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Education

Department of Aeronautical Engineering

AEROCHRONIC

Annual Technical Magazine

Empowering **Aeronautical Aspirations**

Established in 2013, the Department of Aeronautical Engineering delivers an NBA-accredited B.Tech program, fostering innovation, hands-on training, and academic excellence through industry-aligned curriculum and state-of-the-art laboratories.

"We don't just teach aeronautics—we inspire students to reach new heights in engineering, innovation, and impact.

Student-Centric **Excellence in Action**

- 🔧 Practical & Project-Based Learning
- 🌐 Collaboration with IITs, NITs & Industry
- 🎯 Strong Placement & Alumni Success
- 💻 Modern Computing & Simulation Facilities

Where Innovation Meets Education

Annasaheb Dange College of Engineering & Technology (ADCET), Ashta—an empowered autonomous institute with NAAC 'A++' grade and NBA accreditation —champions student-centric, outcome-based education to nurture competent engineers for a better tomorrow.

ABOUT ADCET

Empowering Engineers, Shaping Futures

A Center of Excellence in Technical Education

Annasaheb Dange College of Engineering and Technology (ADCET), Ashta, is a distinguished Empowered Autonomous Institution affiliated with Shivaji University, Kolhapur, and approved by AICTE, New Delhi. Since its inception in 1999, ADCET has become a beacon of technical excellence in Western Maharashtra, offering NBA-accredited undergraduate programs and earning an NAAC 'A++' grade and ISO 9001:2015 certification.

Our 25-acre campus is home to over 3000 aspiring engineers who benefit from a student-centric environment rooted in Outcome-Based Education (OBE). ADCET emphasizes experiential learning through mini/micro/mega projects, hands-on lab sessions, community outreach, and collaborative research. The curriculum is regularly updated to reflect industry demands, guided by a transparent and measurable framework.

What sets ADCET apart is its focus on holistic student development:

- Robust mentorship and scholarship programs ensure that financial constraints do not hinder learning.
- Strategic MoUs with IITs, NITs, and research institutes expand academic and innovation opportunities.
- Strong industry linkages and placement support help students become career-ready professionals.
- Facilities like a well-stocked library, modern hostels, and advanced digital classrooms enrich the learning journey.

ADCET's inclusive culture fosters diversity, equity, and respect, empowering every student to dream big and lead with purpose. Our values are built on the 4 C's that define our mission:

COMPETENCE | CONFIDENCE | COMMITMENT | COMPASSION

Vision of the ADCET

To be a Leader in producing professionally competent engineers.

Mission of the ADCET

We, Annasaheb Dange College of Engineering & Technology, Ashta, are committed to achieve our vision by,

- M1. Imparting effective outcome based education.
- M2. Preparing students through skill oriented courses to excel in their profession with ethical values.
- M3. Promoting research to benefit the society.
- M4. Strengthening relationship with all the stakeholders.

MESSAGE

Hon. Shri. Annasaheb Dange
Founder & Chairman

Our mission began with a simple idea—empowering rural youth through quality technical education rooted in values, purpose, and opportunity. Today, this vision lives on through dedicated efforts to offer affordable, inclusive, and transformative learning experiences.

We don't just shape engineers; we nurture leaders with character, competence, and compassion. Every achievement is a testament to the collective commitment of our faculty, students, and community.

"Dream boldly, work sincerely, and help us carry forward a legacy of service and excellence."

With a vision to uplift rural youth through world-class technical education, we have built a learning environment rooted in dedication, discipline, and development. Every initiative here—be it scholarships, mentoring, or hands-on training—is designed to support holistic student growth.

We are committed to nurturing not only skilled engineers, but also responsible citizens guided by integrity and social values. As you embark on this journey, know that you are part of a mission that transforms lives and shapes futures.

"Your success fuels our purpose."

Adv. Rajendra R. Dange
Secretary

Hon. Vishwanath R. Dange
Joint Secretary

It is a matter of great pride to see the institution's steady rise as a hub of academic excellence and innovation. Guided by the vision of inclusive and value-driven technical education, we are committed to empowering students with not just knowledge, but also purpose and responsibility. Through the dedication of faculty, the enthusiasm of students, and the support of our alumni and partners, we continue to shape socially conscious, industry-ready professionals prepared to meet global challenges.

"Together, let's build a future grounded in excellence, values, and innovation."

We are committed to shaping industry-ready, ethically grounded engineers through quality technical education, modern infrastructure, and innovation-driven learning. With a strong focus on employability, entrepreneurship, and societal impact, we aim to empower students with global competence and local responsibility. Let us move forward together toward new horizons of excellence through collaboration, inclusivity, and continuous growth.

Prof. Rafiq Abu Kanai
Executive Director

ABOUT AERONAUTICAL DEPARTMENT

Department of Aeronautical Engineering

Soaring Beyond Limits | Engineering Flight & Future

Since its establishment in the academic year 2013–14, the Department of Aeronautical Engineering has emerged as a dynamic hub of innovation and excellence, offering a full-time NBA-accredited B.Tech program with an annual intake of 60 students. The department is driven by a clear vision: to produce skilled and industry-ready aeronautical engineers capable of addressing the challenges of aviation and allied sectors.

