



## COURSE OUTLINE

**COURSE:** Strength of materials used in the aircraft industry

**PROGRAM:** 280.CO Aircraft Maintenance

**DISCIPLINE :** 280 Aeronautics

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

<b>Instructor(s)</b>	<b>Office</b>	<b>☎ extension</b>	<b>✉ e-mail or web site</b>
Grenier Denis	A-193	4386	denis.grenier@college-em.qc.ca

### OFFICE HOURS

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Morning					
Afternoon					

<b>Coordinator(s)</b>	<b>Office</b>	<b>☎ extension</b>	<b>✉ e-mail or web site</b>
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## **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 treatment and anticorrosion.
- Interpret stress tests and establish the mechanical characteristics required for the component.

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.

## **MINISTERIAL OBJECTIVE(S) AND COMPETENCIES**

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

## **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 of heat treatment and mechanical test on strength of material.
- Welding exercises.
- Practical work.

Students can enhance their understanding of the material with reference books available in the library as well as specific Internet sites.

**COURSE PLAN – THEORY**

**Activity period: Week 1**

**THEME 1: Aeronautical materials**

Learning objective	Content	Personal study activities
1.1 Identify the main materials used in aircraft construction (Appendix C, part 2, articles 3.8, 8.3 and 13.1)	<ul style="list-style-type: none"> <li>▪ Physical identification and identifying by standards: steel, aluminum alloys, copper alloys, ceramics, plastic, nickel and cobalt super-alloys, wood, and composite materials</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 1.</li> <li>▪ Consult reference books</li> </ul>

**Activity period: Weeks 2 and 3**

**THEME 2: Physical, chemical and mechanical properties of materials**

Learning objective	Content	Personal study activities
2.1 Describe the characteristics of the main materials used in aircraft construction.	<ul style="list-style-type: none"> <li>▪ Physical, chemical and mechanical properties.</li> <li>▪ Interpreting tables and diagrams.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 1.</li> <li>▪ Do the exercises in module 1.</li> <li>▪ Consult reference books.</li> </ul>
2.2 Describe the main mechanical tests. (Appendix C, part 2, articles 3.2).	<ul style="list-style-type: none"> <li>▪ Tension, hardness, impact and shearing tests.</li> <li>▪ Respect for standards.</li> <li>▪ Safety.</li> </ul>	
2.3 Interpret the experimental results and formulate a conclusion.	<ul style="list-style-type: none"> <li>▪ Effects from heat and mechanical treatment on the characteristics of aircraft components.</li> </ul>	

**Activity period: Weeks 4 and 5**

**THEME 3: Heat treatment of aluminum alloys**

Learning objective	Content	Personal study activities
3.1 Describe the main types of heat treatment for some aluminum alloys (Appendix C, part 2, article 3.3).	<ul style="list-style-type: none"> <li>▪ Structural hardening, stress-relief annealing, recrystallization annealing, etc.</li> <li>▪ Respect for technical documents.</li> <li>▪ Standardized types and designation of aluminum alloys.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 2.</li> <li>▪ Do the exercises in module 2.</li> <li>▪ Consult reference books.</li> </ul>
3.2 Describe the influence of treatment on the performance of aircraft components.	<ul style="list-style-type: none"> <li>▪ Improvement of mechanical strength and ductility.</li> <li>▪ Residual stress, deformation and oxidation.</li> </ul>	

**Activity period: Weeks 5 and 6**

**THEME 4: Heat treatment for steel**

Learning objective	Content	Personal study activities
4.1 Describe the main types of heat treatment for steel. (Appendix C, part 2, article 3.3)	<ul style="list-style-type: none"> <li>▪ Tempering, cooling, stress-relieving annealing, carburizing, etc.</li> <li>▪ Respect for technical documents.</li> <li>▪ Standardized types and designation of steel.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 3.</li> <li>▪ Do the exercises in Module 3.</li> <li>▪ Consult reference books.</li> </ul>
4.2 Describe the influence of heat treatment on the performance of aircraft components.	<ul style="list-style-type: none"> <li>▪ Improvement of mechanical strength and ductility.</li> <li>▪ Residual strength, deformation and oxidation.</li> </ul>	

**Activity period: Week 6**

**THÈME 5: Manufacturing processes**

Learning objective	Content	Personal study activities
5.1 Describe the influence of the manufacturing processes on the characteristics of aircraft components.	<ul style="list-style-type: none"> <li>▪ Welding, forging, chemical milling, etc.</li> <li>▪ Deformations and residual stresses of components.</li> <li>▪ Chemical, physical and mechanical alterations of materials.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 4.</li> <li>▪ Consult reference books.</li> </ul>
5.2 Determine the influence of maintenance work on the characteristics of aircraft components.	<ul style="list-style-type: none"> <li>▪ Mechanical abuse (scratches, nicks, etc.), heat abuse, machining abuse.</li> </ul>	

