JGI JAIN DEEMED-TO-BE UNIVERSITY | FIRE & COMBUSTION RESEARCH CENTER

Minor in Fire Technology

Preamble

Engineering fire safety has gained importance globally. World has witnessed rapid expansion of urban habitat and industrialization across all sectors. Disruptive technologies have revolutionized the construction, communication and transport sectors. In the process, the combustible content of the built environment has changed significantly in the past few decades. The per capita energy consumption and storage has also gone up multifold leading to an ever increasing fire risk.

Concepts of artificial intelligence, robotics and developments in software technology are being increasingly adopted to mitigate fire risks. Robots are becoming increasingly relevant to urban firefighting and surveillance. Newer advancements in detection/ prediction of fire risks have opened up a plethora of opportunities to engineers with fundamental knowledge in fire behaviour, smoke transport, fire prevention and suppression technologies. Therefore procuring adequate skills in fire behaviour and understanding in its management and mitigation will be a significant value addition to students of all branches of engineering. The course is designed to develop skills in various aspects of the fire domain like fire suppression, fire protection, and simulation of fire phenomena. Students with different engineering backgrounds can become enabled to deal with the specific aspects of fire technology relevant to their branch through suitable internships and projects.

FCRC, Fire & Combustion Research Center is established at Jain (deemed to be) University with a mandate to carry out frontier research in the areas of fire and combustion. A state of the art, NABL accredited laboratory called Underwriters Laboratories -Jain Fire Lab (UL-JFL) for qualifying fire related products is established at JGI Global Campus. Presently fire suppression products like firefighting foams, dry chemical powder and their dispensation systems are being addressed in continuous live interaction with major players in the global fire safety industry. This arrangement has provided an excellent opportunity to develop a focused research group working in the area of fire and combustion research.

In this background a 20 credit minor specialization course in Fire Technology is developed for the benefit of Engineering Students of all core branches.

Essential Credits for Fire Technology Minor Degree

SEM	Subject	Credits
III	Thermochemical Heat Transfer	03 (45 hours)
IV	Fire Driven Flows	03 (45 hours)
V	Fire Suppression	03 (45 hours)
VI	Fire Protection	03 (45 hours)
VII	Fire Simulations	03 (45 hours)
VII& VIII Project/internship: 05 (75 hours)		

The course delivery will be through theory and practical demonstrations. Assessment will be as per JAIN norms.

Thermochemical Heat Transfer

3 Credits, 45 hours, Faculty: Sachin Payyanad, Sowriraajan, & Bhaskar Dixit

Understanding the nature of combustible substances, reaction mechanisms, fire propagation and quantification of heat release rates from fires

Chapter	Content:	Course Outcomes:	Hrs
Intro-duction	Combustion modes, stoichiometry, enthalpy of formation, enthalpy of combustion, Adiabatic flame temperatures, chemical equilibrium, equilibrium products in combustion, Rates of reaction, conservation equations.	Knowledge of chemical reactions in fire	**8**
Gaseous Flames	The mechanism of gas phase combustion, Temperatures of flames, Laminar flame structure, Flame speed, factors influencing flame velocity, stability limits of laminar flames, Diffusion jet flame description, soot formation.	Understanding and classification of physical effects of chemical reactions in fire	**12**
Liquid & Solid Fuels	Nature of fuels, the combustion process, Vapor pressure of liquids, Combustion and energy release, Measurements, characterization, simple model of droplet evaporation & burning, burning of carbon – one film model, particle burning time.	Learning combustion mechanisms and measurement of energy release when fuels are in different phases	**9**
Heat transfer in Fires	Summary of the heat transfer equations, Steady state & Non-steady state conduction, Convection, Radiation, Configuration factors, Radiation from hot gases and non-luminous flames, Radiation from luminous flames and hot smoky gases, heat flux measurements.	Knowledge of heat transfer mechanisms from fires and measurement of fire heat flux	**9**
Case Studies	Approaches for establishing dimensionless groups, Dimensionless Groups from the Conservation Equations, Examples of Specific Correlations, Case studies in pool and crib fires	Learning tools and techniques for modelling and scaling of the reaction phenomena	**7**

References:

1. Understanding combustion by Prof. H.S. Mukunda, Wiley India, 2009
2. Bergman, Theodore L., Adrienne S. Lavine, Frank P. Incropera, et al. Introduction to Heat Transfer. Wiley, 2011
3. An Introduction to combustion by Stephen R Turns, Mc Graw Hill, 2000
4. Fundamentals of Fire Phenomena: James G. Quintiere, University of Maryland, USA, John Wiley & Sons Ltd, 2006.