With a strong foundation in Outcome-Based Education (OBE) and a track record of academic distinction, the department has successfully graduated six batches totaling over 350 students—many of whom have achieved remarkable success in placements, higher education, and research.
What makes the department stand out is its cutting-edge infrastructure and experiential learning approach. Key highlights include:

- Subsonic Wind Tunnel for aerodynamic experiments
- Gas Turbine and Radial Piston Engines for propulsion studies
- Ultrasonic Testing Setup for NDT training
- A full-scale Cessna 152 Trainer Aircraft equipped with original cockpit instrumentation
- A modern computing lab with 40 systems and high-performance workstations

Backed by highly qualified faculty, the department encourages student innovation through micro-projects, internships, national competitions, and research engagement. Emphasis is placed not only on theoretical mastery but also on practical application and industry interface.
At its core, the department remains committed to empowering students with technical competence, ethical values, and the confidence to take flight into a challenging global aerospace landscape.

Our Department's Vision

To be a leader in producing competent aeronautical engineers to meet the present and future needs of the aeronautical and allied industries

Our Department's Mission

We, at the Department of Aeronautical Engineering, Annasaheb Dange College of Engineering and Teaching, Ashta, are committed to achieve our vision by,

- Preparing the students with good fundamental knowledge of aeronautics through outcome-based education.
- Imparting technical knowledge in tune with the current industry requirements through skill-oriented courses.
- Promoting research culture among the faculty and students through sponsored and consultancy projects with industries and research establishments.
- Establishing relationships with all the stakeholders for the benefit of students.

MESSAGE FROM THE HEAD OF DEPARTMENT

Mr. Kiran Babu
Head of the Department

Dear Readers,

As we bring the academic year 2022–23 to a close, I am filled with pride and gratitude for the remarkable journey our department has undertaken. This year has been a testament to our collective commitment to excellence, innovation, and impact in the field of aeronautical engineering.

From the outset in Quarter 1, we laid a strong foundation through industry interactions, guest lectures, and student-led initiatives that connected learning with real-world relevance. Quarter 2, deepened our engagement with technical training programs, national competitions, and faculty enrichment activities that expanded our academic horizons. In Quarter 3, we celebrated research contributions, alumni mentorship, and strategic consultancy projects that showcased our growing reputation and reach. And finally, Quarter 4 brought it all together—with vibrant outreach programs, national-level student accolades, and the formation of our IEEE student chapter, signaling our readiness to lead on global platforms.

Throughout the year, our students have demonstrated resilience, creativity, and leadership. Our faculty have continued to push boundaries in research and pedagogy. Our alumni and industry partners have generously shared their insights and opened doors to new opportunities. I am deeply thankful to each one of you for your role in shaping this vibrant academic ecosystem.

As we look ahead, our vision remains clear: to nurture future-ready aerospace professionals, foster interdisciplinary innovation, and contribute meaningfully to society through education and research. With the release of our Annual Technical Magazine, I invite you to reflect on the milestones we've achieved and the momentum we've built.

Let us carry this spirit forward—toward new challenges, bold ideas, and greater heights.

With warm regards,
Mr. Kiran Babu
Head of the Department
Department of Aeronautical Engineering,
ADCET, Ashta

Program Educational Objectives (POEs)

The graduates of the Department of Aeronautical Engineering at ADCET, Ashta will be able to,

- PEO-1: Pursue successful career in technical profession, entrepreneurship, research and higher studies in the field of aeronautical and allied engineering.
- PEO-2: Demonstrate technical competency in aeronautical engineering by offering best possible engineering solutions.
- PEO-3: Work effectively as an individual and as a team member with professional ethics, social and environmental concern.
- PEO-4: Engage in lifelong learning and adapt to the changing professional requirements.

Program Outcomes (POs)

- *PO-1 Engineering knowledge:* Apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the conceptualization of engineering models.
- *PO-2 Problem analysis:* Identify, formulate, research literature and solve complex engineering problems reaching substantiated conclusions using first principles of mathematics and engineering sciences.
- *PO-3 Design/development of solutions:* Design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
- *PO-4 Conduct investigations of complex problems:* Conduct investigations of complex problems including design of experiments, analysis and interpretation of data, and synthesis of information to provide valid conclusions.
- *PO-5 Modern tool usage:* Create, select and apply appropriate techniques, resources, and modern engineering tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.
- *PO-6 The engineer and society:* Demonstrate understanding of the societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to engineering practice.
- *PO-7 Environment and sustainability:* Understand the impact of engineering solutions in a societal context and demonstrate knowledge of and need for sustainable development.
- *PO-8 Ethics:* Understand and commit to professional ethics and responsibilities and norms of engineering practice.
- *PO-9 Individual and team work:* Function effectively as an individual, and as a member or leader in diverse teams and in multi-disciplinary settings.
- *PO-10 Communication:* Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
- *PO-11 Project management and finance:* Demonstrate a knowledge and understanding of management and business practices, such as risk and change management, and understand their limitations.
- *PO-12 Life-long learning:* Recognize the need for, and have the ability to engage in independent and life-long learning.

Program Outcomes (POs)

- *PSO 1:* Apply the knowledge of aeronautical engineering in the Design and Development, Operating, Maintaining and overhauling of the products enhancing the mobility in the society.
- *PSO 2:* Develop aeronautical and aviation frameworks, and subsystems to overcome the challenges faced by the aviation industry through innovative solutions leading to employability and entrepreneurial development.

