

Mechanical Engineering Laboratories

The Department of Mechanical Engineering at IIT Tirupati houses modern laboratory facilities that support high-quality education, cutting-edge research, and industrial innovation. The department has established 25 well-equipped laboratories, comprising undergraduate teaching laboratories and specialized research laboratories, catering to a wide spectrum of mechanical engineering disciplines. These facilities provide students and researchers with hands-on experience in manufacturing, design, thermal sciences, fluid mechanics, materials engineering, additive manufacturing, robotics, computational engineering, energy storage and hydrogen technologies.

The laboratories are equipped with advanced instruments and state-of-the-art experimental facilities that enable both fundamental and applied research. The department continuously upgrades its infrastructure through funding from national agencies and industrial collaborations, ensuring access to modern equipment aligned with emerging technological trends. These facilities support interdisciplinary research, product development, prototype fabrication, material characterization, testing, and simulation, fostering innovation and technology transfer.

In addition to supporting academic curricula, the laboratory ecosystem encourages project-based learning, undergraduate research, postgraduate dissertations, doctoral research, and consultancy activities. Students actively engage in laboratory experiments, design projects, and research initiatives under the guidance of experienced faculty members. The department also promotes collaboration with industries and research organizations through laboratory demonstrations, training programs, workshops, and sponsored projects. Collectively, these laboratories provide an excellent platform for nurturing skilled engineers, advancing scientific knowledge, and addressing real-world engineering challenges through research and innovation.

The mechanical engineering laboratories cater to the practical experience provided to undergraduate and postgraduate students to carry out high-quality research by the research scholars of the department. The laboratories are equipped with facilities to demonstrate principles in all the domains of mechanical engineering.

1. Applied Thermal Engineering Laboratory

Applied thermal engineering laboratory has been setup to provide hands-on experience to students on thermal engineering concepts such as Internal combustion engines, refrigeration and air conditioning, fuel property measurements. The laboratory consists of following experimental setups:

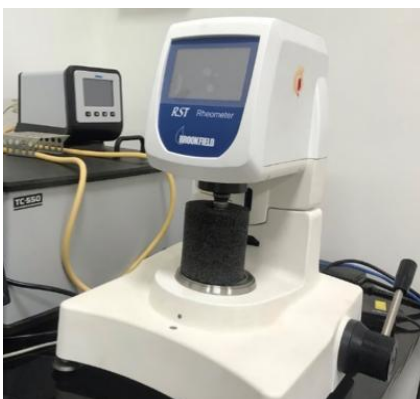
1. Two-cylinder CRDi Diesel engine setup
2. Single cylinder petrol engine setup with open ECU
3. Bomb calorimeter
4. Vapour compression refrigeration system
5. Air conditioning trainer setup
6. Dunuoy Ring tensiometer
7. Rheometer
8. Gas Sorption Analyser



Two-cylinder CRDi Diesel engine setup



Bomb calorimeter



Rheometer



Gas Sorption Analyser

2. Metrology Laboratory

Metrology Lab has been set up for the students to perform various measurement related experiments. We have versatility in the equipment unlike any other metrology lab. We have basic measurement tools (eg. Vernier, micrometer etc.) to the advance equipment (eg. 3D Profiler, CMM, Form tester) to meet the present day Industry requirements. Also we have equipment like Autocollimator, Height gauge, Surface roughness tester, Surface roughness and Contour measurement, . This lab also houses the following metrology hand tools: GO & NOGO ring, plug and feeler gauges, sine bar, dial gauge setup with magnetic base and thread plug gauge.

The Metrology Laboratory is designed to strengthen student's theoretical knowledge which they gained in Metrology course. The laboratory consists of following experimental setups.



Coordinate Measuring Machine



Surface Roughness tester



3D Profiler



Surface Roughness & Contour Tester



Digital Height gauge



Hand Tools

3. Machine Tools Laboratory

Machine tools laboratory has been set up for the students to perform experiments related to advanced machining process. This Lab has advance machines like CNC Lathe, CNC Milling, and CNC Wire cut EDM. We have Master CAM software available in the laboratory to convert CAD based 3D geometry to CNC part program. Also, there is dynamometer available to measure cutting forces in machining.

