Collège
Édouard-Montpetit
École nationale d'aérotechnique

280-3A5-EM
WINTER 2012
Propulsion

COURSE OUTLINE

COURSE: **Aircraft Turbine Engine Operation**

PROGRAM: 280.CO Aircraft Maintenance

DISCIPLINE : 280 Aeronautics

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

Instructor(s)	**Office**	**☎ extension**	**✉ e-mail or website**
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OFFICE HOURS

	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
Morning					
Afternoon					

Coordinator(s)	**Office**	**☎ extension**	**✉ e-mail or website**
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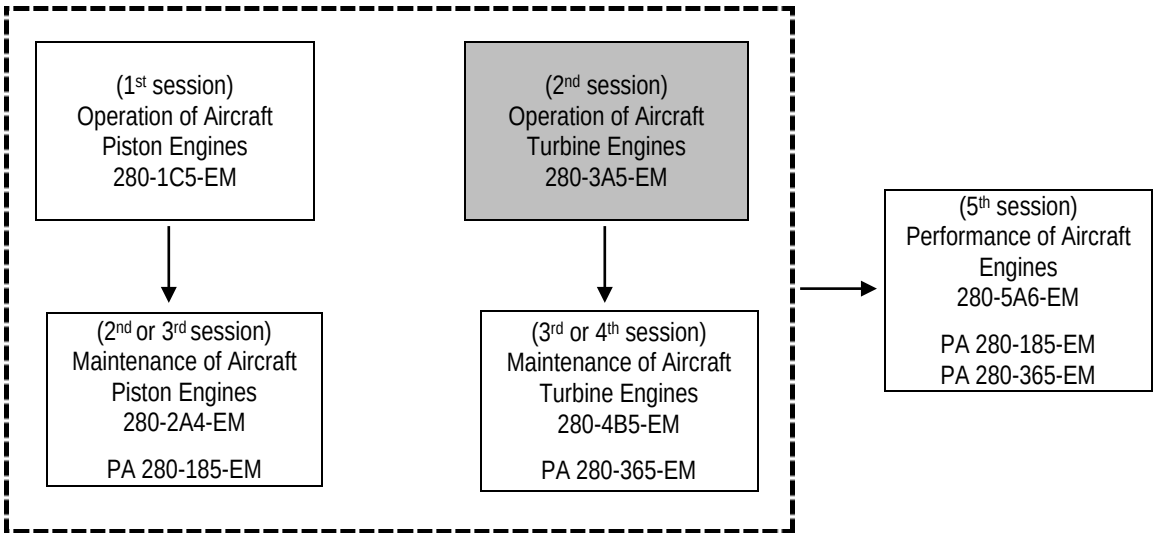
CONTEXT OF THIS COURSE IN THE PROGRAM

This course is given during the second session of the program. By the end of the course, students will have developed their abilities to:

- Explain the principle of turbine engine operation.
- Explain the factors affecting torque or thrust.
- Explain the operation and design of different components and systems associated with turbine engines.
- Evaluate engine performance.
- Troubleshoot.
- Apply health and safety regulations related to the work area and operations on turbine engines.

This course is a required pre-requisite for courses 280-4B5-EM and 280-5A6-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

0266 To verify the operation of aircraft turbine engines.

TEACHING STRATEGIES

Theory: A variety of pedagogical methods are used including PowerPoint presentations with a multi-media projector or blackboard, use of propulsion models and engine parts; however, the major part of the course is conducted as a formal lecture with formative exercises at the end of certain themes.

Practical Work: The laboratory part of the course is devoted primarily to techniques to help students learn about the operation of aircraft turbine engines and their peripheral systems. Using a variety of teaching methods, the practical work involves a hands-on approach to understand the components and systems that make up an aircraft turbine engine as well as lectures and demonstrations to explain laboratory technologies.

