

# **Engineering Software**

P.O. Box 1180, Germantown, MD 20875

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E-Mail: info@engineering-4e.com

Web Site: http://www.engineering-4e.com

## **Power and Propulsion Systems Analysis 1.1 - Help**

### **Program Description**

### **Claim Sheet**

### **How to Use the Program**

### **Limited Warranty**

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### **License Agreement**

### **Properties**

**Temperature - Pressure**

**Enthalpy - Pressure**

**Entropy - Pressure**

### **Power Cycles**

**Carnot**

**Brayton**

**Power (Ideal)**

**Power (Real)**

**Propulsion (Ideal)**

**Propulsion (Real)**

**Rankine**

**Otto**

**Power (Ideal)**

**Power (Real)**

**Diesel**

**Power (Ideal)**

**Power (Real)**

### **Power Cycle Components/Processes**

**Compression**

**Isentropic (Ideal)**

**Isentropic (Real)**

**Isothermal**

**Combustion**

**Coal/Oil**

Gas

Expansion

Isentropic (Ideal)

Isentropic (Real)

Isothermal

Compressible Flow

Velocity of Sound

Mach Number

Properties

Stagnation

Static

Nozzle

Ideal

Real

Normal Shock

Diffuser

Ideal

Real

Thrust

Ideal

Real

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## **Program Description**

**Engineering Software** has developed a new Windows based software package, **Power and Propulsion Systems Analysis**, that quickly and reliably calculates thermodynamic and transport properties of gaseous, liquid and solid species, analyzes power cycles, power cycle components/processes and compressible flow.

This software package should prove to be a good tool for those who are involved at various levels with design, operation and management of energy conversion systems. It should provide you with the opportunity to more quickly and effectively do your work, explore more options, save time and give more confidence in carrying out your calculations.

To get a free evaluation copy of the program, place an order, find out more about how you can profit or benefit from this software package, please send an e-mail to **[info@engineering-4e.com](mailto:info@engineering-4e.com)** or call **(301) 540-3605**.

### **Thermodynamic and Transport Properties**

Temperature and Pressure ( $270\text{ K} < T < 5,000\text{ K}$ )

Enthalpy and Pressure

Entropy and Pressure

### **Power Cycles**

Carnot

Brayton (Power and Propulsion)

Rankine

Otto

Diesel

### **Power Cycle Components/Processes**

Compression

Combustion (Coal/Oil/Gas)

Expansion

### **Compressible Flow**

Velocity of Sound

Mach Number

Properties (Stagnation and Static)

Nozzle

Normal Shock

Diffuser

Thrust

**Hardware Requirements and Software Compatibility**

80486 or higher microprocessor

16 MB RAM

10 MB available on hard drive

IBM compatible systems:

Microsoft® Windows 98®, Windows 2000®, Windows ME®,  
Windows XP® and Windows Vista®

Note: Required Microsoft® Office 2007® (Microsoft® Access 2007®) for Windows Vista operating system!

Distributed on CD ROM

Free Technical and Product Support

30 Day Money Back Guarantee

Trademarks: All product names, company names and service marks are trademarks or registered trademarks of their respective companies.

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## **Claim Sheet**

**Engineering Software** products allow quick and reliable calculation of thermodynamic and transport properties of gaseous, liquid and solid species, contain coefficients for the calculation of physical properties, steam approximations for both saturated and superheated areas, analyze power cycles, power cycle components/processes and compressible flow.

The aforementioned engineering calculations are valid under the following assumptions:

### **Thermodynamic and Transport Properties**

Single species consideration

Ideal gas approach is used ( $pV=RT$ )

Specific heat is not constant

Coefficients describing thermodynamic and transport properties were obtained from the NASA Glenn Research Center at Lewis Field in Cleveland, OH -- such coefficients conform with the standard reference temperature of 298.15 K (77 F) and the JANAF tables

### **Power Cycles**

Single species consideration -- fuel mass flow rate ignored and its impact on the properties of the working fluid

Basic equations hold (continuity, momentum and energy equations)

Specific heat is constant

### **Power Cycle Components/Processes**

Single species consideration

Basic equations hold (continuity, momentum and energy equations)

Specific heat is constant

### **Compressible Flow**

Single species consideration

Basic equations hold (continuity, momentum and energy equations)

Specific heat is constant

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## **How to Use the Program**

In each section, subsection of the **Power and Propulsion Systems Analysis** program, the user needs to change one or more input values in order to calculate a new case. Input values are in boxes with white background and can be changed by clicking on each individual box or even by using the arrow keys and changing the current value. Output values cannot be modified, changed by the user and they are in boxes with black background.

