I. INTRODUCTION

A. Since man’s first engine powered flight in 1903, the aircraft powerplant has continued to evolve and improve. This course is a study of reciprocating engines and their theory, development and operating principles. The instruction will include inspection, troubleshooting and repair of engine instruments, lubricating and exhaust systems. Basic safety fundamentals will be covered with each topic.

B. This is a required course of study for the Associate Degree of Applied Science in Aviation Maintenance Technology.

C. This course is occupationally related and serves as preparation for careers in the field of Aviation Maintenance.

D. Prerequisite: Successful completion of all required (G) general aviation maintenance courses.

II. LEARNING OUTCOMES

Upon successful completion of this course, Aircraft Reciprocating Engines, the student will:

Identify the components of a reciprocating engine; demonstrate the proper use of manuals and reference materials; inspect, troubleshoot, check, service and repair engine instrument systems; inspect, service and repair lubrication and exhaust systems; and demonstrate proper safety procedures. (C18,F1-F5,F10)

III. INSTRUCTIONAL MATERIALS

A. The instructional materials identified for this course are viewable through www.ctcd.edu/books

January 2007
B. Supplemental Reading: None


IV. COURSE REQUIREMENTS

The following will be required of each student for successful completion of this course:

A. Reading Assignment: Students are required to complete all reading assignments prior to the class in which the materials will be discussed. Students are subject to announced and unannounced written and oral examinations on assigned reading material.

B. Projects: There will be four graded practical exercises. Projects will be assigned based on instructor’s discretion and availability of resources.

1. Correctly remove a cylinder and piston from an engine.

2. Examine the rings installed on a piston for the correct tension, end gap and side clearance.

3. Using the correct measuring instruments, measure the diameter of journals of a crankshaft and determine whether or not they are within the tolerances allowed by the engine manufacturer.

4. Explain the correct method to start an aircraft reciprocating engine.

C. Class performance: Students are required to attend all classes and to be in the classroom on time. The instructor can lower a student’s grade because of excessive tardiness. When absent from class for any reason, it is the student’s responsibility to arrange for and make up assignments missed during the absence.

D. Class Participation: Students will earn a satisfactory grade in the course by attending and regularly participating in class, giving complete attention to class activities, completion of all assigned work and successfully completing
the examinations. Students are required to maintain a minimum GPA of 2.0 to receive a passing grade for the class and are encouraged to compute and monitor their GPA as the class progresses.

V. EXAMINATIONS

A. There will be three written examinations for this course covering all the lecture notes and reading material. Examination 1 will be given covering material from chapters 1 & 2 “Development of Aircraft Powerplants” and “Reciprocating Engine Theory and Construction”, Examination 2 on chapters 3, 6 & 7 “Lubrication Systems”, “Exhaust Systems” and “Cooling Systems and examination 3 from chapter 16 “Instrument Systems”. 

B. Practicum:
Four graded projects will be administered by the instructor with a point weight of 25 points each.

VI. SEMESTER GRADE COMPUTATION

<table>
<thead>
<tr>
<th>EXAMINATIONS</th>
<th>POINTS</th>
<th>POINT TO GRADE RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXAM 1 Chapter 1&amp;2</td>
<td>300</td>
<td>900-1000 = A</td>
</tr>
<tr>
<td>EXAM 2 Chapter 3, 6&amp;7</td>
<td>300</td>
<td>800-899 = B</td>
</tr>
<tr>
<td>EXAM 3 Chapter 16</td>
<td>300</td>
<td>700-799 = C</td>
</tr>
<tr>
<td>Practicum/Projects 1-4</td>
<td>100</td>
<td>600-699 = D</td>
</tr>
<tr>
<td>TOTAL</td>
<td>1000</td>
<td>0-599 = F</td>
</tr>
</tbody>
</table>

VII. NOTES AND ADDITIONAL INSTRUCTIONS FROM COURSE INSTRUCTOR

A. Course Withdrawal: It is the student’s responsibility to officially drop a class if circumstances prevent attendance. In order to be officially withdrawn from the course, a student must obtain, complete and file an Application for Withdrawal form with the College. The student’s transcript will show “W” or “F”, depending on whether the student was passing or failing at the time of withdrawal.

B. Administrative Withdrawal: Students not meeting course objectives or making satisfactory progress may be withdrawn from the course at the discretion of the instructor.