COURSE PLAN

	Theory	Laboratory
1	▪ Course Outline. ▪ Introduction to jet engine operation and classification of these engines. ▪ Symbols, acronyms and jet engine terminology. ▪ Compare jet engine working cycle with piston engine working cycle.	▪ Course Outline. ▪ Name, explain and compare types of jet engines.
2	▪ Symbols, acronyms and jet engine terminology	Understand the function and components of the lubricating system.
3	▪ Inlet duct. ▪ Introduction to compressors.	Draw turbine engine oil system schematic.
4	▪ Compressors (continuation).	PT6A-27 Reduction gear box operation and torque sensing system.
5	• Compressor performance. • Diffuser.	Handling Avon engine and Spey compressor module.
6	EVALUATION	Introduction to inspection terminology. Demonstration of a HSI on a PT6A-27.
7	Turbine and exhaust system.	EVALUATION
8	Review units, define forces, work and power.	Wk 8: Boroscope JT8D, PW100, JT15D and PT6A27 engines. Wk 9: Perform visual part of HSI Wk10: Demonstration of thrust reversers operation. Demonstration of fuel nozzle testing. Demonstration of how to inspect lubricating system components (filter, PRV). Demonstration of an ignition system operation.
9	Corrected thrust (power) and specific fuel consumption, thermal efficiency and propulsive efficiency.	
10	Engine performance evaluation.	
11	EVALUATION	Engine condition trend monitoring and troubleshooting.
12	Fuel systems and major components.	▪ Demonstration of test cell operation.
13	▪ Noise suppressors. ▪ Thrust reversers. ▪ Ignition and starting systems.	Test Engine/Learn component operation (oil cooler, hot air valve, PRV).
14	▪ Anti-icing systems. ▪ Thrust augmentation systems. ▪ Bleed-air system.	▪ Test Engine/Learn component operation (oil cooler, hot air valve, PRV).
15	EVALUATION	EVALUATION

COURSE PLAN – THEORY

The theoretical part of the course is divided into major themes:

1. GENERAL POINTS ABOUT JET ENGINES covers the overall operation of various turbine engines used in aerospace.

2. PERFORMANCE CALCULATIONS AND PARAMETERS that affect the performance of aircraft turbine engines.

3. SYSTEMS covers the systems necessary for the operation of aircraft turbine engines.

ACTIVITY PERIODS:

Theme 1: GENERAL POINTS ABOUT JET ENGINES (Weeks 1 to 7)

Learning Objectives: 1.1, 1.3 and 1.4

Content

1.1 Explain the operation principles of different types of turbine engines.

- Introduction to jet engine operation and classification of these engines.

1.3 Explain the operation and design of different components of turbine engines.

- Air intake section: operating principle, adaptation to flight speed, efficiency, types of air intake (test bench, subsonic, supersonic), etc.
- Compressor section: types of compressors (axial and centrifuge), multi-disk system and materials used, fastening blades and stators, balancing, stalling and surging, efficiency and rate of compression, etc.
- Combustion chamber section: materials used, different types of chambers (separated, annular, mixed), role of various internal air flows, efficiency, etc.
- Turbine section: types, role and efficiency, stress and strain affecting materials used, blade attachments and vanes, etc.
- Exhaust section: presentation of different types (variable and convergent nozzle) and materials used, etc.

1.4 Explain the operation and design of systems associated with turbine engines.

- Fuel systems and fuel metering: fuel nozzles.

Theme 2: CALCULATIONS OF PERFORMANCE (Weeks 8 to 11)

Learning Objective: 1.2

Content

1.2 Explain the factors affecting torque or thrust.

- Physics and mathematical principles associated with generating torque and thrust: Brayton Cycle, calculations of thrust, power and performance evaluation, etc.

Theme 3: SYSTEMS (Weeks 12 to 14)

Learning Objective: 1.4

Content

1.4 Explain the operation and design of the systems associated with turbine engines:

- Fuel system and fuel metering, types of governors, heaters, filters and fuel system instrumentation and fuel consumption, etc.
- Ignition: high and low tension systems and their components, precautions to take when handling, etc.
- Starting: various starters and operation of an automatic starting system and in-flight relight system principle, etc.
- Presentation of anti-icing cooling systems and their components.
- Noise suppressing: principle of noise suppression and different types of suppressors, etc.

Personal Study Activities: Students must read the weekly readings that precede the course. As the course progresses, they must also answer formative questions asked by the instructor or used in the course notes.

COURSE PLAN - LABORATORY

The laboratory part of the course is divided into five themes:

1. Turbine operation.
2. Operation of the lubrication and torque system.
3. Test cells, understanding components operation boroscope inspection.
4. Introduction to inspection terminology and troubleshooting.
5. Engine systems.