Department Faculties

Mr. Kiran Babu
Head of the Department

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Professor

Dr. S. Yuvaraj
Associate Professor

Dr. Vivekanandan
Associate Professor

Mr. Yogesh B. Kumbhar
Assistant Professor

Mr. Reju R
Assistant Professor

Mr. Sanoj P. Suresh
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AEROCHRONIC · AY 2022–23

Annual Technical Magazine · Department of Aeronautical Engineering

This edition of AEROCHRONIC was curated, written, and designed by the following editorial team from the Department of Aeronautical Engineering.

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Expert/Guest Technical Lectures

Guest Lecture on “Introduction to Fuel cell Chemistry“

Organized by the Department of Aeronautical Engineering | August 12, 2022

In an effort to introduce emerging energy technologies to budding aeronautical engineers, the Department of Aeronautical Engineering hosted an expert guest lecture on “Introduction to Fuel Cell Chemistry” on August 12, 2022. The session was delivered by Dr. S. Kalaiselvan, Professor of Chemistry, M. Kumarasamy College of Engineering, Karur, Tamil Nadu. The session aimed to provide foundational knowledge on fuel cell principles, chemical processes, and their relevance to modern engineering applications, particularly in clean energy and transportation sectors.

Fuel cells are electrochemical devices that convert the chemical energy of a fuel directly into electrical energy through redox reactions, offering higher efficiencies than conventional combustion-based power systems. Unlike batteries, fuel cells do not store energy internally; instead, they continuously generate electricity as long as fuel and an oxidant are supplied. The lecture began with an overview of the fundamental components of a fuel cell—anode, cathode, electrolyte, and external circuit—and explained how controlled electrochemical reactions enable sustained power generation.

The chemical principles of fuel cell operation were discussed using the hydrogen–oxygen fuel cell as a representative example. At the anode, hydrogen undergoes oxidation to produce protons and electrons, while at the cathode, oxygen is reduced to form water. The electrolyte selectively allows ionic conduction while blocking electron flow, forcing electrons to travel through an external circuit and deliver useful electrical energy. The overall reaction demonstrates the environmentally friendly nature of fuel cells, with water and heat as the primary by-products.

Various types of fuel cells were introduced based on electrolyte material and operating temperature, including Proton Exchange Membrane Fuel Cells (PEMFC), Solid Oxide Fuel Cells (SOFC), Alkaline Fuel Cells (AFC), and Phosphoric Acid Fuel Cells (PAFC). The lecture highlighted how electrolyte chemistry influences ion transport, efficiency, operating conditions, and application areas. PEM fuel cells, for example, are well suited for automotive and aerospace applications due to their low operating temperatures and rapid start-up.

The session also addressed reaction kinetics, catalytic materials, and efficiency losses such as activation, ohmic, and concentration polarizations. Challenges related to hydrogen production, storage, durability, and cost were discussed, offering insight into current limitations and research directions. The lecture concluded by emphasizing the role of fuel cells in sustainable aviation, space missions, unmanned systems, and electric mobility, reinforcing their importance in future clean energy technologies.

Guest Lecture on "Hydrogen fuels and its Applications for Electric Vehicles"

Organized by the Department of Aeronautical Engineering | September 14, 2022

The Department of Aeronautical Engineering organized an insightful expert session on "Hydrogen Fuels and Its Applications for Electric Vehicles" to familiarize students with hydrogen-based energy systems and their growing role in sustainable transportation. Featuring Mr. Anand Thakar, Industry Expert from CADCAMGURU, Pune, Maharashtra. The session focused on the scientific, technological, and practical aspects of hydrogen as an alternative fuel for next-generation electric vehicles (EVs).

The lecture began with an introduction to hydrogen as an energy carrier, highlighting its high gravimetric energy density and zero tailpipe emissions when used in fuel cell electric vehicles. The professor explained the fundamental pathways for hydrogen production, including steam methane reforming, electrolysis of water, and emerging renewable routes such as green hydrogen generated using solar and wind energy. Emphasis was placed on the importance of clean hydrogen production for achieving true environmental benefits.

Applications of hydrogen in electric mobility were discussed, with particular focus on hydrogen fuel cell electric vehicles (FCEVs). The operating principle of integrating fuel cells with electric drivetrains was explained, where hydrogen is converted into electricity onboard to power electric motors. Comparisons were drawn between battery electric vehicles and hydrogen-powered vehicles in terms of driving range, refueling time, energy efficiency, and infrastructure requirements.

The lecture also addressed key challenges associated with hydrogen adoption, including storage methods, safety considerations, transportation infrastructure, and system cost. Advances in high-pressure tanks, material safety standards, and hybrid energy storage systems were highlighted as solutions to these challenges.

The session concluded by discussing future prospects of hydrogen fuels in public transportation, heavy-duty vehicles, and long-range mobility applications. The guest lecture provided valuable insights into hydrogen-powered electric vehicles and emphasized their potential role in achieving sustainable and low-emission transportation systems.

Faculty Research Focus

Research Article: SCI/Scopus Indexed Journals

Research Spotlight: Flower-like $NiCo_2O_4$ Nanoflakes for Glucose Sensing

DOI: https://doi.org/10.1016/j.mtchem.2022.101156

Dr. A. K. Vivekanandhan
Asso. Prof.