The Machine Tools Laboratory is designed to strengthen student's theoretical knowledge which they gained in Manufacturing course. The laboratory consists of following experimental setups.



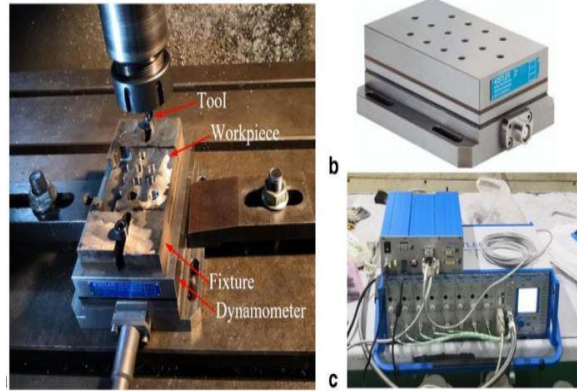
CNC wire cut EDM



CNC Milling Machine



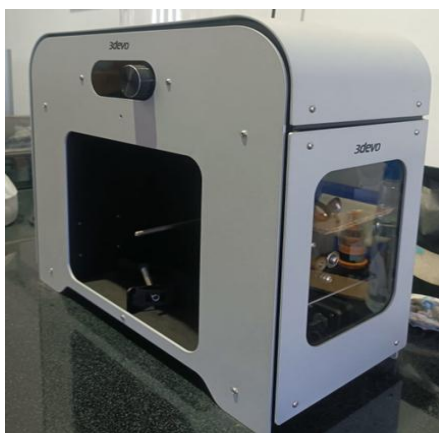
CNC Lathe



Cutting force Dynamometer

4. Composite Filament Fabrication Laboratory

This laboratory facilitates the equipment to develop customized composite filaments suitable for Fused Deposition Modelling (FDM). The conical twin screw extruder (make: AASABI pvt ltd.) can compound the polymer matrix and reinforcement, to produce a composite filament. The filament is then pelletized and characterized. These composite pellets re-extruded into a composite filament, suitable for 3D printing. This machine can perform large scale production. The bench top single screw extruder (make: 3Devo) is meant for small scale production and preferably used for neat polymer filament fabrication. This extruder can process the composite granules with limited solid loading into the composite filaments. The bench top FDM printer (make: Bambu Lab X1 Carbon) can print the polymer filaments as well as composite filaments at faster rates. The nozzle is made up of hardened steel and capable of processing highly infilled filaments.



Single screw extruder



Conical twin screw extruder



Bench top FDM printer

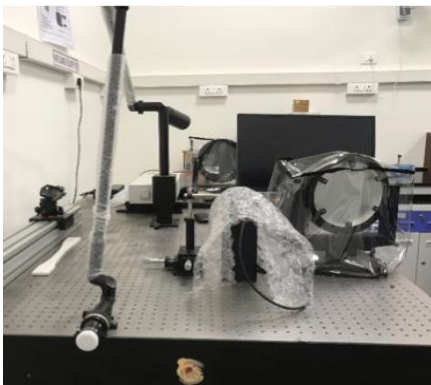
5. Droplet, Spray and Combustion Research Laboratory

Spray Research Lab has been established to conduct fundamental and applied research on sprays and combustion. The research carried out in the laboratory finds application in the areas of spray combustion, nutrient delivery in agriculture, spray coatings etc. The Spray research lab consists of the below mentioned list of equipment.