ACTIVITY PERIODS

Theme 1: OPERATION OF JET ENGINES (Week 1)

Learning Objectives: 1.1 and 1.3

1.1 Explain the operating principles of different types of turbine engines.

- Introduction to operation of engines generating torque, thrust and of the range of uses of different types of turbine engines.

1.3 Explain the operation and design of different components of turbine engines.

Content

Explanation of the general mode of operation, the differences, the names and the general identification of their components using the following engines: Orenda 8 turbo-reactor, PT6A-27 turboprop, Allison 250 C20 turbo engine, RB211 and JT8D turbofan.

Theme 2: OPERATION OF THE LUBRICATION AND ENDOSCOPY SYSTEM (Weeks 2 and 6)

Learning Objectives: 1.4, 2.1, 2.3, 5.2 and 5.3

1.2 Explain the factors affecting torque and thrust.

1.4 Explain the operation and the design of the systems associated with turbine engines:

- Lubrication systems: types of oils and necessary requirements; wet and dry sump circuits and their components, etc.
- Air systems: introduction to anti-icing and cooling circuits.

2.1 Apply safety regulations related to the inspection of internal parts of turbine engines.

2.3 Analyze inspection results and record them in the appropriate documents:

- Inspect the condition of the accessory and reduction gear box.

5.2 Use the procedure described in the manufacturer's manuals for the inspection of turbine engine lubricating systems:

- Demonstrate proper use of protective equipment, of the safety area around the workplace and show respect for precautions to be taken while handling engine systems.

5.3 Analyze inspection results and record them in the appropriate documents:

- Meticulously inspect the lubricating systems oil filter and chip detectors and adjust the pressure regulator.

Content

1. Lubrication Schematic:
   - Explanations and comprehension exercises of the lubrication system operation will be made using oil system diagrams, cut-away engine and engine simulation software.

2. Reduction Gearbox (RGB):
   - Explanation of the reduction principle; the necessity for reduction, types of speed reducers and their operation (gears, the planets, etc) using disassembled PT6A-27 reduction gear boxes.

Theme 3: Test Bench (Weeks 5 to 10)

Learning Objectives: 2.3, 3.1 à 3.3, 6.2, 6.3, 7.2 and 7.3

2.3 Analyze inspection results and record them in the appropriate documents.

3.1 Apply safety regulations related to inspecting ignition systems.

3.2 Follow the procedure described in the manufacturer's manual for inspecting ignition systems:
- Use protective equipment, establish a security zone around the work area and show respect for precautions to be taken while handling parts and equipment

3.3 Analyze inspection results and record them in the appropriate documents. :
- inspect overall condition of the ignition system at high voltage and low voltage, inspect spark plugs and the ignition box.

6.2 Inspect engine instrumentation according manufacturer's manual recommendations.

6.3 Analyze inspection results and record them in the appropriate documents.

7.2 Inspect turbine engine control system according to manufacturer's manual recommendations:
- Carry out detailed inspection of the overall condition of the engine monitoring system; carry out precise operating test runs that includes collecting detailed data from the performance test.

7.3 Analyze inspection results and record them in the appropriate documents:
- Respect engine operating limits.
- Record inspection results in specialized documents or logbooks.

Content

1. Introduction to the test cell.
2. Carry out virtual and real engine tests (PT6A27):
   - Consult documentation and relevant regulations.
3. Evaluate engine performance.
4. Boroscope Inspection:
   - Using boroscope software and boroscope, carry out a hot end inspection of different engines; for example: PT6A-27, PW100, JT15D, JT8D and RB211-22B.
   - Engine components operation.
   - Using manufacturer's manuals, find the operation of engine components such as the oil cooler, hot air valve, etc.

Theme 4: INTRODUCTION TO INSPECTION TERMINOLOGY, TYPES OF INSPECTIONS AND TROUBLESHOOTING (Weeks 11 to 13)

Learning Objectives: 2.1

2.1 Apply safety rules related to the inspection of internal parts of turbine engines:
- describe specialized documents ("z" sheet, inspections and work documents).
- research and explain laws and regulations related to inspecting the operation of turbine engines.
- describe log books and maintenance entries.

Content

1. Introduction to ECTM:
   - Situation scenarios of different kinds of engine failures in order to find solutions.
2. Introduction to maintenance inspection terminology.
3. Demonstration of an HSI of a PT6A-27.
4. Carry out a brief HSI of a PT6A-27.

