibrium and Free Body Diagram (FBD) applied to a component. 9.2 Calculation of torque forces applied on simple mechanical parts and aircraft components.	- Lecture course. - Exercices.	Study : Module 5 and reference books.
11 and 12 12 to 14	10	10.1 Simple stresses on components (beams, shafts, riveted joints, bolted joints, bonded joints): tension, compression and shear. 10.2 Deformation. 10.3 Safety factor. 10.4 Moment of inertia. 10.5 Shear stress due to shaft torsion. 10.6 Diagram of shear effort and bending moment. 10.7 Bending stress due to bending of beams. 10.8 Deflection of a beam.	- Lecture course. - Exercices.	Study : Module 5 and reference books.

WEEK 15 : FINAL EXAM

6 COURSE PLAN – PRACTICAL WORK

LEARNING OBJECTIVES

1. To compare the mechanical properties of the main materials used in aerospace.
2. To describe the effect of manufacturing processes and maintenance work on aerospace components.
3. To describe the main types of heat treatment for aluminum alloys and to understand their influence on the mechanical properties of these metals.
4. To describe the anticorrosion treatments that are used in aerospace : Alodine, anodizing and cadmium plating.
5. Distinction between force, moment and couple.
6. Centroid of a surface; center of gravity of a body.
7. Equilibrium and free-body diagram applied to aerospace components.
8. Stress and deformation of aerospace components.

WEEK	LEARNING OBJECTIVE	CONTENT	LEARNING MODE	DOCUMENTS
1 and 3	1	Demonstration : Hardness test, Charpy test, Tensile test. Analysis of the results. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 1 and reference books.
2 and 4	2	Welding joints using the GTAW (TIG) process. Weld defects. Microstructure of a welded joint. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 4 and reference books.
5	3	Demonstration : Heat treatment on steel and aluminum specimens. Analysis of the results. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Modules 2 and 3 and reference books.
6	2	Stick Welding. Identification of materials. Forming processes : rolling, forging, etc. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 4 and reference books.
7	4	Anodizing, alodine, cadmium plating. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 3 and reference books.
8	2	TIG welding (GTAW). Plasma cutting. Oxycut (oxyacetylen torch). Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 4 and reference books.

WEEK	LEARNING OBJECTIVE	CONTENT	LEARNING MODE	DOCUMENTS
9	5	Demonstration on the concept of forces, moments and couples.	- Practical work. - Lecture course. - Exercices.	Study : Module 5 and reference books.
10	2	Spot welding, MIG welding, brazing. TIG welding. Health and safety .	- Practical work. - Lecture course. - Exercices.	Study : Module 4 and reference books.
11	6 and 7	Center of gravity of a body. Equilibrium and Free-body diagram.	- Practical work. - Lecture course. - Exercices.	Study : Module 5 and reference books.
12	2	Exam : TIG Welding Exam: Identification of materials.		
13	8	Demonstration on the behaviour of riveted, bonded and welded joints under tensile load. Health and safety.	- Practical work. - Lecture course. - Exercices.	Study : Module 6 and reference books.
14	8	Calculation of the stress that is applied to a component : tension, compression and shear. Moment of inertia of a surface.	- Practical work. - Lecture course. - Exercices.	Study : Module 5 and 6 reference books.
15	8	Stress in a beam under bending load.	- Practical work. - Lecture course. - Exercices.	Study : Module 5 and 6 reference books.

7 SYNTHESIS OF SUMMATIVE EVALUATION METHODS

THEORY

Description of evaluation activity	Context	Learning objective(s)	Evaluation criterias	Due date	Weighting
Assignment on the heat treatment of aluminum alloys.	Individual	3	1, 2,3, 4, 5, 6, 8 and 9	Week 6	2 %
Assignment on the heat treatment of steels.	Individual	4	1, 2,3, 4, 5,6 and 9	Week 7	2 %
Written exam on the characteristics of materials, manufacturing processes, corrosion and heat treatment.	Individual, in class, 2 hours	1 to 6	1, 2,3, 4, 6, 7, 8, 9,10 and 11	Week 7	20%
Assignment on forces and moments.	Individual	7	1, 2,3, 4, 5, 12, 13 et 14	Week 9	1 %
Assignment on the equilibrium of aerospace components.	Individual	9	1, 2,3, 4, 5, 6,12, 13, 14, 15,16, 17 and 19	Week 13	2%
Assignment on the allowable stress and deformation of aerospace components.	Individual	10	1, 2,3, 4, 5, 6,12, 13, 14, 15,16, 17 and 19	Week 14	1%