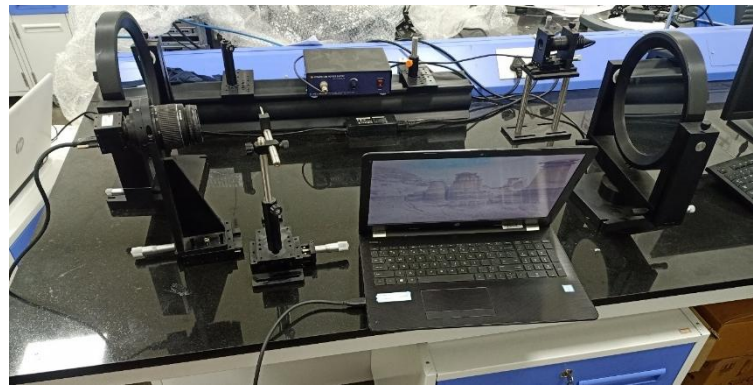
1. High Imaging systems (Photron SAZ and Photron SA1.1) including Long distance microscope and lenses
2. Particle Image Velocimetry Setup (TSI)
3. Spraytec from Malvern with 0.1 to 900 um measurement range
4. High pressure liquid and gas supply systems with flow controllers (max. 3 MPa)
5. High pressure high temperature spray chamber (up to 60 bar and 800K)
6. Spray tower with optical access
7. Schlieren Imaging setup



High Imaging systems



Particle Image Velocimetry



Schlieren imaging setup

6. *Smart Welding and Additive Manufacturing Laboratory (SWAAM Lab)*

Smart Welding and Additive Manufacturing Laboratory is developed to train the undergraduate and postgraduate students on the latest joining processes and metallographic studies. Active research has been performing in the JAM lab where five PhD and four M. Tech students are pursuing their research work. The JAM lab consists of the below mentioned list of equipment.

1. Shielded Metal Arc welding process
2. Gas Tungsten Arc welding process
3. Robotic Gas metal arc welding process
4. Submerged arc welding process
5. Down drought tables



Smart Welding and Additive Manufacturing Laboratory

7. Advanced Materials Manufacturing & Tribology Laboratory -1

In Advanced Materials Manufacturing & Tribology Laboratory, the students perform experiments and computational work-related casting. Advanced metal casting facilities (Stir Casting, Squeeze Casting, Pressure Infiltration and Induction Furnace) have been established at the department of Mechanical Engineering IIT Tirupati. These facilities are used for new materials development such as alloys, composites, metal foams, composite foams and high entropy alloys etc. Foundry 4.0 Student Activity Centre (F4SAC) was also started in association with Indian Institute of Foundrymen (IIF) Chennai and Andhra Chapter on 9th October 2021. Photos of the opening event are as follows:



Foundry 4.0 Student Activity Center programs

7.1 Metal casting/forming simulation facilities

Metal Casting/Forming Simulation software facilities have been started at Advanced Materials Manufacturing and Tribology Lab. The following software are available for students:

Z-CAST PRO Stress : Flow Simulation, Solidification Simulation, Heat Stress Simulation

AFDEX – Metal Forming Simulation Software

AFDEX is an Intelligent Metal Forming Simulation tool, It is based on Rigid or Elasto thermo-visco-plastic finite element analysis using quadrilateral / tetrahedral elements thus providing faster & higher accuracy results.

AFDEX is a general-purpose metal forming simulator, which meets the requirements of intelligent bulk-metal-forming (BMF) simulation (BMFS): Forging, Extrusion, Rolling, Deep Drawing, Sheet Forming, Swaging, Open/Closed Die Forming, Hot/Warm/Cold Forming, Rotary Forging, Swagging, Cogging etc.

VCNC PRO – CNC Simulation Software

VCNC pro simulation software analyses a NC code programmed, and transmits machine-commands to the virtual controller. The Virtual CNC machine simulates the NC code in the 3-dimentional environments.

QFORM Software

QForm is a professional engineering software for simulation, analysis and optimization of metal forming processes based on the Finite Element Method. QForm software allows simulation of an entire technological chain at high speed and excellent reliability and provides a wide range of possibilities for process analysis.

The most important economic benefits of QForm software include:

1. Decreasing production lead time
2. Eliminating defects in metal forming production
3. Increasing quality and improving product properties
4. Reducing material consumption
5. Elimination of test dies

6. Reduced development time and improved efficiency

7.2 Casting facilities

The laboratory also has equipment related to casting including a Bottom Pouring stir casting machine and a Vacuum Induction Furnace. Bottom Pouring stir casting machine is a casting machine that allows you to mix the reinforcements in the base metal and pour it into the mold with ease and without loss in the melt temperature.