Theme 5: OPERATION OF THE ENGINE SYSTEMS (Week 14)

Learning Objectives: 1.3, 1.4, 4.2, 4.3 and 7.2

1.3 Explain the operation and design of different components of turbine engines:
- Ejection section: introduction to different types.

1.4 Explain the operation and design of turbine engine's auxiliary systems:
- Explain fuel systems and metering system types of FCU: fuel nozzles; fuel heaters; filters and fuel system indicators; fuel consumption, etc.

4.2 Use the procedure described in the manufacturer's manual for inspecting fuel systems for turbine engines:
- Use protective equipment, establish a security zone around the work area and show respect for precautions to be taken while handling parts and equipment

4.3 Analyze inspection results and record them in the appropriate documents:
- Perform detailed inspection of fuel filters, fuel injector nozzles, the fuel pump and fuel control unit; check for fuel contamination and make precise adjustments of the engine control linkage.

7.2 Use the procedure described in the manufacturer's manual for the inspection of turbine engine control systems.

Content

1. Fuel system:
   - Demonstration of the operation of fuel nozzles.
2. System operation:
   - Demonstration of the operation of thrust reversers: JT8D and RB211-22B.
   - Inspection of fuel nozzles.
   - Maintenance inspection exercise. For example: check the overall condition of the lubricating system and the oil filter and the precisely adjust the oil pressure regulator.
   - Inspection of the ignition system.

N.B.: Learning Objectives 1.5, 1.6, 2.2, 4.1, 5.1, 6.1, 7.1, 8.1 and 8.2 apply to all laboratory courses.

Safety rules, standard operating procedures of overall or specific inspection:

1.5 Identify the safety rules related to working on turbine engines:
- Instrumentation/sensors: pressure indicating system, temperatures, speed and flow sensors, etc.
- Examples of applications of different systems.

1.6 Consult appropriate documentation and regulations for checking the operation of turbine engines:
- Procedures for safely handling material.

2.2 Apply safety rules related to inspecting internal turbine engine parts:
- Describe specialized documents (registration sheets for measurements, inspections and work documents).
- Research and explain the laws and regulations that apply to inspecting the operation of turbine engines.
- Describe log books and maintenance entries.

4.1 Apply safety rules to the inspection of turbine engine fuel systems:
- Respect the limits described in the manuals or documents accompanying the engine.
- Record inspection results in specialized documents or in log books.

5.1 Apply safety rules related to inspecting turbine engine lubricating systems:
- Respect the limits described in the manuals or the documents accompanying the engine.
- Record inspection results in specialized documents or in the log books.

6.1 Apply safety rules related to inspecting the instrumentation used on turbine engines:
- Use protective equipment, establish a security zone around the work area and use caution r while handling parts and equipment.

7.1 Apply safety rules relative to the inspection of turbine engine control systems:
- Use protective equipment, establish a security zone around the work area and use caution while handling parts and equipment.

8.1 Apply health and safety rules related to the work environment:
- Use necessary protective equipment (glasses, gloves, masks, etc.)

8.2 Apply environmental rules regarding the work environment:
- Dispose of organic material in the appropriate place; put rags to be washed in the designated tub and make sure the work area is clean.

Personal Study Activities: Students must read the lesson assigned before the class on a weekly basis. As the course progresses, they must also answer (if asked) the formative questions asked by the instructor or used in the notes of the course manual.

SYNTHESIS OF EVALUATION METHODS

The evaluations are traditional and/or multiple choice and/or schematic.

Theory

Description of the evaluation activity	Context	Learning Objective(s)	Due Date (date assignment is due or exam date)	Weighting (%)
Exam #1	Individual Up to 3 hours	1.1, 1.3 and 1.4	Week 6	20%
Exam #2	Individual Up to 3 hours	1.2	Week 11	20%
Exam #3	Individual Up to 3 hours	1.1 to 1.4	Week 15	20%