A novel non-enzymatic glucose sensor has been developed using high-porosity nickel cobalt oxide ($NiCo_2O_4$) nanoflakes with and without dopamine-derived carbon. Synthesized via a simple hydrothermal process, the materials exhibit a distinctive flower-like nanoflake morphology, as confirmed by advanced microscopy and spectroscopy techniques.

Among the variants, the carbon-coated C/$NiCo_2O_4$-1 composite demonstrated superior electrochemical performance. This material offers enhanced sensitivity, a broad detection range, and impressive stability, making it highly effective for glucose detection. Notably, it also shows promising results when tested on human blood serum samples. The integration of a carbon layer from dopamine appears to enhance conductivity and structural properties, contributing to its excellent sensing capabilities. This research highlights the potential of C/$NiCo_2O_4$ nanostructures in developing efficient, non-enzymatic glucose sensors for practical biomedical applications.

Citation: Sivakumar, M., A. K. Vivekanandan, G. Panomsuwan, V. Veeramani, S-H. Chen, Z. Jiang, and T. Maiyalagan. "Flower-like NiCo2O4 nanoflake surface covered on carbon nanolayer for high-performance electro-oxidation of non-enzymatic glucose biosensor." Materials Today Chemistry 26 (2022): 101156.

Published by 2022

Faculty Research Focus

Research Article: SCI/Scopus Indexed Journals

Dr. S. Yuvaraj
Associate Professor

Research Spotlight: Comparison Study of Aluminum Camshafts alloyed with different ratio of Silicon

DOI: https://doi.org/Ser.: Earth Environ. Sci. 1100 012023

There has always been a drastic requirement of innovative designs in the automotive industry. To accomplish this, advanced materials and newer techniques have been constantly utilized.

Designers in the automotive industry always look forward towards innovation in design of cam shafts or innovation in its course of action. Weight reduction in automobile parts, constantly plays a major part in all automobile parts. Innovation in design of cam shafts could be brought about by the use of computer aided engineering. Currently, use of composite materials is widespread in order to bring about the required change in the property of materials. Nowadays, Aluminum-Silicon alloy is rapidly used for its greater strength-to-weight ratio, increased wear resistance, less density and its property of less thermal expansion coefficient. In the present work, three types of Aluminum-Silicon cast alloy materials Al-SiC 9, Al-SiC 10 and Al-SiC 12 were modeled using Creo Elements software. It was analysed for structural deformation; viz; stress, deformation and strain using ANSYS static structural 14.5 software. From the results obtained, it was clearly evident that the Aluminum-Silicon cast alloy Al-SiC 12 material shows low stress and deformation values among all three types of Aluminum-Silicon cast alloy materials that was taken for taken in for analysis.

Published by 2022

Citation: Srimath, N., Thomas Renald CJ, and S. Yuvaraj. "Comparison Study of Aluminum Camshafts alloyed with different ratio of Silicon." IOP Conference Series: Earth and Environmental Science. Vol. 1100. No. 1. IOP Publishing, 2022.

Conferences: National/International Level

Mr. Reju Ravindran
Assistant Professor

Research Spotlight: Computational investigation of aerodynamics characteristics over GNVR profile

DOI: https://doi.org/10.1016/j.mtchem.2022.101156

This article presents an aerodynamic characteristics study of GNVR profiles (airships) lighter than aircraft, using the concept of computational fluid dynamics. Airships have huge potential as platforms for various purposes such as surveillance, cargo transportation, and communication. At high-altitudes, because of low density of air, airships need to be designed and developed with a huge body so as to obtain enough buoyancy for balancing its own weight. Thus, the aerodynamic parameters play an important role in control and propulsion of airships. The conceptual design of the Rigid model of airship was developed using CAD model software. The aerodynamics characteristics of the GNVR profile were examined for different angles of attack at fixed velocities. From the numerical work, it was found that the changes of AOA at different flight speeds increase the lift and decrease the drag of the modeled profile.

Citation: Reju Ravindran, Sanoj P. Suresh; Sabarishwaran Rajasekar; Basithrahman Abbas; Oblisamy Lakshminarayanan; Shweata Swaminath Melkunde; Shyam Shashikant Shukla; Vaishnavi Anil Furmalkar. "Computational investigation of aerodynamics characteristics over GNVR profile." DOI: https://doi.org/10.1016/j.mtchem.2022.101156 . AIP Conf. Proc. 2716, 030001 (2023).

Published by 2023

Research Spotlight: Aerodynamic Impact of Sunroofs in SUVs

https://doi.org/10.1063/5.0169024

The research investigates how the longitudinal position of an open sunroof affects airflow behavior, pressure distribution, and aerodynamic drag on an SUV modeled using the Ahmed body profile—a widely accepted benchmark geometry in automotive aerodynamics. The Ahmed body enables systematic analysis of flow separation, wake formation, and drag characteristics while maintaining computational efficiency.

Computational Fluid Dynamics (CFD) simulations were conducted to analyze multiple sunroof locations along the vehicle roof. The simulations employed steady-state turbulence modeling to capture external flow structures and recirculation zones generated due to sunroof opening. Key aerodynamic parameters such as drag coefficient, pressure coefficient distribution, and velocity contours were examined to quantify the influence of sunroof positioning.

The results demonstrate that sunroof placement significantly alters the flow topology over the vehicle roof and rear region. Certain sunroof locations induce strong recirculation zones inside the cabin and increased flow separation near the rear slant, leading to higher aerodynamic drag. Conversely, an optimally positioned sunroof minimizes adverse pressure gradients and reduces flow disturbance, thereby improving aerodynamic efficiency.

