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AEROSPACE

Fundamentals of Gas Dynamics

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Course Description

The Fundamentals of Gas Dynamics (FGD) short course is an introductory training experience in compressible flow. Course material provides a solid understanding of elementary compressible flow principles and processes.

This course equips participants with the analytical tools needed to perform basic compressible flow calculations for a wide variety of flow problems. Instruction delves into the meaning and significance of the governing mass, momentum and energy conservation laws which form the theoretical framework of gas dynamics.

Participants will come to understand the manner in which velocity, Mach number, pressure, density, temperature and other key flow parameters vary through shock waves and expansion waves. They will also gain a basic knowledge concerning the defining features of classic gas dynamic models including calorically-perfect, thermally-perfect and chemically-reacting gases. Other classic topics include shock polars, pressure-deflection diagrams and conical flow.

Course material also provides an in-depth examination of the theory and application of isentropic flows, flow frictional effects (Fanno Flow) and flows with heat addition (Rayleigh Flow). Furthermore, participants will acquire the knowledge and analytical skills to solve a myriad of variable-density flow problems including rocket nozzle, blow-down wind tunnel and propulsion system flows.

Key Course Topics

- Conservation of Mass
- Conservation of Momentum
- Conservation of Energy
- Calorically-Perfect Gas
- Thermally-Perfect Gas
- Isentropic Flow
- Thermodynamics
- Normal Shock Relations
- Hugoniot Equation
- Oblique Shock Relations
- Shock Polars
- Rayleigh Flow
- Fanno Flow
- Area-Velocity Relation
- Pressure-Deflection Diagrams
- Expansion Waves
- Prandtl-Meyer Relations
- Conical Flow
- Blunt Body Flows
- Prandtl Singularities
- High Temperature Effects

Course Outline

Fundamentals of Gas Dynamics (FGD) is intended for the aerospace professional seeking a comprehensive training experience in rudimentary compressible flow principles and processes.

Fundamentals of Gas Dynamics Module Overview

Day	Module	Lecture Title	Key Topics
1	1	Introduction to Compressible Flow	Continuum concept, Perfect Gas Law, Mach regimes, internal energy, enthalpy, entropy, specific heats.
	2	The Conservation Equations: Integral Forms	Continuity equation, momentum equation, energy equation, control volume, infinitesimal fluid element.
	3	One-Dimensional Flow	Normal shock, steady flow, mass, momentum, energy, speed of sound, Mach number, adiabatic, stagnation.
2	4	Normal Shock Waves	Conservation equations, normal shock relations, velocity, pressure, temperature, density, Hugoniot Equation.
	5	One-Dimensional Flows: Heat Addition and Friction Effects	Rayleigh Flow, Fanno Flow, governing equations, property trends, duct flows, thermal choking, frictional choking.
	6	Oblique Shock Waves	Conservation equations, shock polar, pressure-deflection diagram, shock wav intersection, shock wave reflection.
3	7	Prandtl-Meyer Expansion	Governing equations, flow expansion, Prandtl-Meyer Function, Shock-Expansion Theory, shock wave drag.
	8	Quasi-One-Dimensional Flow	Duct flows, governing equations, Velocity-Area Relation, Area-Mach Relation, nozzles, diffusers, choked flow.
4	9	The Conservation Equations: Differential Forms	Conservation form, Non-Conservation form, Substantial derivative, Entropy Equation, Crocco's Theorem, Acoustics.
	10	Conical and Blunt Body Flows	Newtonian Theory, Taylor-Maccoll Equation, axisymmetric flow, bow shock shapes, rotationality, NASA SP-3004.