ÉCOLE NATIONALE D'AÉROTECHNIQUE

UNE ÉCOLE AFFILIÉE AU CÉGEP ÉDOUARD-MONTPETIT

# 280-5A6-EM

**FALL 2022**

**Propulsion Department**

# COURSE OUTLINE

**COURSE:** **Engine Performance**

**PROGRAM:** 280.C0 Aircraft Maintenance

**DISCIPLINE:** 280 Aeronautics

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

| Instructor(s) | Office | ☎ Extention | ✉ Email or Website |
|---|---|---|---|
| David Richer | D-113C | 4614 | david.richer@ena.ca |

**OFFICE HOURS**

| | MONDAY | TUESDAY | WEDNESDAY | THURSDAY | FRIDAY |
|---|---|---|---|---|---|
| Morning | | | | | |
| Afternoon | | | | | |
| Other | | | | | |

| Coordinator | Office | ☎Ext | ✉ Email or Website |
|---|---|---|---|
| Louis Deschênes | D-113D | 4607 | louis.deschenes@ena.ca |

## CONTEXT OF THIS COURSE IN THE PROGRAM

The course *Engine Performance* aims to have students:

- Understand the performance of piston and turbine engines to be able to use them within their optimum range of operation.
- Be able to troubleshoot an engine being repaired for reduced performance and compare it to ideal performance.
- Be able to compare the performance of various aircraft with different types of engines.
- 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) according to Transport Canada requirements. The application of Transport Canada policies regarding absences is available on the *Ma réussite à l'ÉNA* website under the heading « Privilèges accordés par Transports Canada ».

## COMPETENCIES OF THE EXIT PROFILE (STUDENT SKILL PROFILES)

Perform maintenance on engines

## MINISTRY OBJECTIVE(S) AND COMPETENCIES

026B To assess the performance of piston and turbine engines.

## TERMINAL OBJECTIVE OF THE COURSE

**To assess the performances of piston and turbine engines.**

## TEACHING AND LEARNING STRATEGIES

**Theory:**

The method, teaching and learning style use standard pedagogical techniques such as:

- formal lectures
- use of model engines
- films
- parts
- Powerpoint notes.

**Practical Work:**

The method, teaching and learning style use standard pedagogical techniques such as:

- Powerpoint notes
- functioning engines and parts
- Volvo Diesel engine
- Chrysler gas engine
- Rover gas turbine
- SR-30, heat pump

For data reading and for analysis:

- Measuring instruments

Students will perform engine tests in the laboratory.

## COURSE PLAN– THEORY

**Activity Periods:** **Throughout the Session**

| Learning Objective | Content | Personal Study Activities |
|---|---|---|
| **1.** Master simple calculations and units with the ideal gas equation and calculating work. | ▪ Basic units used in the international system, their inter-relation and simplification<br>▪ Association of basic units with their physical concept (for work, Joules). | |

**Activity Period:** **Weeks 6 to 15**

| Learning Objectives | Content | Personal Study Activities |
|---|---|---|
| **2.1** Apply the first law of thermodynamics<br><br>**2.2** Make the link between heat and work<br><br>**2.3** Calculate the performance of a heat engine. | ▪ Analysis of engine performance using tools (concepts) from thermodynamics such as the first law, the closed system, open system (control volume), the law of conservation of mass, the second law, steady airflow, etc.<br>▪ Identification and use for purposes of analysis, the following thermodynamic variables: pressure, temperature, density, internal energy, enthalpy, entropy, etc.<br>▪ Equation of ideal gases, its limitations, and the related notion of mass heat (constant and variable) | |

**Activity Periods:** **Weeks 11 to 15**

| Learning Objective | Content | Personal Study Activities |
|---|---|---|
| 3.1 Explain the details related to power cycles.<br><br>3.2 Compare the performance of various aircraft with different types of engines. | Principles of the following cycles: Carnot, Brayton, turbojet, turboprop, turbo fan, geared fan, and their variations (regenerator, post-combustion) | |