The study identifies an optimal sunroof location that balances cabin ventilation benefits with minimal aerodynamic penalty. The findings provide valuable insights for automotive designers in optimizing sunroof placement during the early design phase to improve vehicle performance, fuel efficiency, and passenger comfort.

Citation: N.V. Raghavendra and Sabarishwaran R, Computational analysis for optimal location of open sunroof for an SUV with ahmed body profile, 10th National Conference on Recent Developments in Mechanical Engineering [RDME 2022] organized by Modern Education Society's College of Engineering in association with AIP Publisher, USA.

All Published by 2022

Conferences: National/International Level

KM Kiran Babu
Assi. Prof. & HOD

Research Spotlight: Lighter-Than-Air (LTA) systems

https://ui.adsabs.harvard.edu/abs/2022cosp...44.3363K/abstract

Lighter-Than-Air (LTA) systems counteract gravitational force through buoyancy generated by a lifting gas enclosed within a suitably sized and shaped envelope. Owing to their ability to remain aloft for extended durations with minimal power consumption, LTA platforms have been used for aerial exploration since their first demonstrations in 1783. These characteristics make LTA systems promising candidates for long-endurance planetary exploration missions.

Venus, Earth's nearest planetary neighbor, has a slow retrograde rotation period of 243 days and a dense, cloud-laden atmosphere. This dense atmosphere makes Venus particularly suitable for atmospheric exploration using LTA systems. Studying the Venusian atmosphere is crucial for understanding extreme greenhouse effects and their influence on planetary climate evolution.

This work focuses on the development of a Multi-Disciplinary Optimization (MDO) framework for preliminary sizing and design of an LTA platform intended for meteorological exploration in the Venusian atmosphere. The framework integrates atmospheric, buoyancy control, trajectory, and thermal models. The atmospheric model is based on the Venus International Reference Atmosphere (VIRA), supplemented by a multidimensional intearpolation scheme using a steady-state Global Circulation Model (GCM) to capture variations in atmospheric properties with altitude, latitude, and longitude.

A point-mass trajectory model is developed by balancing the forces acting on the system and computing the resulting acceleration. This model is validated using GPS data from the Huygens Atmospheric Structure Instrument (HASI) balloon experiment conducted in Earth's atmosphere. A detailed thermal model is coupled with the trajectory model to accurately estimate balloon motion, lifting gas behavior, and envelope temperature variations. Heat transfer contributions include solar radiation (direct, reflected, and scattered), infrared absorption and emission, and both internal and external convection. The coupled trajectory–thermal equations are solved using a fourth-order Runge–Kutta method.

Buoyancy control is modeled using both passive and active techniques. Passive control is achieved through Phase Change Fluids (PCFs), where the lifting gas undergoes phase transitions that alter buoyancy. The phase-change model is validated using data from the Altitude Control Experiment (ALICE). Active buoyancy control is investigated using a variable-volume balloon concept, enabling dynamic altitude control.

The complete MDO framework is implemented using the OpenMDAO library to perform optimization studies based on mission requirements. A comparative assessment of Super Pressure Balloons (SPB), Phase Change Balloons (PCB), and Variable Volume Balloons (VVB) is conducted. Results indicate that while PCF-based passive systems are suitable for limited attitude control, dynamic altitude control requires active variable-volume mechanisms. The study also shows that Venus circumnavigation is feasible using balloon platforms, although trans-latitudinal navigation remains constrained.

Citation: Kiran Babu, K. M., Shantanu Gulawani, and Rajkumar S. Pant. "Multi-Disciplinary Design Optimization Studies on Buoyant System for Exploring Venusian Atmosphere." 44th COSPAR Scientific Assembly. Held 16-24 July 44 (2022): 3363.

All Published by 2022

Conferences: National/International Level

KM Kiran Babu
Assi. Prof. & HOD

Research Spotlight: Lighter-Than-Air (LTA) systems

https://ui.adsabs.harvard.edu/abs/2022cosp...44.3363K/abstract

The shape of a conventional airship's envelope is usually an axisymmetric body of revolution. Previous numerical and experimental studies have indicated that at zero angle of attack, the flow over such shapes is either fully turbulent or transits from laminar to turbulent at nearly half of the envelope's length. In most numerical investigations of such bodies, k-ε or k-ω-SST turbulence models are used. In recent studies, a four-equation k-ω SST-LM transition turbulence model has been proposed and shown to predict transition on a flat plate quite well. In this study, the transition of the laminar boundary layer to the turbulent boundary layer over the bodies of revolution of airship envelopes is investigated using the k-ω SST–LM transition turbulence model. The results obtained in numerical analysis are validated with the data available in the literature. It is seen that the two-equation k-ω SST turbulence model is not able to capture the laminar to turbulent transition, whereas the four-equation k-ω SST-LM transition turbulence model can capture it quite well.

Citation: Magar, Ashish, Shantanu S. Gulawani, KM Kiran Babu, and Rajkumar S. Pant. "Numerical investigation of laminar to turbulent boundary layer transition over airship envelopes." In Lighter Than Air Systems: Proceedings of the International Conference on Design and Engineering of Lighter-Than-Air Systems 2022 (DELTAs-2022), pp. 167-181. Singapore: Springer Nature Singapore, 2022.