Fire Driven Flows

3 Credits, 45 hours, Faculty: Sagar, Adarsh & Bhaskar Dixit

Understanding fluid flows created by fire events and understand functioning of fire and smoke detection and sensing techniques

Chapter	Content	Course Outcomes	Hrs
Diffusion Flames and Fire Plumes	Laminar Jet Flames, Turbulent Jet Flames, Flames from Natural Fires, The Buoyant Plume, The Fire Plume, Interaction of the Fire Plume with Compartment Boundaries, The Effect of Wind on the Fire Plume, Some Practical Applications, Radiation from Flames, The Removal of Smoke, Modelling	* Physics of buoyancy driven flows in open and enclosed conditions *Quantification of Wind effects on fires Smoke generation and handling	**9**
Compartment fires	Fire growth, Flash over- Pre and post compartment fires, flash over conditions, factors affecting fire growth, burning regimes, fully developed fire behavior, fire resistance and severity, flame projection and spread of fire in compartments	*Knowledge of fire growth inside compartments *Identification of various stages of fire insides compartments	**8**
Smoke transport	Formation and Measurement of Smoke, Production of Smoke Particles, Measurement of Particulate Smoke, Methods of Test for Smoke Production Potential, The Toxicity of Smoke. Smoke Movement, Forces Responsible for Smoke Movement, Rate of Smoke Production in Fires,	*Characterization and measurement of smoke and its toxicity *Understanding smoke movement	**12**
Detectors and Sensors	Types of Detectors, Smoke Control Systems, Smoke Control in Large Spaces, The Response of Ceiling-mounted Fire Detectors, Interaction between Sprinkler Sprays and the Fire Plume, Smoke Control in Shopping Centres, Smoke Control on Protected Escape Routes	*Smoke detection and control *Interaction between water spray and fire plumes	**8**
Case Studies	Demos on behavior of fires in compartments, Ignition, Fire Related Human Behavior, Incendiary Fire Analysis and Investigations of fire patterns, Demo of flows associated with fire and explosions	*Practical knowledge through demonstrations of fire driven flows and their effects on safety	**9**

Reference:

1. An Introduction to Fire dynamics, 2nd edition: Dougal Drysdale, University of Edinburgh, UK, John Wiley & Sons, UK
2. SFPE Handbook of Fire Protection Engineering, 3rd edition: National Fire Protection Association, Inc. One Battery march Park, Quincy, Massachusetts 02269, USA, NFPA No.: HFPE-01, ISBN: 087765-451-4
3. Understanding combustion by Prof. H.S. Mukunda, Wiley India, 2009

Fire Suppression

3 Credits, 45 hours, Faculty: Shivakumar, Sowriraajan & Bhaskar Dixit

Awareness of firefighting tools and techniques and the rigor employed in their testing and certification

Chapter	Content	Course Outcomes	Hrs
Introduction	Major Fire accidents, Fire Tetrahedron, Classification of fires, Outdoor and Indoor Fire behavior, Fire extinguishing agents. Codes and standards in fire suppression, Measurement of Temperature and flow	*Differentiation of indoor and outdoor fire behavior *Measuring temperature and flow *Identifying extinguishing agents and their applications *Familiarizing fire codes and standards	**8**
Extinguishing Media	Dry Chemical Powder, Properties and Qualification criteria, Foam concentrates, Properties and Qualification criteria	Understanding the working mechanisms of fire extinguishing agents and characterizing them	**12**
Sprinkler and Spray Nozzles	Sprinkler structure and design, actuation mechanisms, dry and wet risers, K factor, calibration and spray patterns, Spray nozzles, hydrant systems	Learning fire sprinkler working principles, specifications, installation and estimating water requirements	**12**
Qualification of Extinguisher Equipment	Integrity and environmental qualification criteria, Behavior of crib and pool fires in free burning quiescent environment, test fires, foam and sprinkler tests, scaled down testing	Understanding testing and certification of fire extinguishment equipment and systems	**8**
Special Media and Techniques	CO_2, Halogen and Water mist based systems, acoustic techniques, fire suppression in tunnels and bridges	Awareness of special extinguishment media and techniques	**5**

References:

1. Fundamentals of Fire Phenomena: James G. Quintiere, University of Maryland, USA, John Wiley & Sons Ltd.
2. IS 4308: 2003, Dry Chemical Powder for Fighting Band C Class Fires Specification, Bureau of Indian Standards, Manak Bhavan, New Delhi 110002.
3. IS 4989: 2006, Foam Concentrate for Producing Mechanical Foam for Fire Fighting Specification, Bureau of Indian Standards, Manak Bhavan, New Delhi 110002
4. IS 15683: 2018, Portable Fire Extinguishers- Performance and Construction- Specification, Bureau of Indian Standards, Manak Bhavan, New Delhi 110002
5. NFPA 11, Standard for Low, Medium, and High Expansion Foam. National Fire Protection Association, (2005).