C. Cellular Phones and Beepers: Cellular phones and beepers will be turned off while the student is in the classroom or laboratory.

D. American’s with Disabilities Act (ADA): Disability Support Services provide services to students who have appropriate documentation of a disability.
Students requiring accommodations for class are responsible for contacting the Office of Disability Support Services (DSS) located on the central campus. This service is available to all students, regardless of location. Explore the website at www.ctcd.edu/disability-support for further information. Reasonable accommodations will be given in accordance with the federal and state laws through the DSS office.

E. **Instructor Discretion:** The instructor reserves the right of final decision in course requirements.

F. **Civility:** Individuals are expected to be cognizant of what a constructive educational experience is and respectful of those participating in a learning environment. Failure to do so can result in disciplinary action up to and including expulsion.

VIII. **COURSE OUTLINE**

A. **Module One: Development of Aircraft Powerplants**

1. **Learning Outcomes:** upon successful completion of this module, the Student will:

   Explain principles of heat engines including early attempts with steam powered engines and later reciprocating and turbine engines.

2. **Learning Activities:**

   Successfully complete examination 1 covering material presented in module 1. (F1,F5,F10)

3. **Module Outline One: Development of Aircraft Powerplants**

   a. Principle of Heat Engines
   b. External-Combustion Engines
   c. Internal-Combustion Engines
   d. Aircraft Reciprocating engines
   e. Aircraft Turbine Engines

B. **Module Two: Reciprocating Engine Theory and Construction**

1. **Learning Outcomes:** upon successful completion of this module, the Student will:
a. Explain energy transformation.

b. Discuss constant-volume cycle of energy release in the four-stroke and two stroke reciprocating engines.

c. Explain work-power considerations and the measurement of horsepower.

d. Explain factors affecting engine power.

2. **Learning Activities:**

   Successfully complete examination 1 covering material presented in Module 2. (F1,F4,F5,F10,F12)

3. **Module Outline Two: Reciprocating Engine Theory**

   a. **Energy Transformation**
      1. The Constant-Volume Cycle of Energy Release
         a) Four-Stroke, Five-Event Cycle
         b) Two-Stroke Cycle
      2. Work-Power Considerations
         a) Work
         b) Power
         c) Horsepower of a Reciprocating Engine
            1) Indicated Horsepower
            2) Friction Horsepower
            3) Brake Horsepower
         d) Factors Affecting Engine Power
            1) Thermal Efficiency
            2) Volumetric Efficiency
            3) Mechanical Efficiency
            4) Piston Displacement
            5) Compression Ratio
            6) Ignition Timing
      e) Power Variations with Altitude
      f) Engine Thrust
      g) Specific Fuel Consumption

C. **Module Three: Reciprocating Engine Requirements**

   1. **Learning Outcomes:** upon successful completion of this module, the Student will:
a. Explain aircraft engine cylinder arrangements, numbering sequence and firing order for each type of arrangement.

b. Discuss engine cooling and lubricating systems.

c. Explain typical engine identification lettering and numbering.

2. Learning Activities:

Successfully complete examination 1 covering material presented in Module 3. (F1,F5,F10)

3. Module Outline Three: Reciprocating Engine Configurations

a. Cylinder Arrangement
   1. In-line Engines
   2. V-Engines
   3. Radial Engines
   4. Horizontally Opposed Engines

b. Cylinder Numbering
   1. Radial Engines
   2. In-Line and V-Engines
   3. Horizontally Opposed Engines

c. Firing Order
   1. Radial Engines
   2. In-Line and V-Engines
   3. Horizontally Opposed Engines

d. Cooling Systems
   1. Liquid Cooling
   2. Air Cooling
   3. Lubrication Systems
   4. Engine Identification

D. Module Four: Horizontally Opposed Engine Construction

1. Learning Outcomes: upon successful completion of this module, the Student will:

   a. Explain the current production configurations of cylinders.

   b. Explain cylinder head construction and assembly methods used in attaching the head to the cylinder.

   c. Explain the types of valves used in reciprocating engines and associated hardware incorporated into the cylinder head.
d. Discuss construction of pistons, connecting rods and associated hardware.

e. Explain the construction of crankshafts, counterweights, propeller shafts and propeller reduction gearing.

f. Explain the typical crankcase construction, bearing surfaces, seals, camshafts and valve operating mechanisms.