**Theory**

| WEEK | # OBJECTIVE | CONTENT | MODE OF INSTRUCTION AND LEARNING ACTIVITIES | DOCUMENTATIONS, RESOURCES, TECHNOLOGICAL TOOLS AND URL ADDRESS |
|---|---|---|---|---|
| 1 | **1.** Master simple calculations and units with the ideal gas equation and calculating work. | ▪ Basic units used in the international system, their inter-relation and simplification<br>▪ Association of basic units with their physical concept (for work, Joules).<br>▪ Introduction to thermodynamics | In class training. | Theory class documents and related activities. |
| 2 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br><br>**2.2** Make the link between heat and work<br><br>**2.3** Calculate the performance of a heat engine. | ▪ Equation of ideal gases, its limitations, and the related notion of mass heat (constant and variable) | In class training. | Theory class documents and related activities. |

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| 3 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br>**2.2** Make the link between heat and work<br>**2.3** Calculate the performance of a heat engine. | ▪ Power correction<br>▪ Power curves of piston engines | In class training. | Theory class documents and related activities. |
| 4 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br>**2.2** Make the link between heat and work<br>**2.3** Calculate the performance of a heat engine. | ▪ Identification and use for purposes of analysis, the following thermodynamic variables: pressure, temperature, density, internal energy, enthalpy, entropy, etc.<br>▪ Equation of ideal gases, its limitations, and the related notion of mass heat (constant and variable) | In class training. | Theory class documents and related activities. |
| 5 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br>**2.2** Make the link between heat and work<br>**2.3** Calculate the performance of a heat engine. | ▪ Analysis of engine performance using tools (concepts) from thermodynamics such as the first law, the closed system, open system (control volume), the law of conservation of mass, the second law, steady airflow, etc.<br>▪ Identification and use for purposes of analysis, the following thermodynamic variables: pressure, temperature, density, internal energy, enthalpy, entropy, etc. | In class training. | Theory class documents and related activities |

| | | | | |
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| | | ▪ Equation of ideal gases, its limitations, and the related notion of mass heat (constant and variable) | | |
| 6 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br>**2.2** Make the link between heat and work<br>**2.3** Calculate the performance of a heat engine. | ▪ Analysis of engine performance using tools (concepts) from thermodynamics such as the first law, the closed system, | In class training. | Theory class documents and related activities. |
| 7 | | **Exam # 1** | Presential<br>In class | |
| 8 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br>**2.2** Make the link between heat and work<br>**2.3** Calculate the performance of a heat engine. | ▪ Analysis of engine performance using tools (concepts) from thermodynamics.<br>▪ Turboprop performances | In class training. | Theory class documents and related activities. |
| 9 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics | ▪ Analysis of engine performance using tools (concepts) from thermodynamics.<br>▪ Turbofan Performances | In class training. | Theory class documents and related activities. |

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| | **2.2** Make the link between heat and work<br><br>**2.3** Calculate the performance of a heat engine. | | | |
| 10 | **1.** Master simple calculations and units with the ideal gas equation and calculating work.<br>**2.1** Apply the first law of thermodynamics<br><br>**2.2** Make the link between heat and work<br><br>**2.3** Calculate the performance of a heat engine. | ▪ Analysis of engine performance using tools (concepts) from thermodynamics such as the first law, open system (control volume), the law of conservation of mass.<br><br>▪ Identification and use for purposes of analysis, the following thermodynamic variables: pressure, temperature, density, internal energy, enthalpy, entropy, etc.<br><br>▪ Equation of ideal gases, its limitations, and the related notion of mass heat (constant and variable) | In class training. | Theory class documents and related activities. |
| 11 | 3.1 Explain the details related to power cycles.<br><br>3.2 Compare the performance of various aircraft with different types of engines | ▪ Engine efficiency<br><br>▪ Principles of the following cycles: Carnot, Brayton, turbojet, turboprop, turbo fan, geared fan, and their variations (regenerator, post-combustion) | In class training. | Theory class documents and related activities. |
| 12 | 3.1 Explain the details related to power cycles.<br><br>3.2 Compare the performance of various aircraft with different types of engines | ▪ 2e Law of thermodynamics | In class training. | Theory class documents and related activities. |
| 13 | 3.1 Explain the details related to power cycles. | ▪ ECTM performance analysis | In class training. | Theory class documents and related activities. |

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| | 3.2 Compare the performance of various aircraft with different types of engines | | | |
| 14 | 3.1 Explain the details related to power cycles.<br><br>3.2 Compare the performance of various aircraft with different types of engines | ▪ ECTM performance analysis | In class training. | Theory class documents and related activities. |
| 15 | | **Exam # 2** | Presential<br>In class | |

