



WHITE EAGLE
AEROSPACE



Fundamentals of Gas Dynamics

MAKE YOUR CAREER SOAR

Welcome

Thank you very much for your interest in White Eagle Aerospace. Since our founding in 2006, we have become a trusted leader in professional technical training and education throughout the aerospace industry.

As a fellow aerospace professional with nearly 40 years of industry experience, I understand the critical need for ongoing technical training in the workplace. White Eagle Aerospace was established in order to meet this pressing need.

For many years, we have recognized a looming crisis in the aerospace workforce. Throughout the industry, there is an increasingly bimodal distribution of aerospace professionals. One end of that distribution contains young, well trained, highly motivated, but very inexperienced professionals. The other end of that distribution involves individuals who have been around for a long time, have a great deal of experience and are on their way out of their chosen profession. This leaves a valley between the two.

Who is going to pass the baton to the upcoming generation of aerospace professionals? Where will they get their knowledge – knowledge that goes beyond academia and even graduate degrees? Much of what they need to know is not available in today's standard university curricula. What they need is:

- Specialized knowledge over a range of disciplines.
- Knowledge provided by an experienced expert in the field.
- Knowledge conveyed by a master instructor.

White Eagle Aerospace recognizes these issues and provides effective solutions for your workforce. We are pleased to present you with this brochure, which outlines our Fundamentals of Gas Dynamics (FGD) professional short course. Our team of industry experts and master instructors is dedicated to your success. Should you have any questions about our course catalog or desire more information on how we can help MAKE YOUR CAREER SOAR, please contact us today.

Best Regards,



John Terry White,
President/CEO
White Eagle Aerospace



About Our Company

Whether you are new to the aerospace industry or have years of professional experience, we are your provider-of-choice for expert technical training.

Acquiring key knowledge, critical lessons-learned and technical know-how are crucial ingredients for success in today's complex and highly competitive aerospace market. Our nationally-acclaimed short courses cover a wide range of highly useful technical subjects. Each course is delivered by a subject matter expert who is also an expert technical instructor.

We offer you comprehensive technical training in essential topics, with minimal time away from work – all at a price that fits today's tight training budgets.





Target Audience

The Fundamentals of Gas Dynamics (FGD) technical short course is designed for the aerospace professional seeking a comprehensive training experience in basic compressible flow principles and processes.

This intensive short course is intended for individuals seeking a basic working knowledge of high-speed, compressible flows. This knowledge and its application are essential to the successful design, analysis and testing of a wide spectrum of aerospace systems.

Aerodynamicists, fluid systems engineers, wind tunnel operators and systems engineers will particularly benefit from this unique training program. Course material equips participants with enhanced understanding and improved competency in the important realm of compressible flow.

Delivered by a master instructor and subject matter expert with nearly 40 years of professional aerospace experience, this 4-day intensive training course will provide participants with invaluable real-world knowledge, enhanced understanding and improved competency in this key discipline.

Who Will Benefit

- Aerodynamics Engineers
- Air Data System Designers
- Wind Tunnel Operators
- Fluid Systems Engineers
- Aircraft Systems Engineers
- Missile Systems Engineers
- Propulsion Engineers
- Flight Test Engineers
- Shock Tunnel Operators
- Flight Simulation Specialists
- Stability and Control Specialists
- Systems Engineers
- Program Managers
- College Students

Group Discounts

White Eagle Aerospace is dedicated to meeting your organization's professional training needs. In order to better serve you, we offer special group discounts rates and on-site training. If you have a group of 15 or more participants, we will bring our nationally acclaimed FGD short course to your location at a discounted rate. Please contact us today to learn how we can help MAKE YOUR ORGANIZATION SOAR!





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

The Fundamentals of Gas Dynamics (FGD) short course is an intensive 4-day training program that provides a maximum training experience to aerospace professionals with minimum time away from work.

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 Form	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 Flow With Heat Addition and Friction	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 wave 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.
	9	The Conservation Equations: Differential Form	Conservation form, Non-Conservation form, Substantial derivative, Entropy Equation, Crocco's Theorem, Acoustics.
4	10	Conical and Blunt Body Flows	Newtonian Theory, Taylor-Maccoll Equation, axisymmetric flow, bow shock shapes, rotationality, NASA SP-3004.
	11	Unsteady Wave Motion	Shock tubes, x-t diagram, Hugoniot Equation, shock wave reflection, characteristics lines, unsteady flow, expansions.
	12	Introduction to Numerical Techniques	Grid discretization, method of characteristics, finite differences, compatibility equations, unit processes.