Bottom Pouring stir casting machine



Vacuum Induction Furnace



Induction furnace

8. Advanced Manufacturing Laboratory

Advanced manufacturing laboratory is a research laboratory, and the laboratory is equipped with various polishing machines. The following finishing machines are available in this laboratory

1. Abrasive flow finishing
2. Plasma Polishing
3. Drag Finishing
4. Electro polishing Machine



Drag Finishing



Abrasive flow finishing

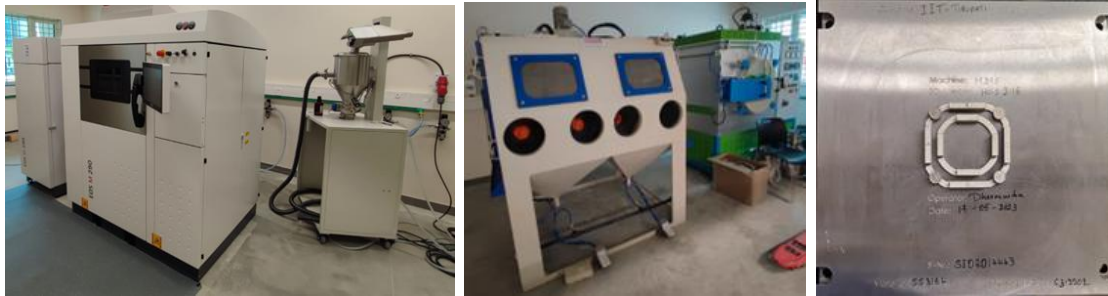


Plasma Polishing

9. Additive Manufacturing Laboratory

The additive manufacturing lab is developed to introduce/train students, especially research scholars, to the latest technologies in the field of additive manufacturing. It is a research lab rather than a curriculum lab. The lab is filled with the metal 3D printer (M290) EOS make and its accessories, including a vacuum furnace, shot peening equipment,

automatic argon gas bank with automatic change-over setup, dehumidifier, etc., 3D Scanner and a plastic 3D printer at present.



3D printer



3D Scanner

Plastic 3D printer

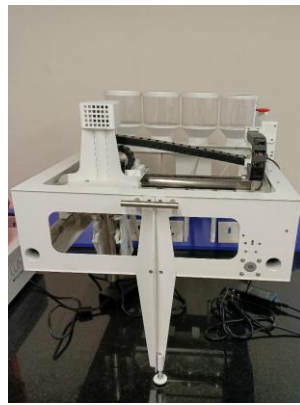
10. Precision Machining Laboratory

This is an advanced manufacturing and finishing laboratory. Manufacturing to finishing instruments are available in this laboratory and the available equipment's are listed below

1. LumenX 3D BioPrinter
2. 3D Metal foam Printer
3. Rheometer
4. Micromachining Center
5. 5-Axis polishing machine
6. Hybrid Laser Micromachining Center
7. Magnetic Polishing Machine
8. Dry Electro Finishing Equipment



BioPrinter



3D Metal foam Printer



Micro-machining Center



Rheometer



Magnetic Polishing Machine



Dry Electro Finishing Equipment



5-Axis polishing machine Hybrid Laser



Micromachining Center

11. Dynamic Experimentation and Theoretical Research Lab

This is a research laboratory under design stream. The available instruments are mainly used for vibration and dynamics studies. The available instruments are listed below

1. Data Acquisition System
2. Accelerometers
3. Force Sensors
4. Free Field microphone
5. Calibration Shaker for Accelerometer
6. Dynamic Shaker
7. Pistonphone calibrator
8. Modal Impact Hammer



Data Acquisition System Accelerometers

Force Sensors



Free Field microphone



Calibration Shaker



Dynamic Shaker



Pistonphone calibrator



Modal Impact Hammer

12. Fluid mechanics laboratory

The Fluid Mechanics Laboratory is designed to fortify students' theoretical knowledge which they learn in the Fluid Mechanics course. In the fluid mechanics laboratory, the students perform experiments related to basic principles of fluid mechanics. Students from both Civil and Mechanical Engineering departments conduct their experiments on these equipment sets, ranging from Reynold's apparatus, Bernoulli's principle, impact of jets on flat and curved surfaces, frictional head losses in pipes, estimation of flow rates in pipes using venture meter/orifice meter, estimating meta-centric height of floating bodies, to flow visualisation using streamlines. The laboratory consists of the following experimental setups:

