**BIRLA INSTITUTE OF TECHNOLOGY & SCIENCE, PILANI**

**WORK INTEGRATED LEARNING PROGRAMMES**

**Digital Learning**

Part A: Content Design

|  |  |
| --- | --- |
| **Course Title** | Mechatronics |
| **Course No(s)** | DE ZG516 / DM ZG511 / ES ZG511 |
| **Credit Units** | 5 |
| **Credit Model** | 1-1-2  (32 Hours of Class-room Instruction + 32 Hours of Case-studies/Tutorials/Laboratories + 64 Hours of Student Preparation) |
| **Content Authors** |  |

**Course Objectives**

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| --- | --- |
| **No** | Objective |
| **CO1** | An introduction to the applications of mechatronics in various household and industrial products like in washing machines, microwave ovens, computers, printers, programmable logic controllers, CNC machines etc. |
| **CO2** | Introduction to the various mechatronics building blocks like the System modelling, Signal sensing and conditioning, Control system engineering, Electrical and mechanical actuation systems etc. |
| **CO3** | Learning about Sensors and Transducers, Operational Amplifiers, Hydraulic and Pneumatics, Dynamic response of systems, System transfer function, Frequency response, Closed loop controllers, Programmable logic controllers etc. |

**Text Book(s)**

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| --- | --- |
| T1 | Mechatronics by W. Bolton, 4th Edition, Pearson |
| T2 | Introduction to Mechatronics and Measurement Systems by D.G. Alciatore and M.B. Histand, 4th Edition, Tata McGraw Hill |

**Reference Book(s) & other resources**

|  |  |
| --- | --- |
| R1 | Mechatronics, HMT Limited, Tata McGraw Hill, 1998 |
| R2 | Pneumatics and Electropneumatics: Basic Level by Festo Didactic |
| R3 | Fluid Power with Applications by Anthony Esposito, Prentice Hall |
| R4 | Control Systems by W. Bolton, Newnes |

**Content Structure**

1. Introduction to Mechatronics
   1. Measurement systems
      1. Sensors
      2. Transducers
      3. Need for signal conditioning
   2. Control systems
      1. Open and Closed loop controllers
      2. Microprocessors and Microcontrollers

1.3. Actuators

1.3.1. Electric actuators

1.3.2. Mechancal actuators

* 1. Application examples
     1. Mechatronics in Industry
     2. Mechatronics in home appliances

1. Sensors and Transducers
   1. Definition of sensors and transducers

2.2. Performance terminology

2.2.1. Range and Span

2.2.2. Errors: Hystersis and Non-linearity errors

2.2.3. Accuracy, precision and sensitivity

2.2.4. Resolution

2.2.5. Repeatibility and Stability

2.3. Static and Dynamic characterisitcs

2.3.1. Response, rise and settling times

2.3.2. Time constant

2.4. Sensing various physical quantities

2.4.1. Sensing displacement, position and proximity

2.4.2. Sensing force, velocity and motion

2.4.3. Sensing fluid flow rate, pressure and level

2.4.4. Sensing temperature with the following:

Thermocouples, Thermistors, RTDs, AD590, LM35

2.5. Sensor selection

1. Signal Conditioning
   1. Need for signal conditioning

3.1.1. Signal protection

3.1.2. Noise elimination

3.1.3. Getting right type and level of signal

3.1.4. Signal manipulation

* 1. Signal conditioning with operational amplifiers
     1. Inverting amplifier
     2. Non-inverting amplifier
     3. Summing amplifier
     4. Difference amplifier
     5. Integrating amplifier
     6. Differentiating amplifier
     7. Logarithmic amplifier
     8. Analog to Digital conversion and vice versa
  2. Wheatstone bridge
     1. Applications with strain gauges
     2. Temperature compensation
     3. Temperature compensation

1. System modelling and dynamic response
   1. Basic system models
      1. Mechanical, electrical, thermal and fluid systems
      2. Rotational-translational systems
      3. Electromechanical systems
      4. Hydraulic-mechanical systems
   2. Dynamic response of systems
      1. 1st and 2nd order systems and their identification
      2. Performance measures
   3. System transfer functions
      1. 1st and 2nd order systems
      2. Systems in series
      3. Systems with feedback loops
      4. Effect of pole location on transient response