**Activity period: Week 6**

**THEME 6: Corrosion and methods to control it**

Learning objective	Content	Personal study activities
6.1 Describe the main types of corrosion and appropriate ways to prevent it. (Appendix C, part 2, articles 3.1 and 3.5)	<ul style="list-style-type: none"> <li>▪ General corrosion, pitting, from high temperatures, etc.</li> <li>▪ Anodising, painting, metal coating, etc.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 3.</li> <li>▪ Consult reference books.</li> </ul>

**Activity period: Week 7**

**EXAM**

**Activity period: Weeks 7 and 8**

**THÈME 7: Forces and moments**

Learning objective	Content	Personal study activities
7.1 Distinguish force, couple and moment. (Appendix C, part 2, article 13.1)	<ul style="list-style-type: none"> <li>▪ Forces and vectors : definitions and characteristics.</li> <li>▪ Resultant forces.</li> <li>▪ Moment of force.</li> <li>▪ Couple.</li> <li>▪ Pulleys.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Do the exercises in Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity period: Week 9**

**THEME 8: Centroid and centre of gravity of a part**

Learning objective	Content	Personal study activities
8.1 Determine the centroid and the centre of gravity of mechanical parts. (Appendix C, part 2, articles 23.3 and 23.6)	<ul style="list-style-type: none"> <li>▪ Difference between the centroid and the centre of gravity.</li> <li>▪ Locating the centroid and the centre of gravity.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Do the exercises in Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity period: Week 10**

**THEME 9: Mechanical systems in equilibrium**

Learning objective	Content	Personal study activities
9.1 Explain the equilibrium of simple mechanical parts and aircraft components. (Appendix C, part 2, articles 6.1.1 and 13.1)	<ul style="list-style-type: none"> <li>▪ Categorising interface support of components.</li> <li>▪ Calculating torque forces applied on simple mechanical parts and aircraft components.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Do the exercises in Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity period: Week 11**

**EXAM**

**Activity period: Weeks 11 and 12**

**THEME 10: Calculating stresses applied to aircraft components**

Learning objective	Content	Personal study activities
10.1 Calculate simple stresses applied to aircraft components as well as their deformation. (Appendix C, part 2, article 12.10)	<ul style="list-style-type: none"> <li>▪ Simple stresses and tension from compression and shearing on the beams, on the shafts, on the tanks and on the riveted, bolted, glued and welded assemblies.</li> <li>▪ Stresses and deformations caused by twisting.</li> <li>▪ Safety factors.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Do the exercises in Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity period: Weeks 12, 13 and 14**

**THEME 9 (continued): Calculating stresses applied to aircraft components**

Learning objective	Content	Personal study activities
11.1 Calculate the moment of inertia of simple and composite surfaces.	<ul style="list-style-type: none"> <li>▪ Moment of inertia.</li> <li>▪ Diagrams of shear forces and bending moments.</li> <li>▪ Simple and combined stresses.</li> <li>▪ Beam deflection.</li> <li>▪ Concentration of stresses.</li> <li>▪ Fatigue.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 6.</li> <li>▪ Do the exercises in Module 6.</li> <li>▪ Consult reference books.</li> </ul>
11.2 Mark out diagrams of shear forces and bending moments to calculate the stresses applied to beams, shafts, rods, etc. (Appendix C, part 2, article 12.10)		

**Activity period: Week 15**

**FINAL EXAM**

## COURSE PLAN – PRACTICAL WORK

**Activity Period: Weeks 1, 3, 5 and 7**

**Mechanical Tests, heat treatment and corrosion**

Learning objective	Content	Personal study activities
1. Using mechanical tests, compare mechanical properties of the main materials used in aeronautics.	<ul style="list-style-type: none"> <li>▪ Demonstration on: • hardness test; • charpy impact test; • tension test.</li> <li>▪ Safety.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 1.</li> <li>▪ Consult reference books.</li> </ul>
2. Describe the main types of heat treatment for aluminum alloys and their influence on the mechanical properties of these metals.	<ul style="list-style-type: none"> <li>▪ Demonstration using aluminum and steel alloy test specimens.</li> <li>▪ Health and safety.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Modules 2 and 3.</li> <li>▪ Consult reference books.</li> </ul>
3. Describe anti-corrosion treatment by anodizing, Alodine, cadmium plating, etc.	<ul style="list-style-type: none"> <li>▪ Demonstration on : • anodizing; • Alodine.</li> <li>▪ Health and safety.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 3.</li> <li>▪ Consult reference books.</li> </ul>

