

## MHRD Scheme on Global Initiative on Academic Network (GIAN)

### Internal Combustion Engine Fundamentals and Advances

#### Overview

The invention and development of the internal combustion (IC) engine in the nineteenth century has had a profound impact on human life. IC engine offers a relatively small, lightweight source for the amount of power it produces. The most common IC engines are the piston-type gasoline and Diesel engines used in most automobiles. Since the invention of IC Engines, the magnitude of developments have been introduced in order to increase its efficiency, improve performance and reducing the exhaust emissions. Advanced combustion concepts such as Homogeneous Charge Compression Ignition (HCCI), Gasoline Direct Injection (GDI) etc. have been introduced and implemented by the manufacturer. The scarcity of petroleum fuels led to the utilization of alternative fuels such as alcohols, biodiesels etc. The introduction of common rail fuel injection system and gasoline direct injection have improved the performance and efficiency significantly. This program is designed to provide extensive knowledge about basics and recent advances about Internal Combustion Engines to students, researchers, and faculty members from reputed institutes. The program comprises theoretical lecture sessions, tutorials, and experimental sessions. Theoretical concepts will be taught and discussed during lecture sessions. Tutorial and lab sessions will include discussions and problem-solving in a quantitative manner. Relevant lecture sessions will be followed by rigorous experimental sessions each day of the program which will provide practical exposure to the participants.

#### Course Objectives

The primary objectives of the course are as follows:

- i) To introduce the students and researchers with the fundamentals of Internal Combustion Engine by expert lectures. To improve the understanding about the advances in Spark Ignition and Compression Ignition Engines. Experimental exercises and demonstration for Performance Parameter Evaluation
- ii) Explaining about the recent Engine Emission regulations that are being followed in various parts of the world. Demonstration and experimentation for Gravimetric analysis for Emission Measurement
- iii) Demonstration of several experiments to expose the students with various practical aspects about IC Engines such as In-cylinder pressure study, Heat Release Rate, Combustion Phasing, Combustion Duration, Emission Measurements, Particulate Sampling and Characterization etc.
- iv) Exposure and demonstration for various alternative fuels production techniques and its characterization like Transesterification process for Biodiesel Production, Pre-treatment and Fermentation for Ethanol Production from First and Second Generation Organics etc.

#### Teaching Faculty with allotment of Lectures and Tutorials

1. **Prof. Jacek Hunicz (JH):** 6 hrs lectures and 6 hrs tutorials
2. **Dr Pravesh Chandra Shukla (PCS):** 4 hrs lectures and 4 hrs tutorials