4.4. Frequency response of systems

4.4.1. Frequency response with a sinusoidal input

4.4.2. Bode plots

4.4.3. Performance specifications

1. Controllers
   1. Controller types
      1. Open loop controllers
      2. Closed loop controllers
   2. Various control modes
      1. Two step control mode
      2. Proportional control mode
      3. Derivative control mode
      4. Integral control mode
      5. PID controllers
   3. Control system performance
      1. Controller tuning
2. Actuators
   1. Electrical actuators
      1. Relays, contactors and solenoids
      2. Electric motors: AC, DC, stepper
   2. Mechanical actuators
      1. Gears, belt and chain drives
      2. Linkage mechanisms, Ratchet and pawl
3. Hydraulics and Pneumatics
   1. Hydraulics
      1. Hydraulic power pack
      2. Various types of pumps, valves, cylinders, motors
      3. Hydraulic component symbols and drawings
   2. Pneumatics
      1. Various types of compressors
      2. Compressed air distribution
      3. Various types of valves, cylinders, pneumatic motors
   3. Hydraulic and pneumatic circuits
      1. Circuit for single and double acting cylinders
      2. Circuits for counter-balancers
      3. Expand here
4. Microprocessors and Microcontrollers
   1. Microprocessor systems
      1. Buses
      2. Microprocessor components
      3. Memory and input / output
   2. Microcontrollers
      1. Difference with microprocessor
      2. Motorola M68HC11
      3. Intel 8051
      4. Programming
5. Programming Logic Controllers
   1. Basic structure of a PLC
      1. Input and output modules
      2. Power supply and CPU
      3. Sinking and sourcing inputs and outputs
   2. PLC programming
      1. Ladder logic programming
   3. Timers, Counters, Internal relays, Registers

**Learning Outcomes: Students will be able to**

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| --- | --- |
| LO1 | Apply mechatronics in the design of products |
| LO2 | Acquire concepts of signal sensing and conditioning, control and decision making and output actuation. |
| LO3 | Illustrate working of various sensors and transducers, system modelling and dynamic response, open and closed loop controllers, electrical and mechanical actuators. |
| LO4 | Develop hydraulic and pneumatic drawings for industry automation |
| LO5 | Put to use PLC programming using ladder logic. |

**Part B: Learning Plan**

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| **Academic Term** | Second Semester 2019-2020 |
| **Course Title** | Mechatronics |
| **Course No** | DE ZG516 / DM ZG511 / ES ZG511 |
| **Lead Instructor** | SAMATHA MAJUMDAR |

Contact Hour 1

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Introducing Mechatronics, Concepts of signal measurement, control and output actuation | T1: Chapter 1, T2: Chapter 1 |
| Post CH |  |  |  |

Contact Hour 2

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T2 | Mechatronics application examples | T2: Page no. 84, 98, 101, 108, 146, 188, 245, 247, 290, 312, 405, 449 |
| Post CH |  |  |  |

Contact Hour 3

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Sensor and Transducers: Definition and performance terminology, Static and dynamic characteristics | T1: Chapter 2, T2: Chapter 9 |
| Post CH |  |  | Chapter end problems |

Contact Hour 4

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Sensing physical quantities: Displacement, position and proximity | T1: Chapter 2, T2: Chapter 9 |
| Post CH |  |  | Chapter end problems |

Contact Hour 5

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Sensing physical quantities: Force, strain, velocity and motion | T1: Chapter 2, T2: Chapter 9 |
| Post CH |  |  | Chapter end problems |

Contact Hour 6

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Sensing physical quantities: Fluid flow rate, pressure and liquid level | T1: Chapter 2, T2: Chapter 9 |
| Post CH |  |  | Chapter end problems |

Contact Hour 7

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Sensing physical quantities: Temperature measurement with Thermocouples, Thermistors, RTDs, AD590, LM35 | T1: Chapter 2, T2: Chapter 9 |
| Post CH |  |  |  |

Contact Hour 8

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Signal conditioning: Need for condioning, protection, noise elimination | T1: Chapter 3, T2: Chapter 5 |
| Post CH |  |  |  |

Contact Hour 9

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Signal conditioning with operational amplifiers: Inverting, non-inverting amplifiers | T1: Chapter 3, T2: Chapter 5 |
| Post CH |  |  | Chapter end problems |

Contact Hour 10

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Signal conditioning with operational amplifiers: Summing and difference amplifiers | T1: Chapter 3, T2: Chapter 5 |
| Post CH |  |  | Chapter end problems |

Contact Hour 11

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Signal conditioning with operational amplifiers: Integrating, Differentiating and lograthimic amplifiers | T1: Chapter 3, T2: Chapter 5 |
| Post CH |  |  | Chapter end problems |

Contact Hour 12

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Signal conditioning: Wheatstone bridge, application examples and temperature compensation | T1: Chapter 3, T2: Chapter 9 |
| Post CH |  |  |  |

Contact Hour 13

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Signal conditioning: Analog to digital conversion and vice versa | T1: Chapter 4 |
| Post CH |  |  |  |

Contact Hour 14

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | System modelling: Modelling of mechanical and electrical systems, Modelling of thermal and fluid systems | T1: Chapter 10 |
| Post CH |  |  | Chapter end problems |

Contact Hour 15

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | System modelling: Modelling of rotational and translational systems, Modelling of electromechanical systems | T1: Chapter 11 |
| Post CH |  |  | Chapter end problems |

Contact Hour 16

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | System modelling: Modelling of hydraulic-mechanical systems | T1: Chapter 11 |
| Post CH |  |  |  |

Contact Hour 17

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Dynamic response of systems: 1st and 2nd order systems and their performance measures | T1: Chapter 12 |
| Post CH |  |  | Chapter end problems |