Description of evaluation activity	Context	Learning objective(s)	Evaluation criterias	Due date	Weighting
Assignment on the stresses induced by shear, bending and torsional loads.	Individual	10	1, 2,3, 4, 5, 6,12, 13, 14,15,16, 17, 18 and 19	Week 15	2%
Final exam.	Individual, in class, 3 hours	1 to 10	All of them, except 5	Week 15	30 %
				Sub-total :	**60%**

Evaluation Criteria

1- Clarity and precision of answers;
2- Appropriate justification of the answers;
3- Appropriate use of units;
4- Conformity of the technical terms;
5- Respect of the rules of presentation. For example, tables, charts, etc.
6- Proper application of physical, chemical and mechanical properties;
7- Precise calculation of the mechanical properties obtained by means of mechanical tests;
8- Fair description of the main heat treatments of aluminum alloys and their influence on the performance of aircraft components;
9- Appropriate description of the main heat treatments and the main surface treatments of steels and their influence on the performances of the components of aircraft;
10- Appropriate description of manufacturing processes and their influence on the performance of aircraft components;
11- Appropriate description of the influence of corrosion on the performance of aircraft components;
12- Precise calculation of the forces and their resultant;
13- Appropriate application of equilibrium equations;
14- Precise calculation of the moments;
15- Precise calculation of the center of gravity while indicating its exact position on the component;
16- Precise establishment of the FBD
17- Precise calculation of the reactions on the different components of any mechanism;
18- Precise calculation of the moment of inertia;
19- Correct calculation of the mechanical stresses due to the shearing force and the bending moment as well as the deformations which follow it.

PRACTICAL WORK

Mechanical tests, heat treatment and corrosion

Description of evaluation activity	Context	Learning objective(s)	Evaluation criterias	Due date	Weighting
▪ Hardness and Charpy tests.	▪ Demonstration on the standard method for hardness and charpy impact testing.	1	1, 2,3, 4, 5 and 6	Week 3	4%
▪ Tensile test	▪ Demonstration on the standard method for tensile testing.	1	1, 2,3, 4, 5 and 6	Week 5	4%
▪ Heat treatment of Aluminum alloys and steels.	▪ Demonstration on the quenching technique (furnace, hardening bath and test specimens).	1 and 3	1, 2, 3, 4, 5, 6, 7 and 8	Week 7	9%

Evaluation criteria

1- Appropriate justification of the answers;
2- Appropriate use of units;
3- Consistent application of technical terms;
4- Respect of the rules of presentation. For example, tables, charts, mediagraphy, etc.
5- Precise calculation of mechanical properties obtained by mechanical tests;
6- Appropriate analysis of the results;
7- Description of the main heat treatments of aluminum alloys and their influence on the performance of aircraft components;
8- Fair description of the main heat treatments and surface treatments of steels and their influence on the performance of aircraft components;

Welding and manufacturing process

Description of evaluation activity	Context	Learning objective(s)	Evaluation criterias	Due date	Weighting
Practical exam on the execution of a GTAW (TIG) joint welding.	Individual	2	4, 8 and 9	Week 12	10 %
Practical exam on the manufacturing processes and identification of materials.	Individual	2	2, 3,6, 10, and 11	Week 12	5%

Evaluation criteria

1- Appropriate use of units;
2- Consistent application of technical terms;
3- Respect of the rules of presentation. For example, tables, charts, mediagraphy, etc.
4- Judicious choice of parameters to avoid weld defects;
5- Proper description of the TIG welding procedure;
6- Proper execution of the weld to avoid welding defects;
7- Fair identification of materials according to their physical and mechanical properties;
8- Fair identification of manufacturing processes according to the function of the aircraft components;
9- Proper description of welding processes;
10- Relevant interpretation of welding parameters;
11- Clarity and precision of answers.