All Published by 2022

Conferences: National/International Level

Research Spotlight: Multi-Disciplinary Design Optimization Studies on Buoyant System for Exploring Venusian Atmosphere

KM Kiran Babu
Assi. Prof. & HOD

https://ui.adsabs.harvard.edu/abs/2022cosp...44.3363K/abstract

Lighter-Than-Air (LTA) systems generate buoyancy using a low-density lifting gas contained within a suitably designed envelope, enabling them to counteract gravitational forces with minimal power consumption. Owing to their capability to remain aloft for extended durations, LTA platforms have been utilized for aerial exploration since their first demonstrations in 1783. In recent years, they have emerged as promising candidates for long-endurance planetary atmospheric exploration.

Venus, the closest planetary neighbor to Earth, possesses a dense and cloudy atmosphere and exhibits slow retrograde rotation with a period of approximately 243 Earth days. The high atmospheric density of Venus makes LTA systems particularly well suited for in situ atmospheric investigations. Studying the Venusian atmosphere is critical for understanding extreme greenhouse effects and planetary climate evolution.

The present work focuses on the development of a Multi-Disciplinary Optimization (MDO) framework for the initial sizing and design of an LTA system intended for meteorological exploration of Venus. The framework integrates key engineering disciplines, including atmospheric modeling, buoyancy control, trajectory dynamics, and thermal analysis. Atmospheric inputs are derived from the Venus International Reference Atmosphere (VIRA) model, enhanced using a multidimensional interpolation scheme based on global circulation models to account for variations with latitude, longitude, and altitude.

A point-mass trajectory model is developed by balancing aerodynamic, buoyant, and gravitational forces and is validated using Earth-based balloon flight data. A coupled thermal model accounts for solar radiation, infrared exchange, and convective heat transfer, all of which significantly influence lifting gas behavior and balloon trajectory. Buoyancy control is studied using both passive and active techniques. Passive control employs phase change fluids, while active control is achieved through variable volume mechanisms, enabling dynamic altitude regulation.

The MDO framework, implemented using OpenMDAO, is used to compare Super Pressure Balloons, Phase Change Balloons, and Variable Volume Balloons for Venus missions. Results indicate that while passive systems offer simplicity, active buoyancy control provides superior altitude maneuverability, making it more suitable for complex planetary exploration missions.

Citation: Kiran Babu, K. M., Shantanu Gulawani, and Rajkumar S. Pant. "Multi-Disciplinary Design Optimization Studies on Buoyant System for Exploring Venusian Atmosphere." 44th COSPAR Scientific Assembly. Held 16-24 July 44 (2022): 3363.

All Published by 2022

Advances in Aircraft and Space Systems: A Global Technical Review

1. Artemis I Uncrewed Lunar Mission (November–December 2022)

NASA successfully conducted the Artemis I uncrewed lunar mission, marking a major milestone in the development of next-generation deep-space exploration systems. The mission served as the first integrated flight test of the Space Launch System (SLS), the most powerful launch vehicle ever developed, and the Orion spacecraft, designed for human-rated lunar and interplanetary missions.

From an aeronautical and aerospace engineering perspective, Artemis I was critical in validating structural integrity under extreme launch loads, including vibration, acoustics, and dynamic pressure effects experienced during ascent. The performance of the SLS propulsion system, comprising solid rocket boosters and cryogenic liquid engines, provided valuable data on thrust balance, propellant feed stability, and engine control under real flight conditions.

The mission also tested guidance, navigation, and control (GNC) algorithms for translunar injection, lunar flyby trajectories, and deep-space maneuvering. Orion's thermal protection system was a key focus area, particularly during high-energy atmospheric re-entry, where the spacecraft re-entered Earth's atmosphere at velocities exceeding those of low Earth orbit missions. Temperature, heat flux, and material response data collected during re-entry are essential for certifying crewed missions.

Overall, Artemis I generated comprehensive flight data across propulsion, structures, aerodynamics, thermal systems, and avionics. The mission provided engineers with real-world validation of analytical models and simulations, significantly reducing risk for future crewed Artemis missions and advancing human spaceflight capabilities.

Source link: https://www.nasa.gov/mission/artemis-i /

The Orion spacecraft during trans-lunar injection, to bring an Artemis mission to the moon. (Image credit: NASA)

2. James Webb Space Telescope – Early Science Operations (2022–2023)

NASA, in collaboration with the ESA, commenced early science operations of the James Webb Space Telescope (JWST) during 2022–2023, successfully validating one of the most complex space observatories ever engineered. JWST represents a major advancement in space systems engineering, combining large deployable structures, ultra-precise optics, and advanced thermal management.

From an engineering standpoint, the mission demonstrated the successful deployment and alignment of a 6.5-meter segmented primary mirror, requiring micron-level precision achieved through actuators, wavefront sensing, and closed-loop control algorithms. The flawless execution of multi-stage deployment sequences highlighted robust mechanical design, hinge mechanisms, and redundancy strategies critical for space structures operating in zero-gravity environments.

A key engineering achievement was the performance of JWST's five-layer sunshield, which enabled passive cooling of the telescope to cryogenic temperatures below 50 K. This thermal architecture is essential for infrared observations and showcased advanced thermal isolation, material selection, and heat transfer control in deep space. Additionally, vibration isolation and structural damping played a vital role in maintaining optical stability during spacecraft maneuvers.