2. Learning Activities:

   a. Successfully complete examination 1 covering material presented in Module 4. (F1,F5,F10)

   b. Complete projects: 1-3. (C18,F1,F5,F10)

3. Equipment and Materials:


   b. Hand tools and special tools (valve spring compressors, piston ring compressors, piston ring remover/installer, dial indicator, thickness gauges, micrometers, “T” gauges and torque wrenches) required for removal/reinstallation of major components: cylinders, valves, crankshafts, cam shafts and pistons and piston rods.

   c. Shop towels and hand cleaner.

4. Module Outline Four: Horizontally Opposed Engine Construction

   a. Cylinders
      1. Cylinder barrels
      2. Cylinder Heads

   b. Valve Assemblies
      1. Valves
      2. Valve Guides
      3. Valve Seats
      4. Valve Springs and Retainers

   c. Pistons
      1. Wrist Pins
      2. Piston Rings
         a) Compression Rings
b) Oil Control Rings  
c) Oil Wiper or Scraper Rings

3. Connecting Rods

4. Crankshaft  
a) Propeller Attachment  
b) Dynamic Dampers

5. Propeller Reduction Gearing  
a) External Spur-Type Reduction Gearing  
b) Internal Spur-Type Reduction Gearing  
c) Planetary (Epicyclic) Reduction Gearing  
1) Bevel Planetary Gears  
2) Spur Planetary Gears

6. Crankcase  
a) Bearings  
b) Crankcase Oil Seals

7. Valve Operating Mechanism  
a) Camshaft  
b) Valve Lifters  
1) Hydraulic Valve Lifters  
c) Pushrods  
d) Rocker Arms

E. Module Five: Radial Engine Construction

1. Learning Outcomes: upon successful completion of this module, the Student will:

   a. Explain the properties of radial engine cylinders, crankcases, crankshafts, connecting rods and propeller reduction gearing.

   b. Explain valve operating mechanisms.

   c. Discuss supercharger function on radial engines.

2. Learning Activities:

   Successfully complete examination 1 covering material presented in Module 5. (F1,F5,F10)

3. Equipment and Materials:

b. Hand tools and special tools (valve spring compressors, piston ring compressors, piston ring remover/installer, dial indicator, thickness gauges, micrometers, “T” gauges and torque wrenches) required for removal/reinstallation of major components: cylinders, valves, crankshafts, cam shafts and pistons and piston rods.

c. Shop towels and hand cleaner.

5. **Module Outline Five**: Radial Engine Construction

   a. Cylinders
   b. Crankcase
   c. Connecting Rods
   d. Propeller Reduction Gearing
   e. Bearings
   f. Valve Operating Mechanisms
      1. Hot Valve Clearance
      2. Cold Valve Clearance
      3. Valve Adjustment: Engines with Floating Cam Rings
   g. Supercharger

F. **Module Six**: Lubrication Systems

1. **Learning Outcomes**: upon successful completion of this module, the Student will:

   a. Explain five benefits of lubrication in aircraft engines.
   b. Explain properties of organic and synthetic aircraft lubricating oil.
   c. Discuss types of reciprocating engine lubrication systems.
   d. Explain lubricating system components and component functions.
   e. Discuss lubrication system instrumentation.
   f. Explain how spectrometric oil analysis is used in monitoring component wear.

2. **Learning Activities**:
Successfully complete examination 2 covering material presented in Module 6. (F1,F5,F10)

3. **Module Outline Six: Lubrication Systems**

a. Function of the Lubrication System
   1. Reduces Friction
   2. Seals and Cushions
   3. Removes Heat
   4. Cleans Inside of Engine
   5. Protects Against Corrosion
   6. Performs Hydraulic Action

b. Reciprocating Engine Lubricating Oils
   Characteristics of the Reciprocating Engine Lubricating Oil
   a) Viscosity
   b) Viscosity Index
   c) Gravity
   d) Ignition Points
   e) Low-Temperature Points
   f) Color
   g) Residue

c. Types of Reciprocating Engine Lubricating Oil
   1. Straight Mineral Oil
   2. Metallic-Ash Detergent Oil
   3. Ashless-Dispersant Oil
   4. Multiviscosity Oil
   5. Synthetic Oil
   6. Semisynthetic Oil
   7. Extreme Pressure (EP) Lubricants

d. Compatibility of Lubricating Oils

e. Reciprocating Engine Lubrication Systems
   Types of Lubrication Systems
   a) Oil Supply Storage
      1) Wet-Sump
      2) Dry-Sump
   b) Internal Lubrication

f. Lubrication Systems Components
   1. Pumps
      a) Spur-Gear Pump
      b) Gerotor Pump
   2. Pressure Relief Valve
   3. Oil Filter Systems
   4. Oil Filter Elements
   5. Oil Coolers
6. Oil Reservoirs  
   a) Wet-Sump  
   b) Dry-Sump  