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## **Limited Warranty**

This software package is sold **AS IS**, without warranty as to its performance. The entire risk (as to) the quality and of the performance of this computer software program is assumed by the user.

However, to the original purchaser only, **Engineering Software** warrants the medium on which the program is recorded to be free from defects in materials and faulty workmanship under normal use and service for a period of thirty (30) days from the date of purchase. If during this period a defect on the medium should occur, the medium may be returned to **Engineering Software** or to an authorized **Engineering Software** distributor, and **Engineering Software** will replace the medium without charge to you. Your sole and exclusive remedy in the event of a defect is expressly limited to replacement of the medium as provided above.

If the failure of the medium, in the judgment of **Engineering Software** resulted from accident, abuse, or misapplication of the medium, then **Engineering Software** shall have no responsibility to replace the medium under the terms of this warranty.

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### **Suggestion/Evaluation Form**

Please FAX or Mail This Suggestion/Evaluation Form To:

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Name:

Title:

Company/Organization:

Street Address:

City:

State:

Zip:

Phone:

FAX:

E-Mail:

#### **Power and Propulsion Systems Analysis**

Quality:

Usefulness:

Possible areas of improvement:

Other suggestions:

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## **License Agreement**

This software is the property of **Engineering Software** and is protected by federal copyright law. While **Engineering Software** continues to own the software, you will have certain rights to use the software after your acceptance of this license. Your rights and obligations with respect to the use of this software are as follows:

You may:

- use one copy of the software on a single computer,
- make one copy of the software for backup purposes, and
- use the software on a network, provided that you have a licensed copy of the software for each computer that can access the software over the network

You may not:

- copy the documentation which accompanies the software,
- sublicense, rent or lease any portion of the software, and
- reverse engineer, decompile, disassemble, modify, translate, make any attempt to discover the source code of the software, or create derivative works from the software

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## **Properties**

This section provides physical properties of available species for assigned two state values such as: temperature and pressure, enthalpy and pressure, and entropy and pressure. Physical properties are given in both U.S. customary and International units.

Note: Physical properties for H<sub>2</sub>O(S), H<sub>2</sub>O(L) and H<sub>2</sub>O(G) are available. The accuracy of the available H<sub>2</sub>O properties is only good for the purpose of combustion calculation. Therefore, this indicates that steam table calculations are not available.

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### **Properties: Temperature - Pressure**

This subsection provides physical properties of the selected species for assigned temperature and pressure.

Input Values:

Species, Temperature, Pressure

Output Values:

Physical Properties

Assumptions:

Specific heat is not constant

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### **Properties: Enthalpy - Pressure**

This subsection provides physical properties of the selected species for assigned enthalpy and pressure.

Input Values:

Species, Enthalpy, Pressure

Output Values:

Physical Properties

Assumptions:

Specific heat is not constant

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### **Properties: Entropy - Pressure**

This subsection provides physical properties of the selected species for assigned entropy and pressure.

Input Values:

Species, Entropy, Pressure

Output Values:

Physical Properties

Assumptions:

Specific heat is not constant

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### **Power Cycles**

This section provides analysis of a few power cycles (Carnot, Brayton, Rankine, Otto and Diesel).

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### **Power Cycles: Carnot**

This subsection provides analysis of the Carnot cycle.

Input Values:

Heat Addition Temperature, Heat Rejection Temperature

Output Values:

Cycle Efficiency, Heat Rate

Assumptions:

Isentropic compression and expansion. Heat addition and rejection occur at constant temperature. Specific heat is constant.

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### **Power Cycles: Brayton**

This subsection provides analysis of the Brayton cycle for both power generation and propulsion applications.

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### **Power Cycles: Brayton: Power (Ideal)**

This subsection provides analysis of the Brayton cycle for the power generation application.

#### Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Compressor Inlet Temperature, Compressor Inlet Pressure, Turbine Inlet Temperature, Turbine Inlet Pressure, Fuel HHV

#### Output Values:

Power Output, Fuel Consumption, Cycle Efficiency, Heat Rate

#### Assumptions:

Isentropic compression and expansion. Ideal combustion, heat transfer. Fuel mass flow rate is ignored when calculating the gas turbine power output. No pressure loss. Specific heat is constant.