Sub-total : 60%

Laboratory

Description of the evaluation activity	Context	Learning Objective(s)	Due Date (date assignment is due or exam date)	Weighting (%)
Exam #1	Individual Up to 2 hours	1.1 to 1.4, 2.1, 2.3 and 5.3 * General Points	Week 7	15%
Exam #2 ✓Written : Test cell ✓Lab Report	Individual or in groups Up to 2 hours.	1.6, 6.1 to 6.3 and 7.1 to 7.3	Weeks 10-11	5%
Exam #3	Individual Up to 2 hours	Comprehensive * General Points	Week 15	20%

** General Points: On all laboratory courses: 1.5, 1.6, 2.2, 4.1, 5.1, 5.2, 6.1, 7.1, 8.1 and 8.2*

Sub-total : 40%

TOTAL : 100%

REQUIREMENTS TO PASS THE COURSE

(1) Passing Mark

In order to earn a college diploma from the Ministry of Education, the minimum mark to pass this course is 60% for the theory part of the course and 60% for the practical work (laboratory) part.

Under no circumstance may these two parts of the course be split up, even for partial accreditation.

Students who fail the course must repeat the entire course (theory and practical work) and fulfill all the requirements for the course which include talking all of the evaluations and being present in class.

(2) Course Attendance

Students are responsible for attending all courses and actively participating in all learning activities planned by the instructor. In compliance with the institutional policies for evaluating learning (PIEA, Articles 6.3.4 and 6.2.5), the administration has approved this attendance requirement for the laboratory courses.

Students who are absent for serious reasons (illness, death in the family, critical situation, etc.) are responsible for taking all necessary measures within three days following their return to ENA.

The following rules apply in this case:

- As soon as the absence reaches 10% of the course hours, students will receive a warning regarding the absence; when it reaches 20% of the course hours, students will be excluded from the course.
- Students who have accumulated a mark of 60% or more will automatically receive a mark of 55% the moment they are excluded from the course due to absence.

The Department complies with Transport Canada standards which tolerates absences up to 5% of the course (theory and laboratory). Information regarding the application of Transport Canada standards for absences can be found on the College website and in the student agenda under the heading *Privilèges accordés par Transports Canada.*

(3) Tardiness

Students who arrive more than 10 minutes after the beginning of the first period of the course may be considered absent according to the instructor's discretion.

No tardiness will be tolerated for subsequent periods of the same course.

Following a break between class periods, students must return to class at the time stated by the instructor. Students who arrive late may be refused access to this period of the course.

(4) Teacher's Absence

If the teacher's absence has not been posted on the TV screens in the college, students must wait 10 minutes before considering the instructor absent for the first period of the course.

(5) Attendance for Summative Evaluations

Students must be present for summative evaluations.

Any absence from an evaluation activity that is not justified with a serious reason (illness, death in the family, critical event, etc.) will result in a mark of zero (0) for this activity.

To justify an absence, students must comply with the article regarding attendance (*Présence aux cours).*

(6) Special Policy for Examinations

The only calculator that is authorized for examinations is the SHARP EL 531.

(7) Class Participation Expectations

The use of computers belonging to students as well as the use of any audio or video recording device is forbidden in class.

Theory:

- The instructor may have specific requirements or prohibitions to improve class management. These may be explained at the beginning of the course or during the session.

Practical Work (Laboratory):

- Students must read assigned readings before class and, as the course advances, answer formative questions asked by the instructor or used in the course notes.
- The teacher may have specific requirements or prohibitions to improve class management. These may be explained at the beginning of the course or during the session.
- After handling equipment, the material and manuals used must be cleaned and returned to their proper place; papers must be thrown out in the trash baskets and the work area must be cleaned.
- The contents of the toolbox must be checked and put in order before and after each course.
- Attendance, involvement and demonstrated professionalism is taken into account in marking the laboratory reports.
- Food and drink are prohibited in the laboratory.

Instructors who consider that these conditions have not been met may take off points from the laboratory mark.

(8) Laboratory Safety

Everyone must wear safety shoes or boots, ENA overalls or lab coat and safety glasses. Sandals, shorts or any other inappropriate clothing will not be permitted for security reasons.

(9) 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 recherché.***

(10) Submitting Assignments

Assignments must be submitted by the date, place and time determined by the instructor. Any assignment submitted after the due date will be penalized 10% per day for each day it is late up to a week. After one week, the assignment will receive a zero (0) unless other arrangements have been made with the instructor.

11) Evaluation Criteria

Summative evaluations are in a traditional written format: short answer, multiple choice or a combination of the two types.

