Transducers and Instrumentation: Theory & Lab

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| Semester | Jan – April 2023 (14-16 weeks) |
| Course Instructor | Sivakumar Balasubramanian [ [siva82kb@cmcvellore.ac.in](mailto:siva82kb@cmcvellore.ac.in) ] |
| Teaching Assistants | Diwakar Reddy [ [bkdiwakar34@gmail.com](mailto:bkdiwakar34@gmail.com) ]  Arjun Ram [ [arjunram11697@gmail.com](mailto:arjunram11697@gmail.com) ]  Samuel Ellias [ [samuel.elias411@gmail.com](mailto:samuel.elias411@gmail.com) ]  Sujith Christopher [ [chrisbon95@gmail.com](mailto:chrisbon95@gmail.com) ] |
| Weekly Schedule | 3 hrs of lecture videos  2 hrs of in-person tutorials; 1hr sessions on Monday and Friday of every week  3 hrs of lab per week |

Detailed Course Content

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| Introduction to measurement  Measurement, Measuring instrument, Transducer & sensors, Generalized static characteristics of sensors, Generalized dynamic characteristics, Error analysis. |
| **Basic Instrumentation**  Operational amplifier, Linear circuits with op-amps, First order and second order filters, System identification. |
| **Measuring movements: linear and rotational**  Resistive, Inductive, Capacitive, Digital sensors, Camera based tracking, Accelerometer, Gyroscope. |
| **Measuring effort: Force and Torque**  Strain gauges. |
| **Measuring pressure, flow, volume**  Piezoelectric sensors, differential/absolute pressure, flow, and volume sensing methods. |
| **Measuring temperature**  Thermocouple, Thermistor, Radiation thermometry. |
| **Measuring biopotentials**  Origins of biopotentials, Review of basic electrochemistry, Electrode half-potentials, Electrical equivalent circuits of electrodes. |

Course Grading

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| Assignment | Quiz | Midterm | Final |
| 10% | 20% | 20% | 50% |

Assignments are due at 5 PM on the due date and are to be submitted online. Late submissions will result in a loss of 20% of the maximum score for the assignment per day of delay in submission.

The final score for the assignment will consider the best 8/9 assignments, which allows students to miss one assignment.

Quizzes will be held during each tutorial session. They will start 5 mins after the scheduled start of the tutorial session. The best 20/25 quizzes will be considered for the final score for the Quiz.

Submission for revaluation of Quizzes/Assignments should be done within 24 hours after receiving the answer sheet.

Course Textbook

Webster, John G., ed. Medical instrumentation: application and design. John Wiley & Sons, 2017.

Detailed Schedule

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| Week 1 | Jan 02 – Jan 07 |
| Orientation to the course and the course logistics. | |
| **Lectures:** | Introduction (in person)  [Lecture video 1 (Introduction to Transducers and Sensors)](https://youtu.be/99bOpjIB8sw) |
| **Tutorial:** | Monday – None  Friday – None |
| **Quiz:** | Monday – None  Friday – Quiz 0 (not considered for course grade) |

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| Week 2 | Jan 09 – Jan 14 |
| Continuing Module 01 on ‘Intro to Measurements’. | |
| **Lectures:** | [Lecture video 2 (Static sensor characteristics)](https://youtu.be/Q5y1_s6hi6o)  [Lecture video 3 (Dynamic sensor characteristics, LTI systems)](https://youtu.be/VyfCm8ByACg) |
| **Tutorial:** | Monday – Problem set 2.1: static sensor characteristics  Friday – Problems set 2.2: dynamic sensor characteristics |
| **Quiz:** | Monday – Quiz 2.1  Friday – Quiz 2.2 |