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### **Power Cycles: Brayton: Power (Real)**

This subsection provides analysis of the Brayton cycle for the power generation application.

#### Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Compressor Inlet Temperature, Compressor Inlet Pressure, Turbine Inlet Temperature, Turbine Inlet Pressure, Fuel HHV, Compressor Isentropic Efficiency, Turbine Isentropic Efficiency, Combustor Efficiency

#### Output Values:

Power Output, Fuel Consumption, Cycle Efficiency, Heat Rate

#### Assumptions:

Isentropic compression and expansion. Ideal combustion, heat transfer. Fuel mass flow rate is ignored when calculating the gas turbine power output. No pressure loss. Specific heat is constant.

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### **Power Cycles: Brayton: Propulsion (Ideal)**

This subsection provides analysis of the Brayton cycle for the propulsion application.

#### Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Compressor Inlet Temperature, Compressor Inlet Pressure, Turbine Inlet Temperature, Turbine Inlet Pressure, Fuel HHV

#### Output Values:

Thrust, Fuel Consumption

#### Assumptions:

Isentropic compression and expansion. Ideal combustion, heat transfer. Fuel mass flow rate is ignored when calculating the gas turbine power output. Ambient pressure is equal to compressor inlet pressure. No pressure loss. Specific heat is constant.

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### **Power Cycles: Brayton: Propulsion (Real)**

This subsection provides analysis of the Brayton cycle for the propulsion application.

#### Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Compressor Inlet Temperature, Compressor Inlet Pressure, Turbine Inlet Temperature, Turbine Inlet Pressure, Fuel HHV, Compressor Isentropic Efficiency, Turbine Isentropic Efficiency, Combustor Efficiency

#### Output Values:

Thrust, Fuel Consumption

#### Assumptions:

Isentropic compression and expansion. Ideal combustion, heat transfer. Fuel mass flow rate is ignored when calculating the gas turbine power output. Ambient pressure is equal to compressor inlet pressure. No pressure loss. Specific heat is constant.

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### **Power Cycles: Rankine**

This subsection provides analysis of the Rankine cycle.

Input Values:

Turbine Inlet Conditions (Temperature and Pressure), Steam Mass Flow Rate, Fuel HHV

Output Values:

Power Output, Fuel Consumption, Cycle Efficiency, Heat Rate

Assumptions:

Isentropic compression and expansion. Ideal combustion and heat transfer.

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### **Power Cycles: Otto**

This subsection provides analysis of the Otto cycle for power applications.

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### **Power Cycles: Otto (Ideal)**

This subsection provides analysis of the Otto cycle.

#### Input Values:

Working Fluid, Ambient Temperature, Ambient Pressure, Compression Ratio, Combustion Temperature, Number of Revolutions, Fuel HHV  
Number of Cylinders, Cylinder Stroke, Stroke to Diameter Ratio

#### Output Values:

Compression Temperature, Compression Pressure, Combustion Pressure, Exhaust Temperature, Exhaust Pressure, Cycle Efficiency, Working Fluid Mass Flow Rate, Heat Rate, Power Output, Fuel Consumption

#### Assumptions:

Specific heat is constant. Four stroke engine.

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### **Power Cycles: Otto (Real)**

This subsection provides analysis of the Otto cycle.

#### Input Values:

Working Fluid, Ambient Temperature, Ambient Pressure, Compression Ratio, Combustion Temperature, Number of Revolutions, Fuel HHV, Number of Cylinders, Cylinder Stroke, Stroke to Diameter Ratio, Compression Isentropic Efficiency, Combustion Efficiency, Expansion Isentropic Efficiency

#### Output Values:

Compression Temperature, Compression Pressure, Combustion Pressure, Exhaust Temperature, Exhaust Pressure, Cycle Efficiency, Working Fluid Mass Flow Rate, Heat Rate, Power Output, Fuel Consumption

#### Assumptions:

Specific heat is constant. Four stroke engine

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### **Power Cycles: Diesel**

This subsection provides analysis of the Diesel cycle for power applications.

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### **Power Cycles: Diesel (Ideal)**

This subsection provides analysis of the Diesel cycle.