**Activity Period: Weeks 2, 4, 6, 8, 10 and 12**

**Welding and manufacturing processes**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
1. Weld joints using the GRAW (TIG) process.	<ul style="list-style-type: none"> <li>▪ Welding under gas protection with non-fusible electrodes (GTAW).</li> <li>▪ Carrying out GTAW soldering on sheets and tubes.</li> <li>▪ Welding defects.</li> <li>▪ Microstructure of a welded joint.</li> <li>▪ Plasma welding.</li> <li>▪ Plasma cutting.</li> <li>▪ Identification of materials.</li> <li>▪ Welding by electric resistance.</li> <li>▪ Health and safety.</li> <li>▪ Forging.</li> <li>▪ Lamination.</li> <li>▪ Molding.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 4.</li> <li>▪ Consult reference books.</li> </ul>
2. Describe the main welding and cutting processes used in aeronautics and their influence on the mechanical properties of the components.		
3. Demonstrate the concepts studied in the theory class.		
4. Describe the principle manufacturing processes.		

**Activity Period: Week 9**

**Forces and stresses**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
1. Distinguish force, couple and moment of force.	<ul style="list-style-type: none"> <li>▪ Lab session accompanied by a short demonstration of forces, moments and couples.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity Period: Week 11**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
2. Study the equilibrium of mechanical parts according to the forces exerted on them.	<ul style="list-style-type: none"> <li>▪ Lab session on centre of gravity and equilibrium equations.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5.</li> <li>▪ Consult reference books.</li> </ul>

**Activity Period: Week 13**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
3. Compare shear strength of riveted, glued and welded assemblies	<ul style="list-style-type: none"> <li>▪ Demonstration on riveted, glued and welded test samples.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 6</li> <li>▪ Consult reference books</li> </ul>

**Activity Period: Week 14**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
4. Study simple stresses applied to mechanical parts.	<ul style="list-style-type: none"> <li>▪ Lab session on tensile, compression and shear stresses.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 6.</li> <li>▪ Consult reference books.</li> </ul>

**Activity Period: Week 15**

<b>Learning objective</b>	<b>Content</b>	<b>Personal study activities</b>
5. Study the moment of inertia, shear force, the bending moment and stresses.	<ul style="list-style-type: none"> <li>▪ Lab session on the calculation of stresses caused by shear force and the bending moment including a short demonstration.</li> </ul>	<ul style="list-style-type: none"> <li>▪ Study: Module 5 and 6.</li> <li>▪ Consult reference books.</li> </ul>

**SYNTHESIS OF SUMMATIVE EVALUATION METHODS**

**Theory**

Description of evaluation activity	Context	Learning objective(s)	Due date (approximate date assignment due or exam given)	Weighting (%)
Written quiz on materials and their characteristics.	Individual, in class, for up to 20 minutes.	1 and 2	Week 4	3%
Work on aluminum alloy heat treatment.	Individual homework.	3	Week 6	2%
Work on steel heat treatment.	Individual homework.	4	Week 7	2%
Written exam on the characteristics of materials, manufacturing processes, corrosion and heat treatment.	Individual, in class, for 1½ hours.	1 to 6	Week 7	11%
Assignment on forces, moments and couples.	Individual homework.	7	Week 8	1%
Assignment on calculating the center of gravity.	Individual homework.	8	Week 10	1%
Assignment on the equilibrium of simple mechanical parts and of aircraft components.	Individual homework.	9	Week 11	1%
Written exam on forces, moments, the center of gravity and the equilibrium of mechanical parts.	Individual, in class, for one hour.	7 to 9	Week 11	7%
Assignment on allowable stresses applied to mechanical parts and on aircraft components as well as their deformation.	Individual homework.	10	Week 12	1%
Assignment on the stresses applied to simple riveted, bolted, glued and welded assemblies and the moments of inertia.	Individual homework.	10 and 11	Week 13	1%
Assignment on the stresses caused by shear force, the bending moment and torsional stress.	Individual homework.	11	Week 14	1%
Assignment on combined stresses and the concentration of stresses.	Individual homework.	11	Week 15	1%
Final written exam.	Individual, in class, for two to three hours.	1 to 11	Week 15	25%
Évaluation of professional attitude: • respect for regulations; • respect for others; • autonomy; • etc.	Individual.		Weeks 1 to 15	3%