Fire Protection

3 Credits, 45 hours, Faculty: Sowriraajan, Shivakumar & Bhaskar Dixit

Awareness of techniques of fire prevention and attenuation of life and property loss during fire accidents including the relevant codes and standards

Chapter	Content	Course Outcomes	Hrs
Introduction	Major Fire accidents, Fire prevention mechanisms, classification of occupancies, fire retardant materials, smoke and toxicity, egress, codes and standards, Prescriptive and performance based approaches	Learning various techniques employed to prevent fire events	**8**
Burning Behavior	Stages of fire growth, Time -temperature curves, ignition of thermally thin and thick materials, smouldering combustion, time available for egress	* Quantifying and characterizing fire impact on enclosure walls *Effect of smoke on life safety	**12**
Fire Rating	Fire furnaces, Fire performance analysis and fire rating of Building elements like doors, dampers and fire stops, fire retardant and intumescent coatings	Evaluating response of various building elements & protection devices to fire assault	**12**
Measure-ment Techniques	Temperature and flow Measurement Techniques, Cone calorimeter, non-combustibility test, limiting oxygen index, Fire impingement tests	Hands-on experience in measurement of temperature, heat flux and fire response of materials	**8**
Fire Audit	fire load assessment of occupancy, provision of Integrated fire protection measures, behaviour of occupants, fire drills, mutual aid scheme	*Calculation of fire loads in built environment * Understanding fire safety needs of the building occupants	**5**

Reference:

1. Charles A Harper, Handbook of building materials for fire protection, The Mc Graw Hill Companies Inc, USA, DOI: 10.1036/0071433309
2. Fundamentals of Fire Phenomena: James G. Quintiere, University of Maryland, USA, John Wiley & Sons Ltd.

Fire Simulations

3 credits, 45 hours, Faculty: Prasanna D'souza & Bhaskar Dixit

Development of skillsets in simulation of fire associated phenomena

Chapter	Content	Course Outcomes	Hrs
Introduction	Major fire accidents, Pool fires, Fire driven flows in built environment, Prescriptive and performance based fire safety assessment, Compartment fires,	Recapitulation of basics of fire driven flows Techniques for assessment of fire safety	**12**
Modelling	CFAST, one and two zone models, Modelling Fire driven flows, Smoke and transport, flame height correlations, zonal models	Simple numerical modelling techniques for fire and smoke transport	**8**
Pre Processing	The Basic Structure of an Input File, Setting the Bounds of Time and Space, Global Simulation Parameters, Initial Conditions, Building the Model, Fire and Thermal Boundary Conditions, Ventilation, Chemical Species, Combustion, Devices and Control Logic	Developing skills in modelling fire and smoke transport using free software called Fire Dynamics Simulator	**12**
Post Processing	Using Smoke view, Visualizing Smoke, Visualizing Quantitative data, Visualizing Zone Fire Data, Controlling and Customizing Smoke view		**5**
Case Studies	FDS EVAC Model, Small Pool Fires, Flow fields, Sprinkler, HVAC		**8**

References:

1. Fundamentals of Fire Phenomena: James G. Quintiere, University of Maryland, USA, John Wiley & Sons Ltd.
2. FDS Volume I: User's Guide

NIST Special Publication 1017-1, Sixth Edition, Smokeview, A Tool for Visualizing Fire Dynamics Simulation Data

Project/Internship

5 credits, 75 hours, Faculty: Two students per faculty

Understanding of activities in various industries needing expertise in fire technology

*Internship will be decided before commencement of the final year of the Engg Degree.
Student will complete a minimum of 10 days in the relevant industry and submit reports.
*He will make 3 progress presentations during final year.

***Fire industry majors like UL, Chola MS risk, Johnson Controls International, Honeywell, HD Fire, etc, Architects from construction industry, Oil industry majors, NGOs in fire safety, fire and emergency services, industries in Defence, chemical, food and power with needs in fire safety, can be approached for internships**

Company	Person contacted	Response
Underwriters Laboratories (UL)	Suresh Shanmugam Asia Pacific Leader Operational Strategy, Product Development, P&L Accountability, New & Innovative Services	"Glad to hear that JU-FCRC kicking off a great initiative to offer "Fire Technology Minor" to engineering students and Thank you for letting us know. We are happy to accommodate two students at UL Solutions Bangalore as part of their internship. Please also be informed that for one of the two students, the internship location can also be UL Solutions Mumbai office as we have capability available in Mumbai as well."
Honeywell	Manjuprakash Rao Director, Innovations	"Thanks for your email. The course you are proposing is a great initiative in training the next generation of engineers in the fire safety aspects and this is commendable. Honeywell would be interested to participate in what whatever capacity we can to support this initiative."
JCI	Santosh Muzumdar Director, Government Relations and Sustainability	"Thank you Sir, looks comprehensive. The only suggestion I have at this point is to include NFPA 13 and NFPA 72, EN 54 would be nice to have. I have reached out to my colleagues for the internship program and will get back as soon as I have an update. "