- 1) Reynolds experiment setup to visualise laminar and turbulent flows
- 2) Different flow measuring set-ups such as venturimeter, orifice plate, rotameter
- 3) Free and forced vortex experimental setup
- 4) Impact of jet on surfaces to verify momentum conservation
- 5) Experimental setup to verify Bernoulli's theorem
- 6) Experimental setup to study losses in different pipe segments
- 7) Fluid property measurement equipment to measure density, viscosity, surface tension
- 8) Water flow bench to visualise flow around different shapes
- 9) Experimental setup to study the stability of floating bodies



Views of Fluid Mechanics Laboratory

13. Solid Mechanics Laboratory

The Solid Mechanics laboratory consists of a universal testing machine for tensile tests, hardness testing machine, torsion measurement, stresses in thick and thin cylinders, strain measurement using strain gauges, bending of beams, photoelasticity measurements and impact tester.



Universal Testing Machine



Strain Gauge



Transmission Polariscope

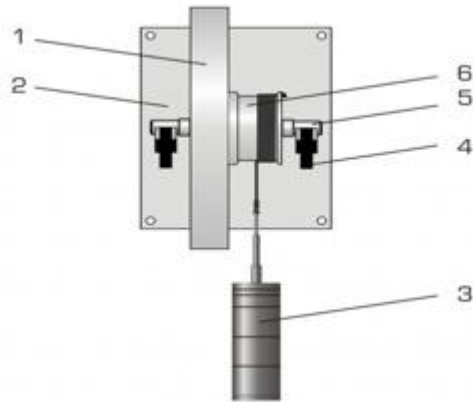


Rockwell Hardness Tester



Thick Cylinders

Dynamics laboratory consists of bearing friction setup, a setup for determining the dynamic forces in a reciprocating engine, gyroscope, flywheel, a setup where a disc rolling on an inclined plane, worm and wheel apparatus:



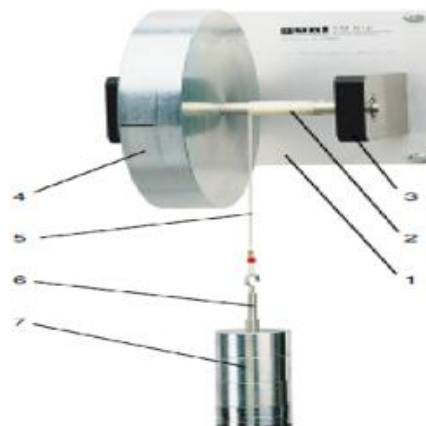
Bearing Friction



Forces in a reciprocating engine



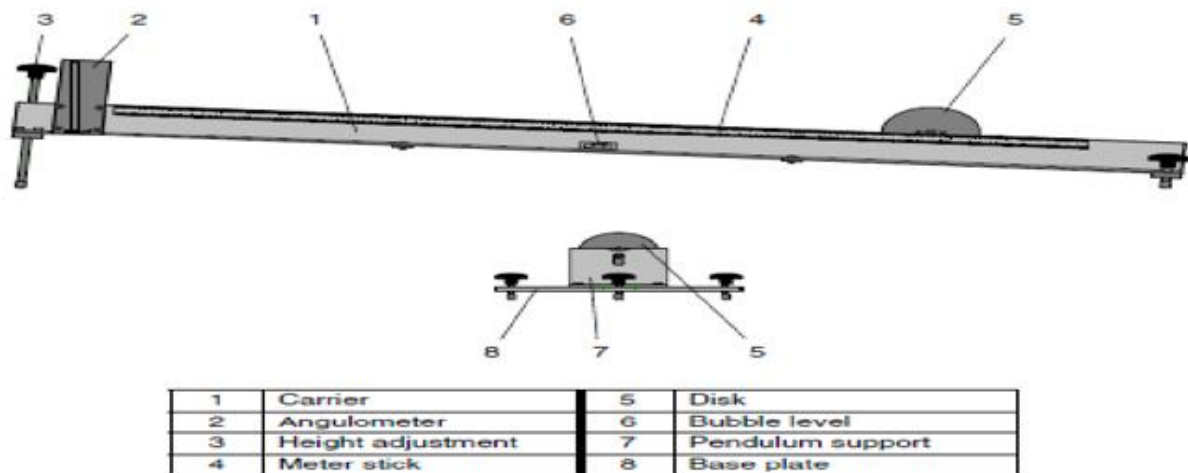
Gyroscope



Flywheel apparatus

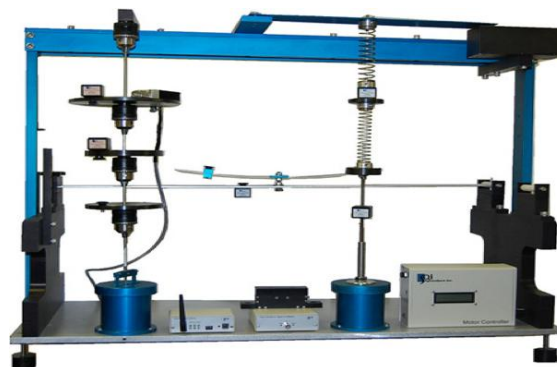


Worm and wheel apparatus



Disc rolling on an inclined plane

The vibration laboratory consists of two vibration fundamental training systems, a torsional vibration system, a beam vibration system, and a balancing fault simulator.



Beam vibration training systems



Torsional vibration system

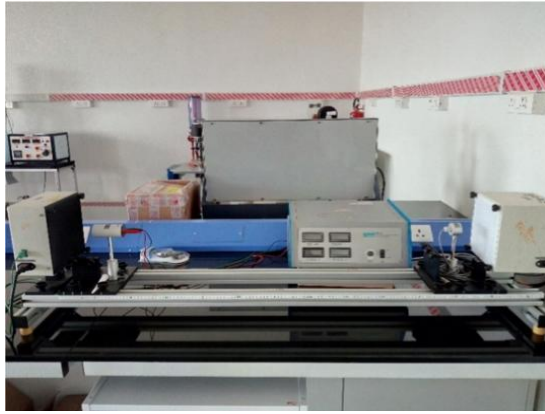


Balancing fault simulator

14. Heat Transfer Laboratory

The heat transfer laboratory at IIT Tirupati is also a part of the applied thermal engineering laboratory. It has various experimental setups to enhance student's understanding of concepts of heat transfer. This laboratory consists of the following experimental setups:

- 1) Thermal conductivity measurement of solids and fluids
- 2) Linear and Radial heat conduction setups
- 3) Free and forced convection over different objects
- 4) Pool boiling and condensation experimental setup
- 5) Heat exchanger setup with tube in tube, shell and tube, Plant and fin and jacketed vessel heat exchangers
- 6) Different temperature measurement instruments and their calibration
- 7) Thermal conductivity measurements of insulating materials
- 8) Experimental setup to verify Kirchhoff's law and Stephen Boltzmann Law



Stephen Boltzmann Law experiment



Thermal conductivity measurement setup

15. Robotics & Autonomous System laboratory

This is a new laboratory added under mechanical department to study the robotic movements and forces acting on it. An industrial grade Doosan 1013 robot is housed in this lab, UG/PG and PhD students are doing their projects/research work on that. The Doosan 1013 Cobot is an industrial grade 6 degree-of-freedom (6DoF) Cobot with a reach of 1.3 m, capable of handling a load of 10 kg, and having a repeatability of 0.05 mm. The Cobot can also sense the forces and moments experienced by the joints and can therefore work together with human operators. It will primarily be used to demonstrate the geometry, kinematics, and dynamics of robot manipulation to undergraduate and postgraduate students, as part of their regular coursework. Besides that, the robot can also be used to perform experiments where an object has to undergo a prescribed motion. The Cobot comes with a teach pendant, a controller, and an electric three-finger end-effector.