Course Details:	
Dates	<b>11-15th December 2023</b>
Location	The course will be conducted via <b>offline mode</b> at the <b>Indian Institute of Technology Bhubaneswar (IIT Bhubaneswar)</b> , Kutebhabata, Durg, (C.G.) 491001 (India)
Course Schedule	<p>11th Dec. 2023</p> <p><b>Inauguration: 9:00 AM-9:30 am</b>  <b>Lecture 1 (10:00-11:00 hrs): 1 hrs: JH</b>  Fundamentals of Internal Combustion engines, Different types of reciprocating internal combustion engines (ICE), Their Typical Design Features, Engine Performance Parameters, Indicated Thermal Efficiency, Brake Thermal Efficiency, Mean Effective Pressure,  <b>Lecture 2 (11:30-12:30 hrs): 1 hrs : JH</b>  Engine Heat Transfer And its Relation to Thermal Loading of Engine Components and Cooling, Thermodynamics of Combustion, Combustion Stoichiometry, Application of First Law of Thermodynamics to Combustion  <b>Tutorial 1 (14:30-16:30 hrs): 2 hrs: JH</b>  Lab Sessions and Problems Related Engine efficiency and Power output, Frictional Losses, Calculations of IP and BP, Problems based on Otto and Diesel Cycles, Thermochemistry related Problems, Lean and Rich Mixture</p> <p>12th Dec. 2023</p> <p><b>Lecture 3 (10:00-11:00 hrs): 1 hrs: JH</b>  Combustion in Spark Ignition Engines, Pre-mixed Charge Combustion, Laminar and Turbulent Pre-mixed Flames, Flammability Limits, SI Engine combustion Conceptual Models, Flame Development, Flame Propagation, Flame Termination, Thermodynamic Analysis of Combustion, Single and Two Zone Combustion Model, Knocking in SI Combustion  <b>Lecture 4 (11:30-12:30 hrs): 1 hrs: JH</b>  Combustion in Compression Ignition Engines, Fuel Spray and Spray Structure, Fuel Atomization and Droplet Distribution, CI Engine Combustion Conceptual Models, Ignition Delay, Premixed Combustion, Mixing Controlled Combustion (Diffusion Combustion), Thermodynamic Analysis for Rate of Heat Release  <b>Tutorial 2 (14:30-16:30 hrs): 2 hrs: JH</b>  Lab Sessions/Problems related to Combustion Study, In-cylinder Pressure Measurement, Heat Release Rate calculation, Calculations of Ignition Delay, Combustion Duration, Combustion Phasing, Peak in-cylinder Pressure, Maximum Rate of Heat release</p> <p>13th Dec. 2023</p> <p><b>Lecture 5 (10:00-11:00 hrs): 1 hrs: PCS</b>  Formation of Engine Emissions, Sources of Engine Emissions, Formation of Carbon Monoxide, Nox Formation, Thermal Nox, Fuel Borne Nox, Prompt Nox, Unburned Hydrocarbon Emissions in SI and CI Engines  <b>Lecture 6 (11:30-12:30 hrs): 1 hrs: PCS</b>  Engine Particulate Basics, Composition and Structure of particulate, Mechanism of Particulates, Diesel NOx-Soot Trade-off, Particle Number Emissions, Emission Regulations, Effect of Various Fuel Introduction/Injection Strategies on Emissions in SI and CI Engines,  <b>Tutorial 3 (14:30-16:30 hrs): 2 hrs: PCS</b>  Lab Sessions for Emission Studies, Measurement and Analysis of Gaseous Emission Components for SI and CI Engines, Gravimetric Analysis, Particulate Sampling and its Physico-chemical Analysis</p> <p>14th Dec. 2023</p> <p><b>Lecture 7 (10:00-11:00 hrs): 1 hrs: JH</b>  Advances in Internal Combustion Engines, Homogeneous Charge Compression Ignition (HCCI), Reactivity Controlled Compression Ignition (RCCI), Premixed Charge Compression Ignition (PCCI), Gasoline Direct Injection (GDI) Engines, Fuel</p>