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| Week 3 | Jan 16 – Jan 21 |
| Continuing Module 01 on ‘Intro to Measurements’. | |
| **Lectures:** | [Lecture video 4 (LTI systems)](https://youtu.be/WMoqoHO52ic)  [Lecture video 5 (LTI systems)](https://youtu.be/UBPEWRrNDk0) |
| **Tutorial:** | Monday – Problem set 3.1: Linear time invariant systems  Friday – Problems set 3.2: Linear time invariant systems |
| **Quiz:** | Monday – Quiz 3.1  Friday – Quiz 3.2 |

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| Week 4 | Jan 23 – Jan 28 |
| Continuing Module 01 on ‘Intro to Measurements’ and starting Module 02 ‘Basic Instrumentation’. | |
| **Lectures:** | [Lecture video 6 (LTI systems)](https://youtu.be/wRX8pVv7z3w)  [Lecture video 7 (Basic of linear circuits)](https://youtu.be/4ZGajeM1Xhw) |
| **Tutorial:** | Monday – Problem set 4.1: Linear time-invariant systems  Friday – Problems set 4.2: Linear time-invariant systems |
| **Quiz:** | Monday – Quiz 4.1  Friday – Quiz 4.2 |
| **Lecture Slides:** | [Module 01(a)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-01/module01-01.pdf) [Module 01(b)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-01/module01-02.pdf) |

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| Assignment 1: Due Jan 28 |

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| Week 5 | Jan 30 – Feb 04 |
| Continuing Module 02 on ‘Basic Instrumentation’. | |
| **Lectures:** | [Lecture video 8 (Operational amplifiers)](https://youtu.be/m8mL50jeugQ)  [Lecture video 9 (Frequency response; Active filters)](https://youtu.be/QqtOEB3k68A) |
| **Tutorial:** | Monday – Problem set 5.1: Basic linear circuits  Friday – Problems set 5.2: Operational amplifiers |
| **Quiz:** | Monday – Quiz 5.1  Friday – Quiz 5.2 |
| **Lecture Slides:** | [Module 02](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-02/module02.pdf) |

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| Assignment 2: Due Feb 04 |

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| Week 6 | Feb 06 – Feb 11 |
| Module 03 on ‘Measuring movements’. | |
| **Lectures:** | [Lecture video 10 (Measuring position)](https://youtu.be/JgmkeLM6SPo)  [Lecture video 11 (Measuring position)](https://youtu.be/wK80-d56IbA)  [Lecture video 12 (Measuring position and acceleration)](https://youtu.be/MAc4tbux0fY) |
| **Tutorial:** | Monday – Problem set 6.1: Measuring position  Friday – Problems set 6.2: Measuring position |
| **Quiz:** | Monday – Quiz 6.1  Friday – Quiz 6.2 |
| **Lecture Slides:** | [Module 03(a)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-03/module03-01.pdf) |

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| Assignment 3: Due Feb 11 |

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| Week 7 | Feb 13 – Feb 18 |
| Continuing Module 03 on ‘Measuring movements’. | |
| **Lectures:** | [Lecture video 13 (Measuring acceleration and angular velocity)](https://youtu.be/nbALojMAR4I) |
| **Tutorial:** | Monday – Problem set 7.1: Measuring acceleration  Tuesday – Problems set 7.2: Measuring angular velocity |
| **Quiz:** | Monday – Quiz 7.1  Tuesday – Quiz 7.2 |
| **Lecture Slides:** | [Module 3(b)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-03/module03-02.pdf) |

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| Assignment 4: Due Feb 18 |

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| Week 8 | Feb 20 – Feb 25 |
| Review for mid-term on Friday of this week. | |
| **Lectures:** | None |
| **Tutorial:** | Monday – None  Friday – Review |
| **Quiz:** | Monday – None  Friday – None |

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| Assignment 5: Due Feb 25 |

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| Week 9 | Feb 27 – Mar 04 |
| Mid-term week and starting Module 04. | |
| **Lectures:** | [Lecture video 14 (Measuring force and torque)](https://youtu.be/TTCLR6g4emI) |
| **Tutorial:** | Monday – None  Friday – Review of mid-term questions |
| **Quiz:** | Monday – None  Friday – None |