## COURSE PLAN – PRACTICAL WORK

**Activity Periods:** **Throughout the Session**

| Learning Objectives | Content | Personal Study Activities |
|---|---|---|
| **1.1** Define the characteristic curves of various engines: diesel, gasoline and turbine.<br><br>**1.2** Use a variety of measuring instruments. | ▪ Using instruments such as the dynamometer, pressure gauge and densimeter, calculate torque, power, fuel flow, air flow, specific fuel consumption and the fuel/air ratio. | |
| **2.1** Demonstrate the various principles of a cooling/heating system.<br><br>**2.2** Be able to perform certain energy exchange calculations. (Be able to calculate energy exchange.) | ▪ Using pressure and temperature measurements, calculate heat exchange and the performance coefficient. | |
| **3.** Study the effect of fuel/air mixture in a piston engine. | ▪ Calculating the theoretical fuel/air mixture.<br>▪ Measuring and calculating the effects of a different mixture on the exhaust temperature, torque, power and specific fuel consumption. | |
| **4.** Establish energy balances of various piston and turbine engines. | ▪ Measuring and calculating the distribution of fuel energy in an engine. | |
| **5.** Calculate the performance of various turbine engine components. | ▪ Measuring and calculating the power received or produced and the performance of each component, the overall engine thrust. | |

### Practical Work

| WEEK | # OBJECTIVE | CONTENT | MODE OF INSTRUCTION AND LEARNING ACTIVITIES | DOCUMENTATIONS, RESOURCES, TECHNOLOGICAL TOOLS AND URL ADDRESS |
|---|---|---|---|---|
| 1 | 1.1, 1.2,2.1,2.1,3,4,and 5 | ▪ Introduction to engine performances | In class training | Lab class documents and related activities. |
| 2 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Diesel Volvo engine performance | In class training | Lab class documents and related activities.<br>Diesel Volvo engine |

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| 3 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Chrysler engine performance | In class training | Lab class documents and related activities. Chrysler engine |
| 4 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Turbojet sr-30 engine performance | In class training | Lab class documents and related activities. Turbojet sr-30 engine |
| 5 | | **Exam # 1** | Presential in class | Open book exam |
| 6 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Piston vs turbine engine performances | In class training | Lab class documents and related activies. PT6 engine test bench |
| 7 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Air/Fuel mixture on Chrysler engine performance | In class training | Lab class documents and related activities. Chrysler engine |
| 8 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Energy balance on a Chrysler engine | In class training | Lab class documents and related activities. Chrysler engine |
| 9 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Heatpump principles | In class training | Lab class documents and related activities. Lab class heatpump. |
| 10 | | **Exam # 2** | Presential in class | Open book exam |
| 11 | 1.1, 1.2,2.1,2.1,3,4,and 5 | JT-8 performances / Case study | In class training | Lab class documents and related activities. |
| 12 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Aircraft accident/ Case study | In class training | Lab class documents and related activities. |
| 13 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Volkswagen engine performances | In class training | Lab class documents and related activities. |
| 14 | 1.1, 1.2,2.1,2.1,3,4,and 5 | Thrust and traction / Performance calculations | In class training | Lab class documents and related activities. |
| 15 | | **Exam # 3** | Presential in class | Open book exam |

## SYNTHESIS OF EVALUATION METHODS

**Theory**

| Description of the Evaluation Activity | Context | Learning Objective(s) | Evaluation Criteria | Due Date (date assignment is due or exam date) | Weighting (%) |
|---|---|---|---|---|---|
| Performance Analysis of piston engines and turbines | 3 period Individual written exam, with calculator. | 1 and 2 | Precision of calculations. Compliance of units. Accurate analysis of engine performance. | Week 7 | 20% |
| Performance Analysis of piston engines and turbines | 3 period Individual written exam, with calculator. | all | Precision of calculations. Compliance of units. Accurate analysis of engine performance. | Week 15 | 30% |