**Sub-total : 60%**

**Practice**

Mechanical Tests, Heat Treatment and Corrosion

Description of evaluation activity	Context	Learning objective(s)	Due date (approximate date assignment due or exam given)	Weighting (%)
<ul style="list-style-type: none"> <li>▪ Hardness tests, tension and strength.</li> <li>▪ Questionnaire.</li> </ul>	Demonstration using the machine for tensile testing, hardness, Charpy impact and using test samples.	1	Week 4	3%
<ul style="list-style-type: none"> <li>▪ Aluminum alloy and steel heat treatment.</li> <li>▪ Questionnaire.</li> </ul>	Demonstration using a furnace, a hardening bath and test samples.	2	Week 6	6%
<ul style="list-style-type: none"> <li>▪ Treat for corrosion (anodisation).</li> <li>▪ Questionnaire.</li> </ul>	Demonstration using chemical solutions and a source of electrical current.	3	Week 7	2%

Welding and Manufacturing Processes

Description of evaluation activity	Context	Learning objective(s)	Due date (approximate date assignment due or exam given)	Weighting (%)
Work related to parameters for carrying out a GTAW (TIG) joint welding.	Individual homework.	1	Week 5	4%
Practical exam on the execution of a GTAW (TIG) joint welding.	Individual, in the laboratory, for up to one hour.	1	Week 12	6%
Practical exam on the manufacturing processes and identification of materials.	Individual, in the laboratory, for up to 30 minutes.	All	Week 12	3%



Forces and Stresses

Description of evaluation activity	Context	Learning objective(s)	Due date (approximate date assignment due or exam given)	Weighting (%)
Lab session on forces, moments and couples.	Individual, in class.	1	Week 9	2%
Lab session on the centre of gravity and equilibrium of mechanical pieces.	Individual, in class.	2	Week 11	2%
<ul style="list-style-type: none"> <li>▪ Shearing test.</li> <li>▪ Writing a report.</li> </ul>	Demonstration and basic concepts.	3	Week 13	3%
Lab session on simple stresses applied to individual mechanical parts.	Individual, in class.	4	Week 14	2%
Lab session on the moment of inertia, the bending moment, shearing strain and stresses.	Individual, in class.	5	Week 15	2%
Evaluation of professional attitude : <ul style="list-style-type: none"> <li>• respect for regulations</li> <li>• respect for others</li> <li>• autonomy</li> <li>• etc.</li> </ul>	Individual and in teams in the laboratory.		Weeks 1 to 15	5%

**Sub-total : 40%**

**TOTAL : 100%**

## **REQUIREMENTS TO PASS THE COURSE**

### **(1) Passing Mark**

Students must have a minimum mark of 60% on the theory evaluation and a minimum of 60% on the practical work evaluation. Students who do not meet these requirements will receive the lower of the two marks (theory and practical work) on their final report cards.

### **(2) Attendance for Summative Evaluations**

Students must be present for summative evaluations.

### **(3) Submitting Assignments**

All assignments must be submitted by the date, hour and location designated by the instructor(s). Students who are absent must obtain information about any work done in class or assignments from their classmates.

Late assignments will be penalized in the following manner:

- 1 day - 10%
- 2 days - 20%
- 3 days - 50%
- one week - 100%

### **(4) Presentation of Written Work**

Students must follow the standards adopted by the College for written work (« *Normes de présentation matérielle des travaux écrits* »). These can be found in the documentation centre on the College web site (<http://ww2.college-em.qc.ca/biblio/normes.pdf>) under the heading ***Aides à la recherche***.

## **RULES 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 Construction 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.

## **REQUIRED MATERIAL**

Course Notes (available on LEA); scientific calculator; ruler; graph paper; protractor; safety glasses; overalls.

## **MEDIAGRAPHY**

Bouchy, Godin. *Métallurgie*, Armand Collin, Paris.

Côté, Michèle. *Résistance de matériaux CCDMD*, les éditions "Le Griffon d'argile".

Dell K., Allen. *Metallurgy Theory and Practice*, American Technical Society.

E. Paul de Garno. *Materials and Processes in Manufacturing*, McMillan Co.

Frier. *Elementary Metallurgy*, McGraw-Hill.

Hilly & Chaisson. *Cours de métallurgie*, Dunod, Paris.

Lignon J. & M. Nijon. *Matériaux, propriétés, traitements normalisation*, Delagrave, Paris.

Levinson, I.J. *Mechanics of Materials*, Prentice-Hall.

Meriam, J.L. *Engineering Mechanics : volume 1, Statics*, Wiley.

Sacks, Raymond J. & Edward R. Bohnart, *Welding Principles and Practices*, McGraw-Hill.

## **INSTITUTIONAL POLICIES AND REGULATIONS**

All students enrolled at Collège 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 College web site at the following address: [www.college-em.qc.ca](http://www.college-em.qc.ca). 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.

## **OTHER DEPARTMENTAL REGULATIONS**

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

<http://www.college-em.qc.ca/>

[www.college-em.qc.ca/ena/preenvol/reglements](http://www.college-em.qc.ca/ena/preenvol/reglements)