#### Input Values:

Working Fluid, Ambient Temperature, Ambient Pressure, Compression Ratio, Cut-Off Ratio, Number of Revolutions, Fuel HHV, Number of Cylinders, Cylinder Stroke, Stroke to Diameter Ratio

#### Output Values:

Compression Temperature, Compression Pressure, Combustion Temperature, Combustion Pressure, Exhaust Temperature, Exhaust Pressure, Cycle Efficiency, Working Fluid Mass Flow Rate, Heat Rate, Power Output, Fuel Consumption

#### Assumptions:

Specific heat is constant. Four stroke engine.

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### **Power Cycles: Diesel (Real)**

This subsection provides analysis of the Diesel cycle.

#### Input Values:

Working Fluid, Ambient Temperature, Ambient Pressure, Compression Ratio, Cut-Off Ratio, Number of Revolutions, Fuel HHV, Number of Cylinders, Cylinder Stroke, Stroke to Diameter Ratio, Compression Isentropic Efficiency, Combustion Efficiency, Expansion Isentropic Efficiency

#### Output Values:

Compression Temperature, Compression Pressure, Combustion Temperature, Combustion Pressure, Exhaust Temperature, Exhaust Pressure, Cycle Efficiency, Working Fluid Mass Flow Rate, Heat Rate, Power Output, Fuel Consumption

#### Assumptions:

Specific heat is constant. Four stroke engine.

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### **Power Cycle Components/Processes**

This section provides analysis of power cycle components/processes (compression, combustion and expansion).

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### **Power Cycle Components/Processes: Compression**

This subsection provides analysis of compression.

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### **Power Cycle Components/Processes: Compression: Isentropic (Ideal)**

This subsection provides analysis of isentropic compression.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Inlet Temperature, Inlet Pressure, Outlet Pressure

Output Values:

Power Input, Outlet Temperature

Assumptions:

Isentropic compression. Specific heat is constant.

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### **Power Cycle Components/Processes: Compression: Isentropic (Real)**

This subsection provides analysis of isentropic compression.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Inlet Temperature, Inlet Pressure, Outlet Pressure, Compressor Isentropic Efficiency

Output Values:

Power Input, Outlet Temperature

Assumptions:

Isentropic compression. Specific heat is constant.

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### **Power Cycle Components/Processes: Compression: Isothermal**

This subsection provides analysis of isothermal compression.

Input Values:

Working Fluid, Working Fluid Mass, Inlet/Outlet Temperature,  
Inlet Pressure, Outlet Pressure

Output Values:

Inlet Volume, Outlet Volume, Outlet Density

Assumptions:

Isothermal compression

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### **Power Cycle Components/Processes: Combustion**

This subsection provides analysis of combustion.

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### **Power Cycle Components/Processes: Combustion: Coal/Oil**

This subsection provides analysis of the combustion process when coal or oil are considered as the fuel.

#### Input Values:

Fuel Composition, Fuel Temperature, Oxidant Composition, Oxidant Temperature, Stoichiometry, Combustion Efficiency

#### Output Values:

Fuel HHV, Fuel Enthalpy, Oxidant Enthalpy, Oxidant to Fuel Ratio, Flame Temperature, Combustion Gas Composition

#### Assumptions:

Complete combustion. No gas dissociation. No heat loss.

Specific heat is not constant.

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### **Power Cycle Components/Processes: Combustion: Gas**

This subsection provides analysis of the combustion process when gas is considered as the fuel.

#### Input Values:

Fuel Composition, Fuel Temperature, Oxidant Composition, Oxidant Temperature, Stoichiometry, Combustion Efficiency

#### Output Values:

Fuel HHV, Fuel Enthalpy, Oxidant Enthalpy, Oxidant to Fuel Ratio, Flame Temperature, Combustion Gas Composition

#### Assumptions:

Complete combustion. No gas dissociation. No heat loss.

Specific heat is not constant.

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### **Power Cycle Components/Processes: Expansion**

This subsection provides analysis of expansion.

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### **Power Cycle Components/Processes: Expansion: Isentropic (Ideal)**

This subsection provides analysis of isentropic expansion.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Inlet Temperature, Inlet Pressure, Outlet Pressure

Output Values:

Outlet Temperature, Power Output

Assumptions:

Isentropic expansion. Specific heat is constant.

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### **Power Cycle Components/Processes: Expansion: Isentropic (Real)**

This subsection provides analysis of isentropic expansion.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Inlet  
Temperature, Inlet Pressure, Outlet Pressure, Turbine Isentropic  
Efficiency

Output Values:

Outlet Temperature, Power Output

Assumptions:

Isentropic expansion. Specific heat is constant.