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| Feb 27: Mid-term |

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| Week 9 | Mar 06 – Mar 11 |
| Module 04 on ‘Measuring force and torque’. | |
| **Lectures:** | [Lecture video 15 (Measuring force and torque)](https://youtu.be/s3xLYkL74VA) |
| **Tutorial:** | Monday – Review of mid-term questions  Friday – Problems set 9.1: Measuring force and torque |
| **Quiz:** | Monday – None  Friday – Quiz 9.1 |
| **Lecture Slides:** | [Module 04](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-04/module04.pdf) |

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| Week 10 | Mar 13 – Mar 18 |
| Module 05 on ‘Measuring pressure, flow and volume’. | |
| **Lectures:** | [Lecture video 16 (Measuring pressure)](https://youtu.be/L7RGQZwGx3s)  [Lecture video 17 (Measuring pressure)](https://youtu.be/BwVCHIJMzFE) |
| **Tutorial:** | Monday – Problems set 10.1: Measuring force and torque  Friday – Problems set 10.2: Measuring pressure |
| **Quiz:** | Monday – Quiz 10.1  Friday – Quiz 10.2 |

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| Assignment 6: Due March 18 |

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| Week 11 | Mar 20 – Mar 25 |
| Module 05 on ‘Measuring pressure, flow and volume’. | |
| **Lectures:** | [Lecture video 18 (Measuring flow)](https://youtu.be/omYoRAJjcHM)  [Lecture video 19 (Measuring volume)](https://youtu.be/ESlYcgvec0o) |
| **Tutorial:** | Monday – Problems set 11.1: Measuring pressure  Friday – Problems set 11.2: Measuring flow |
| **Quiz:** | Monday – Quiz 11.1  Friday – Quiz 11.2 |
| **Lecture Slides:** | [Module 05(a)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-05/module05-01.pdf) [Module 05(b)](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-05/module05-02.pdf) |

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| Week 12 | Mar 27 – Apr 01 |
| Module 06 on ‘Measuring temperature’. | |
| **Lectures:** | [Lecture video 20 (Measuring temperature)](https://youtu.be/KZE0_U34wbA) |
| **Tutorial:** | Monday – Problems set 11.1: Measuring flow  Friday – None |
| **Quiz:** | Monday – Quiz 12.1  Friday – Quiz 12.2 |
| **Lecture Slides:** | [Module 06](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-06/module06.pdf) |

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| Assignment 7: Due Apr 01 |

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| Week 13 | Apr 03 – Apr 08 |
| Module 07 on ‘Measuring biopotentials. | |
| **Lectures:** | [Lecture video 21 (Measuring biopotentials)](https://youtu.be/YUl4oMee3aA) |
| **Tutorial:** | Monday – Problems set 11.1: Measuring temperature  Friday – None |
| **Quiz:** | Monday – Quiz 13.1  Tuesday – Quiz 13.2 |

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| Assignment 8: Due Apr 08 |

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| Week 14 | Apr 10 – Apr15 |
| Module 07 on ‘Measuring biopotentials. | |
| **Lectures:** | None |
| **Tutorial:** | Monday – Problems set 13.1: Measuring biopotentials  Friday – None |
| **Quiz:** | Monday – Quiz 14.1  Friday – Quiz 14.2 |
| **Lecture Slides:** | [Module 07](https://github.com/siva82kb/teaching/raw/master/transducers_and_instrumentation/lectures/module-07/module07.pdf) |

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| Assignment 9: Due Apr 15 |

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| Week 15 | Apr 17 – Apr 22 |
| Review week | |
| **Lectures:** | None |
| **Tutorial:** | Monday – Review  Friday – Review |
| **Quiz:** | Monday – None  Friday – None |

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| Apr 29: Final |