Doosan 1013 Cobot

16. Metallography Laboratory

Metallography Laboratory is developed to train undergraduate and postgraduate students on metallographic studies. This lab is being used actively by five Ph.D. and four M. Tech. students who are pursuing their research there. The metallography lab consists of the below-mentioned equipment:

1. Precision cutting machine
2. Hot mounting press
3. Double disc polishing machine
4. Single disc automatic polishing machine
5. Stereomicroscope
6. Upright metallurgical microscope
7. Heat treatment furnace (1200⁰C)
8. Heat treatment furnace (1600⁰C)
9. Melting furnace (1500⁰C)
10. Residual Stress measurement by portable XRD
11. Micro Hardness tester



Precision cutting machine



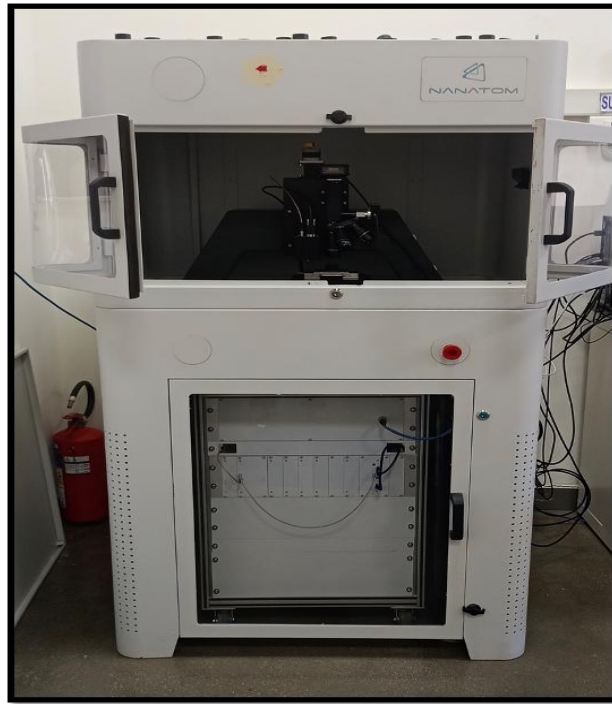
Portable XRD



Metallurgical microscope



Heat treatment furnace



Micro Hardness tester

17. Advanced Materials Manufacturing and Tribology (AM2T) Research Laboratory -2

This is a research-based laboratory basically working on experimental tribology and tribological issues of fouling, friction and corrosion, and the use of advanced techniques to understand bio tribological performance at the interface of artificial material. The working group develops novel self-repairing, adaptive, regenerative multifunctional surfaces for smart applications.

The group has an outstanding history of experimental tribology research and focusing on tribological issues of fouling, friction and corrosion, and the use of advanced techniques to understand bio tribological performance at the interface of artificial material. We develop novel self-repairing, adaptive, regenerative multifunctional surfaces for smart applications. The Department of Mechanical Engineering has started Advanced Materials Manufacturing and Tribology (AM²T) Research Laboratory at IIT Tirupati. The Tribology and Surface Engineering facility was inaugurated on 3rd June 2022 by Prof. Satish V. Kailas, President TSI. A multifunctional Tribometer MFT-5000 has been procured for various tribology tests

1. Creep Fatigue UTM
2. Universal Tribometer
3. High Temperature Vacuum Hot Press
4. Twin Roller Sampling System
5. Manual Double Disc Polishing Machine
6. Diamond Cutter Machine



Creep Fatigue



UTM Universal Tribometer



High Temperature Vacuum Hot Press



Twin Roller Sampling System

18. Fluid Science and Renewable Energy Technology (FSRE) lab

The lab aims to establish the lowest turbulence wind tunnel in India at IIT Tirupati which can be employed in both fundamental and applied research. The lab is equipped with the following advanced measurement systems for flow diagnostics. The instruments available in this lab are used for measuring velocity of fluids, velocity measurements in wind tunnel testing, and analyse propulsion systems. The available equipment's are listed below