Aerospace History

Much has transpired during the 100-plus years of powered flight. We are both the beneficiaries and stewards of the technological progress that previous generations have bequeathed to us.

However, many professionals in today's aerospace workforce have little knowledge of the key people, events and innovations that comprise the history of their own profession. While we cannot live in the past, we must learn from it if we are to be successful now and in the future. Further, like our predecessors, we must protect and preserve this legacy knowledge for succeeding generations.

It is for these reasons that White Eagle Aerospace strongly emphasizes aerospace history in its technical short courses. This is done through the mediums of special presentations, videos and field trips. The Fundamentals of Gas Dynamics (FGD) short course features several key historical programs.

Featured Programs

- **D-558-I Skystreak**
- **F-108 Rapier**
- **STANDARD Missile**
- **Trident SLBM**
- **Atlas ICBM**
- **Gemini-Titan**
- **Saturn V**
- **Mercury-Redstone**
- **Navaho**
- **BOMARC**
- **X-3 Stiletto**
- **Space Shuttle Orbiter**





Information at a Glance

The Fundamentals of Gas Dynamics (FGD) short course provides participants with a comprehensive training experience in classical compressible flow principles and phenomena.

Course material provides a firm understanding of elementary compressible flow principles and processes, in addition to the analytical tools needed to perform basic compressible flow calculations for a wide variety of flow problems. This knowledge and its application are essential to the successful design, analysis and testing of a wide spectrum of aerospace systems.

Delivered by a master instructor and subject matter expert with nearly 40 years of professional aerospace experience, this 4-day intensive training course will provide participants with invaluable real-world knowledge, enhanced understanding and improved competency in this key discipline.

Contact White Eagle Aerospace

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Key Course Information

- **Instructor:** J. Terry White
- **Duration:** 4 instructional days; 32 instructional hours.
- **Materials:** 1) Comprehensive set of course lecture slides in bound form and 2) DVD containing course lecture slides, images, videos, reference documents and homework solutions.
- **Cost:** \$1,760 for single seat.
- **Registration:** Please visit our website to view the most current Course Calendar. To register for a scheduled course, simply complete and submit the online registration form.
- **Group Discounts:** In order to better serve your organization, we offer special group discount rates and on-site training. For information, please contact Phyllis White at pjwhite@whiteeagleaerospace.com.





J. Terry White

Aerosciences Instructor

John Terry White is president and CEO of White Eagle Aerospace. With headquarters in Oro Valley, Arizona, White Eagle Aerospace is a leading provider of engineering consulting, professional training, history of flight lectures and technical publication services to the aerospace community.

White's nearly 40 years of professional aerospace experience includes the NASA Space Shuttle Program, NASA X-43A Flight Project, and United States Navy STANDARD Missile Program. During his extensive career, he has served on the engineering technical staff of Rockwell International, General Dynamics Corporation, Hughes Missile Systems Company, NASA Dryden Flight Research Center and Raytheon Missile Systems.

In 2009, White completed a 2-year assignment as manager of the Aerodynamics Department in the Guidance, Navigation, and Control Center at Raytheon Missile Systems in Tucson, Arizona. In this capacity, he was responsible for all aerodynamics work performed at the world's largest tactical missile producer. White resigned from Raytheon in 2010 as an Engineering Senior Fellow in Aerodynamics.

White has authored more than 180 technical papers on a wide variety of aerospace and aerospace subjects. His teaching credentials include 15 years as an instructor in the Aerospace Engineering Department of the California State Polytechnic University, Pomona, 10 years as an instructor in the professional development program at Raytheon and 6 years developing and teaching courses at White Eagle Aerospace. Those who have taken his courses say that White brings an uncommon passion and extensive technical knowledge to the training environment.

White is particularly well known for his inspiring aerospace history lectures and presentations. These "techno-histories" are intense, fast-paced reviews of historically-significant events in United States aerospace history. He has lectured extensively on aerospace history topics at the USAF Test Pilot School, the Society of Experimental Test Pilots, the National Aeronautics and Space Administration, the American Institute of Aeronautics and Astronautics, academia, and industry. White also serves as a motivational keynote speaker for aerospace conferences, business functions, commemorative events, public service organizations, special interest groups, and private business.

Courses Offered

- **Aerodynamics for Engineers**
- **Aerospace Lessons-Learned**
- **Advanced Missile Aerodynamics**
- **Aerospace Vehicle Performance**
- **Basic Missile Aerodynamics**
- **Fundamentals of Earth Reentry**
- **Fundamentals of Gas Dynamics**
- **Fundamentals of Hypersonics**

Contact Information

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