		<p>Injection Strategies, Engine Mapping, Electronic Control Unit (ECU)  <b>Lecture 8 (11:30-12:30 hrs): 1 hrs: JH</b>  Emission Control Technologies, Active and Passive Control Techniques, Optimization of Engine Design Parameters, Exhaust Gas Recirculation, Variable Valve Actuation, Fuel Injection Variation Aftertreatment Devices, Three-way Catalytic Converter, Oxidation Catalyst, Diesel Particulate Filter, Selective Catalytic Reduction  <b>Tutorial 4 (14:30-16:30 hrs): 2 hrs: JH</b>  Demonstration of Some of the Exhaust Aftertreatment Techniques/Devices, Discussion/Problems related to Emission Control Technique</p> <p>15th Dec. 2023</p> <p><b>Lecture 9 (10:00-11:00 hrs): 1 hrs: PCS</b>  Alternative Fuel for SI Engines, Alternative Fuels for CI Engines, Gaseous Fuels, Hydrogen, Methane, Compressed Natural Gas (CNG), Liquefied Petroleum Gas (LPG), Biogas, Producer Gas, Dimethyl Ether (DME)  <b>Lecture 10 (11:30-12:30 hrs): 1 hrs: PCS</b>  Liquid Fuels for IC Engines, Methanol and Ethanol, Straight Vegetable Oil (SVO), Hydrotreated Vegetable Oil (HVO), Biodiesels derived from various feedstocks, First and Second Generation Alternative Fuels, Transesterification for Biodiesel Production  <b>Tutorial 5 (14:30-15:30 hrs): 1 hrs: PCS</b>  Lab Visit/Session to Biodiesel Production Plant*, Transesterification, Fuel Characterization, Demonstration of Various Fuel Characterization Equipment, Bomb Calorimeter, Viscositymeter, Densitymeter, Flash Point Apparatus, Cloud and Pour Point etc.  <b>Evaluation and Feedback (15:30-16:30 hrs): 1 hrs: JH and PCS</b>  Evaluation of Learning Outcomes (Examination/Test, Feedback) and Certificate distribution</p>								
<b>Who should attend?</b>	<ul style="list-style-type: none"> <li>• Anyone with a degree in Mechanical, Production, Environment or relevant branches of Engineering and Science.</li> <li>• Student at all levels (B.Tech./B.Eng./B.Sc./M.Sc./MTech./Ph.D.) and faculty members/academic staff from universities and institutions.</li> <li>• Engineers, Scientists and Professionals working in companies, industries and R&amp;D institutions.</li> </ul>									
<b>Course Fee</b>	<p>All prospective participants need to do web registration for the course on GIAN (<a href="https://gian.iitkgp.ac.in/GREGN/index">https://gian.iitkgp.ac.in/GREGN/index</a>) portal by making a <b>one-time non-refundable payment of Rs. 500/-</b>.</p> <p>After the mandatory web registration, only the shortlisted participants will be informed by email to register for the course by making full payment of the course registration fee either by NEFT (Account holder name: Director, IIT Bhilai, <b>Account No. 7793000100014077</b>; IFSC Code: PUNB0957100; Bank: PNB, Sardar Vallabh bhai Patel Market) or by sending a demand draft in favor of "Director, IIT Bhilai" payable at Punjab National Bank, Dumartarai, Raipur, Chhattisgarh before the last date of registration. Please send an email to the course coordinator in case of any questions: <a href="mailto:pravesh@iitbhilai.ac.in">pravesh@iitbhilai.ac.in</a></p> <p><b>Last Date of Registration for the course: 20th November 2023</b></p> <p>The participation fees for attending the course is as follows:</p> <table border="1"> <tr> <td><b>Participants from abroad:</b></td> <td><b>US\$ 100 + 18% GST</b></td> </tr> <tr> <td><b>Industry/ Research Organizations:</b></td> <td><b>Rs. 2000/- including GST</b></td> </tr> <tr> <td><b>Academic Institutions (Faculty members):</b></td> <td><b>Rs. 1000/- including GST</b></td> </tr> <tr> <td><b>Academic Institutions (Students/Research scholars):</b></td> <td><b>Rs. 500/- including GST</b></td> </tr> </table> <p><i>Limited accommodation may be provided subject to room availability. The charges for the accommodation may be enquired from course coordination separately.</i></p>		<b>Participants from abroad:</b>	<b>US\$ 100 + 18% GST</b>	<b>Industry/ Research Organizations:</b>	<b>Rs. 2000/- including GST</b>	<b>Academic Institutions (Faculty members):</b>	<b>Rs. 1000/- including GST</b>	<b>Academic Institutions (Students/Research scholars):</b>	<b>Rs. 500/- including GST</b>
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## International Expert:



### **Prof. Jacek Hunicz**

Prof. Jacek Hunicz (PhD, DSc.) is an associate professor and head of Powertrains Laboratory at the Lublin University of Technology, Poland. His track record includes experimental engine research and renewable low-carbon fuels. In the area of combustion research, his studies are centered on the control strategies for low-temperature combustion in HCCI engines, including the NVO fuel reforming. With over 23 years of professional expertise in combustion engines and powertrain development, prof Hunicz is a grant holder of several relevant nationwide projects funded by the Ministry of Science and Higher Education and National Science Centre. He is a member of several international research groups. He is also an innovation consultant for domestic off-road vehicle and bus manufacturer Ursus and technical advisor to the Polish military industry in the field of powertrain testing. Since 2018, he has been a board member of the Polish Scientific Society for Combustion Engines.

## Host Faculty:



### **Dr. Pravesh Chandra Shukla**

Dr. Pravesh Chandra Shukla is Assistant Professor in the Department of Mechanical Engineering at Indian Institute of Technology Bhilai. Dr. Shukla received his PhD from Indian Institute of Technology Kanpur. He has also worked as Senior Research Associate (SRA, Pool Scientist) at IIT Kanpur. Prior to joining IIT Bhilai, he was a post-doctoral researcher in the Division of Combustion Engines, Department of Energy Sciences, Lund University, Sweden. He briefly worked in Ecole Centrale de Nantes, France in the field of dual fuel combustion. He is recipient of Young Scientist Award from the International Society for Energy, Environment and Sustainability. Dr. Shukla mainly works in the field of Internal Combustion Engines and Alternative fuels for transportation. He worked on the development of additives for high compression ratio heavy duty engines fueled with alcohol. He is involved in investigating the emission characteristics for alternative fuels like biodiesel, HVO and alcohols for conventional and advanced heavy duty compression ignition engines. Till now, he has published more than 35 technical articles in international journals, conference proceedings and books.

## Contact:

Course Coordinator	Local GIAN Coordinator
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