The telescope's attitude determination and control system enabled extremely accurate pointing and stabilization, allowing long-duration observations with minimal jitter. Data from early science operations validated analytical models related to structural dynamics, thermal behavior, and optical performance..

Source link: https://www.nasa.gov/mission/artemis-i /

This image from NASA's Hubble Space Telescope shows the Circinus galaxy. A close-up of its core from NASA's James Webb Space Telescope shows the inner face of the hole of the donut-shaped disk of gas disk glowing in infrared light. The outer ring appears as dark spots.

3. X-59 QueSST Supersonic Aircraft Rollout (January 2023)

NASA unveiled the X-59 Quiet Supersonic Technology (QueSST) aircraft in January 2023, marking a significant advancement in supersonic aircraft design focused on mitigating sonic boom effects. The X-59 is an experimental research aircraft developed to validate aerodynamic shaping techniques that enable quiet supersonic flight over land.

From an aeronautical engineering perspective, the X-59 features an elongated, highly contoured fuselage and a carefully designed wing–body configuration that redistributes shock waves generated during supersonic flight. Instead of producing a strong N-wave sonic boom, the aircraft is designed to generate multiple weaker pressure waves, resulting in a significantly reduced ground-level noise signature. This approach demonstrates the direct application of computational fluid dynamics (CFD) and high-fidelity aerodynamic modeling in aircraft design.

The aircraft's configuration required extensive CFD-based optimization, wind tunnel testing, and aeroelastic analysis to balance shock control with stability, control, and structural constraints. The X-59 also incorporates advanced fly-by-wire control systems to manage its unconventional aerodynamic layout and ensure safe handling qualities at high Mach numbers.

In addition to aerodynamic shaping, the program evaluated structural integration and propulsion placement to minimize flow disturbances and shock interactions. Data obtained from the X-59 flight test program is intended to validate predictive models of supersonic shock propagation and acoustic signatures.

Overall, the X-59 QueSST aircraft serves as a critical experimental platform for advancing supersonic aerodynamics, shock wave management, and CFD-driven aircraft design, offering valuable learning insights for students studying high-speed aerodynamics and future supersonic transport systems.

Source link: [https://www.nasa.gov/mission/artemis-i /](https://www.nasa.gov/mission/artemis-i/)

NASA's X-59 quiet supersonic research aircraft

4. Stratolaunch Talon-A Hypersonic Test Flights (Octobar 2022)

Stratolaunch conducted a series of hypersonic test campaigns during 2022–2023 using the Talon-A test vehicle, marking an important step in advancing reusable hypersonic flight technologies. The Talon-A program is designed to generate real-flight data in the hypersonic regime, where aerodynamic, thermal, and structural challenges are significantly more complex than in subsonic or supersonic flight.

From an engineering standpoint, the Talon-A vehicle enabled detailed investigation of flight stability and control at high Mach numbers, including vehicle response to shock–boundary layer interactions and rapidly changing aerodynamic loads. The air-launched test architecture allowed controlled release conditions, enabling engineers to isolate hypersonic performance characteristics without the complexities of ground-based launch systems.

A key focus of the test flights was propulsion system integration and its interaction with the airframe under hypersonic flow conditions. The program also emphasized aerothermal effects, including extreme surface heating, thermal gradients, and material performance. Instrumentation onboard the vehicle collected data on heat flux, pressure distribution, and structural response, supporting the validation of computational models and ground-test predictions.

The Talon-A flights further contributed to understanding test vehicle design methodologies, including thermal protection systems, structural reinforcement, and avionics survivability in high-temperature environments. Data obtained from these campaigns is critical for improving hypersonic design tools and reducing uncertainties in future vehicle development.

Overall, the Stratolaunch Talon-A hypersonic test flights provided valuable real-world validation of hypersonic aerodynamics, propulsion integration, and structural heating phenomena, offering students practical insights into one of the most challenging and rapidly evolving domains of aerospace engineering.

Source link: [https://www.nasa.gov/mission/artemis-i /](https://www.nasa.gov/mission/artemis-i/)

Stratolaunch's Talon-A separation test vehicle, TA-0. Credit: Domenic Moen/Stratolaunch

5. Boom Supersonic XB-1 Ground and Taxi Tests (2022–2023)

Boom Supersonic conducted extensive ground and taxi testing of the XB-1 technology demonstrator during 2022–2023, representing a critical phase in the development of next-generation supersonic aircraft. The XB-1 program is intended to validate key aerodynamic, structural, and control technologies required for sustained supersonic flight.

From an aeronautical engineering perspective, the testing campaign focused on verifying airframe integrity, material performance, and systems integration prior to flight. The XB-1 incorporates advanced materials and manufacturing techniques designed to withstand the thermal and mechanical loads associated with high-speed flight. Ground tests allowed engineers to assess structural behavior under static and dynamic loading conditions and to evaluate material responses to temperature variations.