Contact Hour 18

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | System transfer functions: 1st nd 2nd order systems, systems in series and with feedback, effect of pole location | T1: Chapter 13 |
| Post CH |  |  | Chapter end problems |

Contact Hour 19

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Frequency response of systems: Response with a sinusoidal input, Bode plots, Performance specifications | T1: Chapter 13 |
| Post CH |  |  |  |

Contact Hour 20

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R4 | Control systems: Open and closed loop controllers, On-off and proportional control modes | T1: Chapter 15, R4 |
| Post CH |  |  | Chapter end problems |

Contact Hour 21

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R4 | Control systems: Derivative, Integral and PID controllers | T1: Chapter 15, R4 |
| Post CH |  |  | Chapter end problems |

Contact Hour 22

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Actuators: Electric actuators like relay, contactor, solenoid, AC, DC, Stepper motors | T1: Chapter 9, T2: Chapter 10 |
| Post CH |  |  |  |

Contact Hour 23

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Actuators: Mechanical actuators like belt and chain drives, linkage mechanisms | T1: Chapter 8 |
| Post CH |  |  |  |

Contact Hour 24

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R3 | Hydraulics and pneumatics: Hydraulic pumps and valves | T1: Chapter 7, R3: Chapter 6, 8 |
| Post CH |  |  |  |

Contact Hour 25

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R3 | Hydraulics and pneumatics: Hydraulic cylinders and motors | T1: Chapter 7, R3: Chapter 7 |
| Post CH |  |  |  |

Contact Hour 26

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R2,R3 | Hydraulics and pneumatics: Compressed air generation and distribution system, compressors, valves and cylinders | T1: Chapter7, R2, R3: Chapter 11, 12 |
| Post CH |  |  |  |

Contact Hour 27

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, R2,R3 | Hydraulics and Pneumatics: Drawing symbols and basic circuits | R2, R3 |
| Post CH |  |  |  |

Contact Hour 28

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Digital logic: Logic gates, boolean algebra, applications | T1: Chapter 5, T2: Chapter 6 |
| Post CH |  |  |  |

Contact Hour 29

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1, T2 | Microprocessors and micro-controllers: Components and programming | T1: Chapter 17, T2: Chapter 7 |
| Post CH |  |  |  |

Contact Hour 30

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| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Programmable logic controllers: Components, programming using ladder logic | T1: Chapter 21 |
| Post CH |  |  | Chapter end problems |

Contact Hour 31

|  |  |  |  |
| --- | --- | --- | --- |
| Type | Content Ref. | Topic Title | Study/HW Resource Reference |
| Pre CH |  |  |  |
| During CH | T1 | Programmable logic controllers: Use of relays, timers, counters, registers in ladder logic, application examples etc. | T1: Chapter 21 |
| Post CH |  |  |  |

**Assignments**

* Each student is given an individual assignment on any of the topics discussed in the class
* Assignments are take-home and deadline-driven (typically of 2 weeks duration) announced post Mid-semester examination
* Students to spend at least 16 hours of work in study, research, discussion and preparation of the report and presentation.
* As part of deliverables, the student is expected to prepare a report and make a short-presentation in the class

**Evaluation Scheme**

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| --- | --- | --- | --- | --- | --- |
| **Evaluation Component** | **Name** | **Type** | **Weight** | **Duration** | **Schedule** |
| **EC - 1** | Assignments | Individual and Take-home | 10% | 2 Weeks | Throughout |
|  | Lab -1 | Online | 10% | 1 Week | To be announced |
|  | Lab -2 | Online | 10% | 1 Week | To be announced |
| **EC - 2** | Mid-Semester Examination | Closed Book | 30% | 2 Hrs | Saturday, 07/03/2020 (FN)  10 AM – 12 Noon |
| **EC - 3** | End-Semester Examination | Open Book | 40% | 3 Hrs | Saturday, 02/05/2020 (FN)  9 AM – 12 Noon |

**Closed Book** No reference material of any kind will be permitted inside the exam hall.

**Open Book:** Use of any printed / written reference material (books and notebooks) will be permitted inside the exam hall. Loose sheetsPhotocopies and Laser printouts of any material willL not be permitted. Computers of any kind will not be allowed inside the exam hall. Use of calculators will be allowed in all exams. No exchange of any material will be allowed.

**Note:**

It shall be the responsibility of the individual student to be regular in maintaining the self study schedule as given in the course handoutattend the online/on demand lectures as per details that would be put up in the **BITS eLearn (Taxila)** website **elearn.bits-pilani.ac.in** and take all the prescribed components of the evaluation such as Assignments/QuizesMid Semester and End Semester Examination according to the Evaluation Scheme given in the respective Course Handout. If the student is unable to appear for the Regular Examination due to genuine exigenciesthe student must refer to the procedure for applying for Make-up Examinationwhich will be available through the Important Information link on the eLearn website on the date of the Regular Examination. The Make-up Tests/Exams will be conducted only at selected exam centres on the dates to be announced later.

**Instructor-in-Charge**