**Subject Description Form**

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| **Subject Code** | BSE4315 |
| **Subject Title** | Fire Science |
| **Credit Value** | 3 |
| **Level** | 4 |
| **Pre-requisite / Co-requisite/ Exclusion** | BSE2216 Engineering Thermodynamics<br>BSE2217 Heat and Mass Transfer |
| **Objectives** | This objective of this course is to allow students to understand the fundamentals of the fire phenomena and combustion processes. The structure and wildland fire behaviours will be presented and used to derive key analytical relationships that describe fire growth. Application of these relationships to the analysis of common fire scenarios is emphasized. It will also help them to develop an understanding of fire growth and the fully developed fire and methods by which potential fire severity can be assessed. This course will introduce sufficient knowledge to students and enable them to become future fire protection engineers. |
| **Intended Learning Outcomes** | Upon completion of the subject, students will be able to:<br>a. Demonstrate a working knowledge of basic physical and chemical processes in various fire phenomena<br>b. Understand the mechanism of initiation and development of fire and the principle of fire suppression<br>c. Apply basic sciences to the fire safety design of building and urban area, and model fire phenomena using numerical tools<br>d. Identify the fire risk and hazard, and formulate and solve engineering problems representative of those commonly encountered in the fire protection engineering practice<br>e. Recognize the need to engage in life-long learning and ability to maintain state of the art fire protection engineering knowledge and skills. |

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| **Subject Synopsis/ Indicative Syllabus** | • **Heat Transfer in Fire**: heat conduction in solids, convective heat transfer, radiation heat transfer in fire, fire load, heat transfer rate, aerodynamics, fire hazards, ceiling jets, plumes;<br>• **Combustion Fundamentals**: Thermodynamics, heat of combustion, chemical reaction and stoichiometry, measurement of heat of combustion, heat of formation and calculation of flame temperature, chemical equilibrium constant, equilibrium constants, combustion chemical kinetics, elementary reaction rate, and soot formation in flames;<br>• **Premixed and Non-premixed Flames**: laminar burning velocity, Flammability limit, quenching, auto-ignition, explosion, detonation, laminar and turbulent jet flames;<br>• **Fire Dynamics**: Fundamentals of ignition, ignition models, fire spread, extinction process of solid and liquid fire, pyrolysis, fire plumes, flame height, air entrainment, burning rate, heat losses, flames from natural fires, fire properties of materials;<br>• **Fire Plumes and Smoke Transport**: Buoyant plume, combusting plumes, pool fire, fireball, force for smoke movement, smoke toxicity, smoke radiation, and smoke control system;<br>• **Compartmental Fire**: pre-flashover fire, growth period, flashover, post-flashover, fully-developed fire, fire resistance and fire severity, evaluation of fire resistance, zone model, and travelling fire;<br>• **Smouldering Fires**: heterogenous oxidation, kinetic scheme, self-heating ignition, and smouldering emission;<br>• **Wildland Fires**: Fire spread, extreme fire behaviours (firebrands, fire whirls, crown fires, etc.), prescribe fires, fire regime, and fire ecology;<br>• **Scaling Analysis**: Dimensionless groups, dimensional analysis, conservation equations, scale-model experiments, and Froude modelling;<br>• **Numerical Fire Modelling**: heat transfer model, computational fluid dynamics (CFD) model, turbulence model (RANS, LES, and DNS), pyrolysis model, boundary conditions, numerical instabilities, model simplification and validation. |

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| **Teaching/Learning Methodology** | The teaching will involve lecture, lab and computing sessions, tutorials and problem solving, and course projects.<br><br>Related laboratory work is an integral part of this subject, to serve as a vehicle for contrasting theory with practice and provide students familiarity with the fundamentals of combustion and fire phenomena.<br><br>The course project includes the learning of the most successful CFD-based fire code, Fire Dynamics Simulation (FDS), developed by National Institute of Standards and Technology (NIST). Students will learn to use this academic code to further understand the fire behaviours and simulate the smoke propagation. By doing this course project, students will be able to conduct fire safety assessment in the design of building and reproduce the fire process in the case of fire investigation.<br><br>End-of-semester examination is the final assessment for students to ensure their understanding and learning abilities in solving real problems by applying their knowledge of various fire phenomena.<br><br>Independent study by students, such as literature and information searching, is required to achieve all the intended learning outcomes. |

**Assessment Methods in Alignment with Intended Learning Outcomes**

| Specific assessment methods/tasks | % Weighting | Intended subject learning outcomes to be assessed | | | | |
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| | | a | b | c | d | e |
| 1. Course project | 20% | ✓ | ✓ | ✓ | ✓ | ✓ |
| 2. Lab Report | 20% | ✓ | ✓ | | ✓ | |
| 3. Final exam | 60% | ✓ | ✓ | ✓ | ✓ | ✓ |
| Total | 100% | | | | | |

**Students must attain at least grade D in both coursework and final examination (whenever applicable) in order to attain a passing grade in the overall result.**

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| **Student Study Effort Expected** | Class contact: | |
| | ▪ Lectures | 39 Hrs. |
| | ▪ Lab | 15 Hrs. |
| | ▪ Tutorials | 13 Hrs. |
| | Other student study effort: | |
| | ▪ Course Project | 14 Hrs. |
| | ▪ Self-study | 39 Hrs. |
| | Total student study effort | 120 Hrs |
| **Reading List and References** | **Essential Textbook:**<br>• Dougal Drysdale, An Introduction to Fire Dynamics, 3rd edition, John Wiley & Sons, 2011.<br><br>**Reference Textbooks:**<br>• James G. Quintiere, Fundamentals of fire phenomena, John Wiley, 2006.<br>• E.A. Johnson and K. Miyanishi, Forest Fires, Academic Press, San Diego, 2001.<br>• Kevin McGrattan et al. Fire Dynamics Simulator, User's Guide, NIST Special Publication 1019, 6th edition, NIST, 2017. | |