Formative evaluations are in the form of a written or oral questionnaire, a written report or a hands-on assignment.

Students must answer questions according to the content of the question.

In evaluating the test, the instructor will not interpret what the student attempted to communicate but rather what the student actually said or wrote.

The statements written by students in response to a test will be evaluated according to the following criteria:

- Respect for the specific instructions (e.g. describe, explain, comment, define, etc.).
- Truth and validity of the response.
- Technical precision and accuracy.
- Quality and thoroughness of the content.

Specialized technical vocabulary must be used to comply with the definitions given in class.

Success in this course depends not only on mastering the technical aspects of the course but also on the quality of work and personal performance.

REQUIRED MATERIAL

- Safety equipment must be worn in the laboratory course: safety shoes or boots, safety glasses, ENA labcoat or overalls.
- Appropriate course manual(s).
- Cleaning rag (ENA).

MEDIAGRAPHY

Author	Publisher	Edition	ISBN	# pages
Baskharone Erian A.	Principles of Turbomachinery in Air-Breathing Engines *Cambridge Aerospace Series*		0521858100	
Crane Dale	Aviation Maintenance Technician Series : Powerplant *ASA*	2e	1-56027-547-2	776
Dole Charles	Mathematics & Physics for Aviation Personnel *Jeppensen*		0-89100-399-1	94
Dreska Sister Noel & Leonard Weisenthal	Physics for Aviation *Jeppesen*		0-89100-411-4	178
Enga John	Aircraft Inspection & Maintenance Records *Jeppesen*		0-88487-391-6	84
Flack Ronald D.	Fundamentals of Jet Propulsion with Applications *Cambridge Aerospace Series*		0521819830	
Hurst Dale	Aircraft Powerplant Maintenance *Avotek*		0-9708109-3-8	423
Jeppesen	JAA ATPL, Volume 5 : Powerplant *Jeppesen*			
Jeppesen	A&P Technician Powerplant Textbook *Jeppesen*		0-88487-338-2	672
Jeppesen	Aircraft Fuel Metering Systems *Jeppesen*		0-89100-057-7	71
Kroes Michael & James Rardon	Aircraft Basic Science *McGraw-Hill Ryerson*	7e	0-02-801814-1	448
Kroes Michael & Thomas Wild	Aircraft Powerplants *McGraw-Hill Ryerson*	7	0028018745	656
Lombardo David	Advanced Aircraft Systems *McGraw-Hill Ryerson*	1e	007038603x	368
Otis Charles E. & Peter A. Vosbury	Aircraft Gas Turbine Powerplants (text book) *Jeppesen*		0-88487-294-7	513
Pratt & Whitney	Aircraft gas turbine engine and it's operation *Pratt & Whitney*			
Pratt & Whitney	PT6A-27, PW100, JT15D et JT8D Overhaul, Maintenance & Illustrated Parts Catalogs *Pratt & Whitney*		n/a	
Rolls-Royce	Allison 250 C20J, Spey, AVON, DART et RB211-22B Overhaul, Maintenance & Illustrated Parts Catalogs Rolls-Royce		n/a	
Rolls-Royce	The Jet Engine *Rolls-Royce*		0-902121-2-235	288
Transports Canada	Transport Canada		n/a	
Treager Irwin	Aircraft gas turbine engine technology *McGraw-Hill Ryerson - Glencoe Aviation Technology*	3	0028018281	677
Wild Thomas & Ronald Sterkenburg	Aircraft Turbine Engines *Avotek*		1-233182-14-2 978-1-933189-14-7	

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, les conditions particulières concernant le maintien de l'admission d'un étudiant, la Politique de valorisation de la langue française, la Politique pour un milieu d'études et de travail exempt de harcèlement et de violence, les procédures et règles 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. If there is a discrepancy 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 the specific regulations for this course:

www.college-em.qc.ca/ena/propulseur/reglements

ANNEXE

Activity periods written in the course outline for the Propulsion Department serve as a general guideline. Modifications may be made to accommodate any logistical problems that may arise.

NOTE: This Course Outline is a translation of the *Plan de cours* for 280-365-EM: *Fonctionnement de moteurs àa turbine d'aéronefs*. If there is a discrepancy, then the original French version will be considered the official version for legal purposes.