7. Lubrication System Instrumentation  
   a) Oil Pressure Measurement  
   b) Oil Temperature Measurement  
   g) Spectrometric Oil Analysis

G. Module Seven: Exhaust Systems

1. Learning Outcomes: upon successful completion of this module, the Student will:
   a. Discuss the evolution of reciprocating engine exhaust systems.  
   b. Explain how cabin and carburetor heat are provided.  
   c. Explain the use of mufflers.  
   d. Discuss the function of augmentor tubes.  
   e. Explain how turbochargers and power recovery turbines affect engine performance.  
   f. Perform exhaust system inspections and repairs.

2. Learning Activities:

   Successfully complete examination 2 covering material presented in Module 7. (F1,F5,F10)

3. Equipment and Materials:

   a. Operational reciprocating engine with exhaust system components installed in an airframe and maintenance manual.  
   b. Basic hand tools, safety wire, goggles, shop towels and hand cleaner.

4. Module Outline Seven: Exhaust Systems  
   a. Evolution of Reciprocating Engine Exhaust Systems  
   c. Mufflers  
   d. Augmentor Tubes
e. Power Recovery Devices
   1. Turbochargers
   2. Power Recovery Turbines
f. Exhaust System Inspection and Repair
   1. Carbon Monoxide Detection
   2. Exhaust System Inspection
   3. Exhaust System Repairs

H. Module Eight: Instrument Systems

1. **Learning Outcomes:** upon successful completion of this module, the Student will:

   a. Discuss the evolution of powerplant instruments.
   b. Explain different types of pressure and pressure measuring instruments.
   c. Explain temperature measuring instruments for reciprocating and turbine engines.
   d. Discuss mechanical movement instruments including tachometers, fuel flow meters and torque meters.
   e. Demonstrate proper handling, installation and marking of powerplant instruments.
   f. Discuss various digital indicating and control systems associated with powerplant systems.

2. **Learning Activities:**

   a. Successfully complete examination 3 covering material presented in Module 8. (F1,F5,F10)
   b. Complete project:1- 4. (C18,F1,F5,F10)

3. **Equipment and Materials:**

   a. Operational reciprocating engine aircraft with all instruments operational and operators and maintenance manuals.
   b. Basic hand tools, safety wire, goggles, shop towels and hand cleaner.

4. **Module Outline Eight:** Instrument Systems
a. The Evolution of Powerplant Instruments
b. Types of Powerplant Instruments
   1. Pressure Measurement
   2. Types of Pressure
      a) Absolute Pressure
      b) Gage Pressure
      c) Differential Pressure
      d) Total Pressure
      e) Dynamic Pressure
      f) Static Pressure
c. Pressure-Measuring Instruments
   1. Engine Lubricating Oil Pressure
   2. Pressure Gage—Measuring Oil Temperature
   3. Fuel Pressure
   4. Fuel Pressure Warning System
   5. Pressure Gage—Measuring Fuel Flow
   6. MAP (Manifold Absolute Pressure)
   7. EPR (Engine Pressure Ratio)
d. Temperature Instruments
   1. Ratiometer Instruments
   2. Thermocouple Instruments
      a) CHT (Reciprocating Engine Cylinder Head Temperature)
      b) EGT (Reciprocating Engine Exhaust Gas Temperature)
      c) EGT (Turbine Engine Exhaust Gas temperature)
e. Mechanical Movement
   1. Tachometers
      a) Mechanical Tachometers
      b) Electric Tachometers
   2. Synchroscopes
   3. Fuel Flowmeters for Large Reciprocating Engines
   4. Flowmeters for Turbine Engines
   5. Torquemeters
f. Powerplant Instrument Marking, Installation and Maintenance
   1. Instrument Range Marking
   2. Instrument Installation
   3. Instrument Handling
g. Electronic Instruments
   1. Digital Indicating and Control Systems
      Microcomputers
   2. Computerized Fuel System
3. **EICAS (Engine Indication and Crew Alerting System)**