**Sub-total: 50%**

**Practical Work**

| Description of the Evaluation Activity | Context | Learning Objective(s) | Evaluation Criteria | Due Date (date assignment is due or exam date) | Weighting (%) |
|---|---|---|---|---|---|
| Performance Analysis of piston engines and turbines | 3 period Individual written exam, with calculator | 1, 2 | Precision of calculations. Compliance of units. Accurate analysis of engine performance. | Week 5 | 15% |
| Performance Analysis of piston engines and turbines | 3 period Individual written exam, with calculator | 1, 2, | Precision of calculations. Compliance of units. Accurate analysis of engine performance. | Week 10 | 15% |
| Performance Analysis of piston engines and turbines | 3 period Individual written exam, with calculator | 3, 4, 5 | Precision of calculations. Compliance of units. Accurate analysis of engine performance. | Week 15 | 20% |

**Sub-total: 50%**

**TOTAL: 100%**

## SCHEDULE OF THEORY AND PRACTICE COURSES

| Wk | Theory<br>3 hours | Practice<br>3 hours |
|---|---|---|
| **1** | Introduction to thermodynamics | Introduction to engine performances |
| **2** | Perfect gas law | Volvo diesel engine performances |
| **3** | Power correction<br>Power curves of piston engines | Chrysler gasoline engine performances |
| **4** | Heat | SR-30 Jet fuel engine performances |
| **5** | Work | **Exam 15%** |
| **6** | First law closed system | Piston vs Avgas engine performances |
| **7** | **Exam 20%** | Air/Fuel mixture on Chrysler engine |
| **8** | Turboprop performances | Energy balance on a Chrysler engine |
| **9** | Turbofan Performances | Heatpump principles |
| **10** | First law open system | **Exam 15%** |
| **11** | Engine efficiency | JT-8 performances / Case study |
| **12** | 2$^{e}$ Law of thermodynamics | Aircraft accident/ Case study |
| **13** | ECTM performance analysis | Volkswagen engine performances |
| **14** | ECTM performance analysis | Thrust and traction / Performance calculations |
| **15** | **Final Exam 30%** | **Final Exam 20%** |

The periods of the activities listed in the training plans of the propulsion department are indicative only. Changes could be made to these periods to accommodate logistics issues.

## REQUIRED MATERIAL

SHARP EL 531 calculator.

## MEDIAGRAPHY

Ahmed F. El-Sayed, Aircraft Propulsion and Gas Turbine Engines, CRC Press, 2008

Saeed Faroki, Aircraft Propulsion, John Wiley & Sons, Inc, 2009

VAN Wylen, Thermodynamique appliquée, éd. Renouveau pédagogique, Montréal, 736 p., 1981.

MATTINGLY, JACK D. elements of gaz turbine propulsion, McGraw-hill, inc 1996

Bensimhon V. Fonctionnement hors adaptation des turbomachines Masson, physique fondamentale et appliquée.

Walsh P.P. et Fletcher P. Gas Turbine Performance The American Society of Mechanical Engineers

Wilson David Gordon et Korakianitis Theodosios The Design of High-Efficieny Turbomachinery and Gas Turbines Prentice Hall

## REQUIREMENTS TO PASS THE COURSE

### 1. Passing Mark

The passing mark for this course is 60% by adding the marks for the theory and practical work for the course.

### 2. Tardiness

Students who arrive late after the beginning of the first period of a course are considered absent for this period.

### 3. 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 and written in the course outline. Unexcused tardiness for a summative evaluation could result in being excluded from the activity. Any absence from 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 an 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(s), arrangements will be made between the instructor(s) and the student to make up the activity.

### 4. Submitting Assignments

All assignments must be submitted by the date, hour and location designated by the instructor(s). Late assignments will be penalized 10% per day that they are late and will receive a mark of zero (0) after one week.

## METHODS OF COURSE PARTICIPATION

Workclothes (ENA)
Safety glasses
Safety shoes

**For bimodal classes, add this notice:**
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.

## OTHER DEPARTMENTAL REGULATIONS

Students are encouraged to consult the website for the specific regulations for this course:
http://guideena-en.cegepmontpetit.ca/department-rules/
https://mareussite.cegepmontpetit.ca/ena/mon-parcours/mon-programme/regles-departementales

## 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, 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 Cégep web site at the following address: http://ena.cegepmontpetit.ca/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.

**NOTE:** This Course Outline is a translation of the *Plan de cours* for 280-526-EM: *Analyse de performances aux bancs d'essais*. If there is a discrepancy, then the original French version will be considered the official version for legal purposes.

## THE CENTRE FOR ADAPTED SERVICES - 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 accomodations.

Students seeking these accomodations 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 accomodations they have been awarded by the CSA.