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### **Power Cycle Components/Processes: Expansion: Isothermal**

This subsection provides analysis of isothermal expansion.

Input Values:

Working Fluid, Working Fluid Mass, Inlet/Outlet Temperature,  
Inlet Pressure, Outlet Pressure

Output Values:

Inlet Volume, Outlet Volume, Outlet Density

Assumptions:

Isothermal expansion

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### **Compressible Flow**

This section provides analysis of compressible flow.

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### **Compressible Flow: Velocity of Sound**

This subsection provides analysis of velocity of sound.

Input Values:

Working Fluid, Temperature

Output Values:

Velocity of Sound

Assumptions:

Specific heat is constant

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### **Compressible Flow: Mach Number**

This subsection provides analysis of Mach Number.

Input Values:

Working Fluid, Temperature, Velocity

Output Values:

Mach Number

Assumptions:

Specific heat is constant

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### **Compressible Flow: Properties**

This subsection provides analysis of stagnation and static properties in the case of compressible flow.

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### **Compressible Flow: Properties: Stagnation**

This subsection provides analysis of stagnation properties.

Input Values:

Working Fluid, Static Temperature, Velocity

Output Values:

Stagnation Temperature, Stagnation Pressure

Assumptions:

Specific heat is constant

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### **Compressible Flow: Properties: Static**

This subsection provides analysis of static properties.

Input Values:

Working Fluid, Stagnation Temperature, Velocity

Output Values:

Static Temperature, Static Pressure

Assumptions:

Specific heat is constant

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### **Compressible Flow: Nozzle**

This subsection provides analysis of nozzle.

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### **Compressible Flow: Nozzle (Ideal)**

This subsection provides analysis of nozzle.

Input Values:

Working Fluid, Stagnation Temperature, Stagnation Pressure, Velocity

Output Values:

Static Temperature, Static Pressure, Mach Number

Assumptions:

Specific heat is constant

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### **Compressible Flow: Nozzle (Real)**

This subsection provides analysis of nozzle.

Input Values:

Working Fluid, Stagnation Temperature, Stagnation Pressure, Ideal Velocity,  
Nozzle Efficiency

Output Values:

Ideal Static Temperature, Static Pressure, Ideal Mach Number, Static  
Temperature, Mach Number, Velocity

Assumptions:

Specific heat is constant

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### **Compressible Flow: Normal Shock**

This subsection provides analysis of normal shock.

Input Values:

Working Fluid, Inlet Stagnation Temperature, Inlet Stagnation Pressure, Inlet Velocity

Output Values:

Inlet Static Temperature, Inlet Static Pressure, Inlet Mach Number  
Outlet Stagnation Temperature, Outlet Stagnation Pressure, Outlet Velocity, Outlet Static Temperature, Outlet Static Pressure, Outlet Mach Number

Assumptions:

Specific heat is constant

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### **Compressible Flow: Diffuser**

This subsection provides analysis of diffuser.

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### **Compressible Flow: Diffuser (Ideal)**

This subsection provides analysis of diffuser.

Input Values:

Working Fluid, Static Temperature, Static Pressure, Velocity

Output Values:

Mach Number, Stagnation Temperature, Stagnation Pressure

Assumptions:

Specific heat is constant

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### **Compressible Flow: Diffuser (Real)**

This subsection provides analysis of diffuser.

Input Values:

Working Fluid, Static Temperature, Static Pressure, Velocity,  
Diffuser Efficiency

Output Values:

Mach Number, Ideal Stagnation Temperature, Stagnation Pressure,  
Stagnation Temperature

Assumptions:

Specific heat is constant

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### **Compressible Flow: Thrust**

This subsection provides analysis of thrust.

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### **Compressible Flow: Thrust (Ideal)**

This subsection provides analysis of thrust.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Stagnation Temperature,  
Stagnation Pressure, Velocity, Ambient Pressure

Output Values:

Static Temperature, Static Pressure, Mach Number, Thrust

Assumptions:

Specific heat is constant

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### **Compressible Flow: Thrust (Real)**

This subsection provides analysis of thrust.

Input Values:

Working Fluid, Working Fluid Mass Flow Rate, Stagnation Temperature, Stagnation Pressure, Ideal Velocity, Ambient Pressure, Thrust Efficiency

Output Values:

Ideal Static Temperature, Static Pressure, Ideal Mach Number, Thrust, Static Temperature, Velocity, Mach Number

Assumptions:

Specific heat is constant