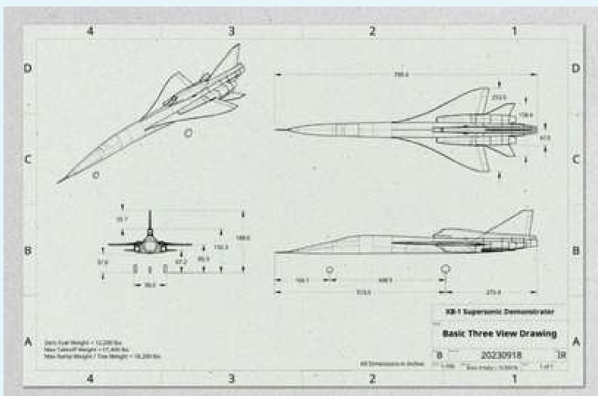
Aerodynamic considerations were central to the XB-1 design, particularly the shaping of the fuselage, wing, and inlet geometry to achieve efficient supersonic performance while maintaining stability and control. Taxi tests provided critical data on low-speed handling, braking performance, steering response, and flight control system behavior, enabling validation of control laws and sensor integration in a real operational environment.

The program also emphasized flight testing methodology, using incremental test expansion to reduce risk and verify system performance step by step. Data collected during ground and taxi tests supported the calibration of analytical and computational models, improving confidence prior to first flight.

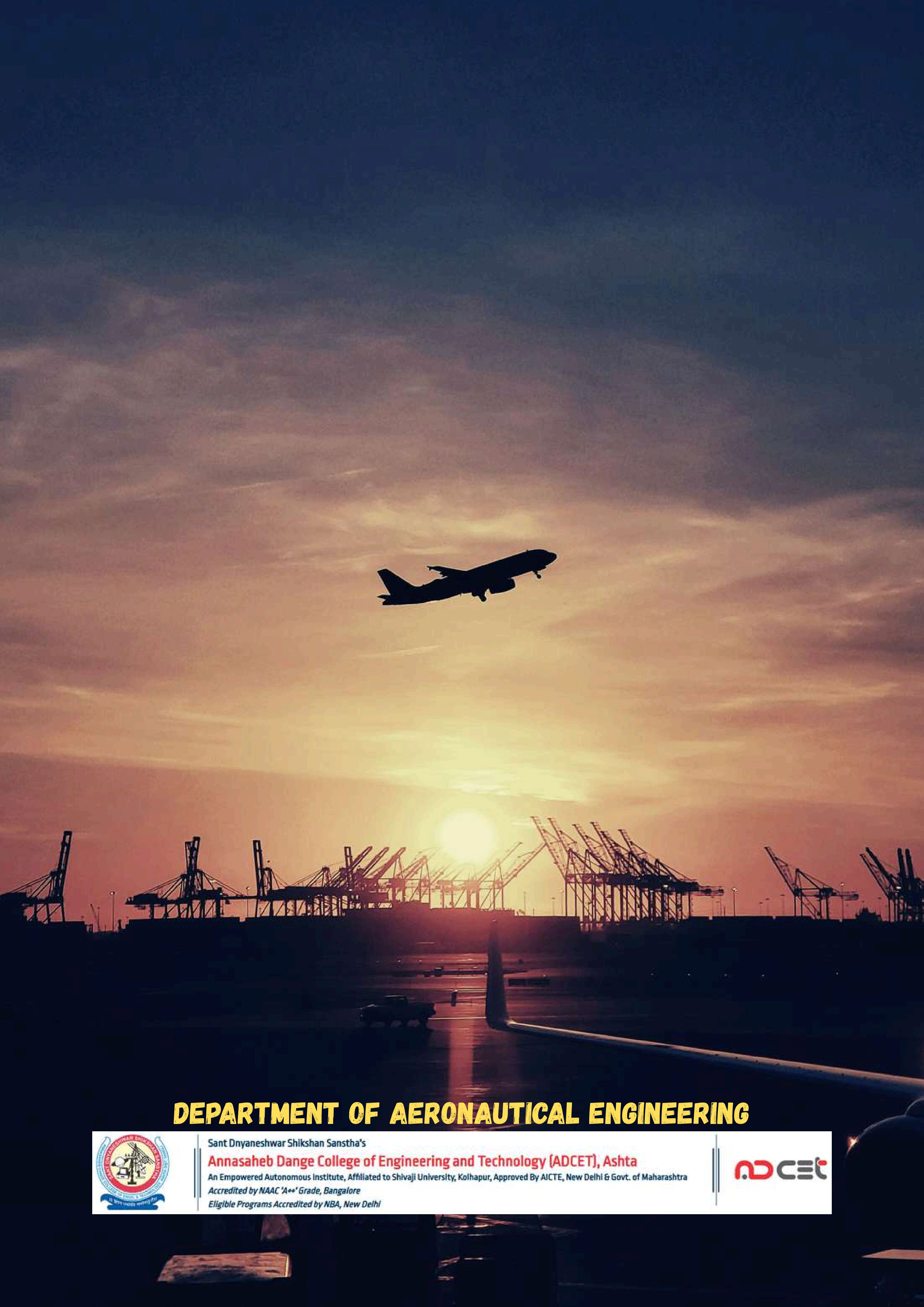
Overall, the XB-1 testing campaign demonstrated the disciplined engineering approach required for high-speed aircraft development and offered students valuable insight into supersonic aircraft design, advanced materials, and systematic flight test practices.

Source link: [https://www.nasa.gov/mission/artemis-i /](https://www.nasa.gov/mission/artemis-i/)

XB-1 takes off on its inaugural flight.



XB-1 is 62.6 feet long with a wingspan of 21 feet and is powered by three GE J85-15 engines with a combined max thrust of 12,300 pounds of force (lbf)



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