Forces and stresses

Description of evaluation activity	Context	Learning objective(s)	Evaluation criterias	Due date	Weighting
Lab session on forces, moments and couples.	Individual	5	1 to 6	Week 9	2%
Lab session on the centre of gravity and equilibrium of mechanical components.	Individual	6 and 7	1 to 10	Week 11	2%
Lab session on the simple stresses aerospace components are subjected to.	Individual	8	1, 2 ,3, 4,5, 6, 7, 8, 9, 10 and 11	Week 14	2%
Lab session on the moment of inertia of a surface, the bending moment and shearing strain and stress.	Individual	8	1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12	Week 15	2%

Sub-total : 40%

TOTAL : 100%

Evaluation criteria

1- Appropriate use of units;
2- Consistent application of technical terms;
3- Respect of the rules of presentation. For example, tables, charts, etc.
4- Proper calculation of the forces and their resultant
5- Accurate calculation of moments;
6- Results analysis;
7- Correct calculation of the center of gravity while indicating its exact position on the component;
8- Precise establishment of the FBD;
9- Proper application of equilibrium equations;
10- Proper calculation of the reactions on the different components of any mechanism;
11- Proper calculation of the moment of inertia;
12- Precise calculation of shear stresses;
13- Respect of the rules of presentation. For example, tables, charts, mediagraphy, etc.
14- Correct calculation of the mechanical stresses due to the shear and the bending moment as well as the deformations that follow

8 REQUIRED MATERIAL

- Coursepack 5628.
- Scientific calculator.
- Ruler.
- Graph paper.
- Protractor.
- Safety glasses and shoes.
- Lab coat (for labs) and standard coverall for welding labs (see in class).

9 MEDIAGRAPHY

1- Bouchy, Godin. *Métallurgie*, Armand Collin, Paris.
2- Dell K., Allen. *Metallurgy Theory and Practice*, American Technical Society.
3- E. Paul de Garno. *Materials and Processes in Manufacturing*, McMillan Co.
4- Frier. *Elementary Metallurgy*, McGraw-Hill.
5- Hilly & Chaisson. *Cours de métallurgie*, Dunod, Paris.
6- Lignon J. & M. Nijon. *Matériaux, propriétés, traitements normalisation*, Delagrave, Paris.
7- Sacks, Raymond J. & Edward R. Bohnart, *Welding Principles and Practices*, McGraw-Hill.
8- Meriam, J.L. *Engineering Mechanics : volume 1, Statics, Wiley*.
9- Côté, Michèle. *Résistance de matériaux CCDMD*, les éditions "Le Griffon d'argile".
10- Levinson, I.J. *Mechanics of Materials*, Prentice-Hall.

10 REQUIREMENTS FOR PASSING THE CLASS

1. Passing Mark

The student must get at least 60% IN BOTH Theory and Lab to pass the class;

Failing to meet these requirements, the student obtains, in his bulletin, the lowest note recorded: that of the theoretical evaluation or that of the practical evaluation of the class.

2. Attendance for Summative Evaluations

Students must be present for summative evaluations and must comply with the instructions given by the instructor to carry out the evaluation activity. Missing an evaluation without a good reason could result in the exclusion from the activity. Any absence at a summative evaluation that is not due to serious reasons (illness, death in the family, etc.) could result in a mark of zero (0) for the activity.

Students are responsible for meeting with the instructor before the evaluation activity is held, or immediately upon returning to ENA to explain the reason for an absence. Proper documentation, such as a medical certificate, a death certificate, legal papers, etc., must be shown if the reason for absence is serious and recognized as such by the instructor. Arrangements will be made between the instructor and the student to make up the activity.

3. Assignment submission

Assignments must be submitted by the date, hour and location decided by the instructor. Late assignments will be penalized according to the TGA department policy (PIEA, article 5.2.5.2). According to that policy, late assignments will not be accepted (except if an agreement has been made with the teacher) and the assignment will be marked 0.

4. Presentation of Written Work

Students must follow the standards adopted by the Cégep for written work. Information can be found at:

http://rmsh.cegepmontpetit.ca/normes-de-presentation-materielle-des-travaux-ecrits-du-cegep/.

According to PIEA, article 5.3.2, a document that does not meet the requirements could be rejected by the teacher, or could be penalized by up to 10%..

11 METHODS OF COURSE PARTICIPATION

Using the equipment, machines and the Department laboratories outside of class hours is strictly forbidden unless an agreement has been made with the Department coordinator.

Appropriate clothing, safety glasses and safety shoes or boots must be worn in the workshops. For safety and security reasons, sandals, shorts and any other inappropriate clothing will not be permitted.

Students whose behavior creates a risk for other people will receive a warning from the teacher; if there is no change then they will be excluded from the laboratory until the situation is reviewed by the instructor and the Coordinator of the Aircraft Techniques de genie aérospatial Department.

Students who do not comply with the rules taught in class regarding the proper usage and maintenance of tools and equipment may be suspended from the course until the situation can be reviewed by the teacher and the Department coordinator.

For online classes:

By attending online classes through videoconference technology, the student understands that his image and voice may be captured on video in the context of his courses and agrees to this. Videos are only visible during live classes and by the teacher and other participants exclusively.

For pedagogical reasons, some courses may be recorded. It is the teacher's responsability to clearly inform students beforehand when their images and voices are to be captured on video . Any student opposed to his image and/or voice being recorded may turn off his camera and microphone but will be required to participate in writing through means established by the teacher. Otherwise, students who activate their cameras or their microphones are deemed to have agreed to their images and voices being taped. These recordings of courses will be available for the express and sole use of those students registered in the courses for the duration of the semester. It is strictly forbidden to broadcast these recordings in any public manner or to use them other than for pedagogical purposes.

No student may record an online course without prior consent from the teacher. Students whose personal information (voices and images) is captured on video may exercise such remedies as provided by the right to access records and the right of rectification per the Act respecting access to documents held by public bodies and the protection of personal information through the Cegep's Secretary General's Office.

12 DEPARTMENTAL POLICIES

Students are invited to consult the website for the specific regulations for this course:

http://guideena-en.cegepmontpetit.ca/department-rules/

13 INSTITUTIONAL POLICIES AND REGULATIONS

All students enrolled at cégep Édouard-Montpetit must become familiar with and comply with the institutional policies and regulations. In particular, these policies address learning evaluations, maintaining admission status, French language policies, maintaining a violence-free and harassment-free environment, and procedures regarding student complaints.

The French titles for the policies are: Politique institutionnelle d'évaluation des apprentissages, Conditions d'admission et de cheminement scolaire, Politique relative à l'usage, à la qualité et à la valorisation de la langue française, Politique pour un milieu d'études et de travail exempt de harcèlement et de violence, Procédures concernant le traitement des plaintes étudiantes.

The full text of these policies and regulations is accessible on the Cégep web site at the following address: http://www.cegepmontpetit.ca/ena/a-propos-de-l-ecole/reglements-et-politiques

If there is a disparity between shortened versions of the text and the full text, the full text will be applied and will be considered the official version for legal purposes.

14 STUDENT ACCESSIBILITY CENTER - FOR STUDENTS WITH DISABILITIES

Students having received a professional diagnosis of impairment (motor skills, neurological, organic, sensory, learning difficulties, mental health, autism spectrum disorder or other) or suffering from a temporary medical condition may request special accommodations.

Students seeking these accommodations must forward their diagnosis to the CSA by either MIO to « Service, CSA-ENA » or email to servicesadaptesena@cegepmontpetit.ca

Students already registered with the CSA must communicate with their teachers at the beginning of the semester to discuss those accommodations they have been awarded by the CSA.