1. Laser Doppler Velocimeter
2. MicroDaq2-32-DTC Pressure scanner
3. 6270A Pressure Controller/Calibrator
4. Hot wire anemometer
5. PXIA Labview Data Acquisition System
6. Propeller test bench



Laser Doppler Velocimeter



6270A Pressure Controller/Calibrator



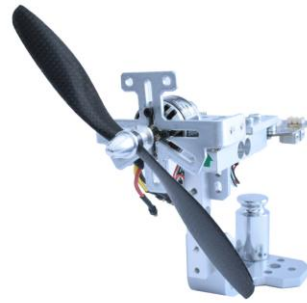
PXIA Labview Data Acquisition System



MicroDaq2-32-DTC Pressure scanner



Hot wire anemometer



Propeller test bench

19. Solid Mechanics & Composite Materials Laboratory

In Solid Mechanics & Composite Materials Laboratory the students are working on composite manufacturing and testing. There are two universal testing machines (UTM) and a confocal microscope are available in this laboratory. The 100 kN Fatigue UTM available in this lab is capable of complex studies on mechanical fatigue to standard tension and bending tests.



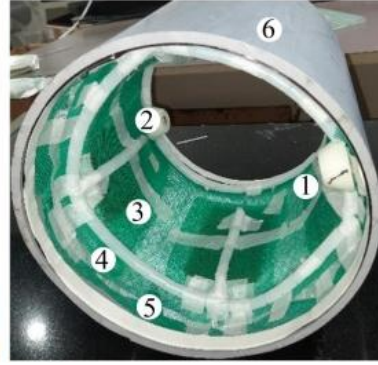
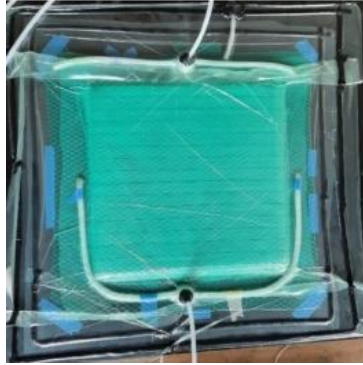
Olympus make Digital Microscope (DSX1000)



50kN UTM



Fatigue UTM



Composite manufacturing facility

20. Hydrogen Energy and Storage Laboratory

Hydrogen Energy and Storage Laboratory is a research lab where UG/PG/PhD students work extensively on projects related to hydrogen energy. The equipment available in this lab is listed below

1. Chiller
2. Heater
3. Vacuum Pump
4. Gas Chromatography
5. Air Heater
6. Data Acquisition system (DAQ)



Data Acquisition system (DAQ)



Mass flow meter



Gas chromatography



Sensible heat storage setup



Vacuum pump, chiller, furnace

21. Smart Manufacturing and Automation Laboratory

The Smart Manufacturing and Automation Laboratory is a dedicated research facility specializing in machine tool dynamics, vibration control, and advanced manufacturing technologies. The laboratory focuses on integrating cutting-edge tools, automation technologies, and intelligent systems into manufacturing processes to develop smart and efficient manufacturing solutions.

The primary objective of this laboratory is to conduct research and develop innovative technologies that contribute to the advancement of the manufacturing, automotive, aerospace, and medical sectors, thereby benefiting society at large. The laboratory supports interdisciplinary research activities in areas such as smart manufacturing, process monitoring, automation, digital manufacturing, and intelligent control systems.

The following instruments and facilities are available in this laboratory:

1. PCB Boards
2. G1200 Digital Electronic Microscope
3. Intel RealSense D435i Depth Camera
4. ZED 2i Stereo Camera
5. Magic Leap 2 Developer Pro Edition
6. Basler ace acA3800-10gm Camera
7. Basler Lens C23-0824-5M f8mm
8. JAKA Zu5 Collaborative Robot with Force Sensor and OnRobot Gripper
9. Speed-Adjustable Belt Conveyor (Customized)

10. Creality Ender 3 DIY 3D Printer
11. Tektronix TBS1000C Series Digital Oscilloscope
12. The Tektronix AFG1022 Arbitrary/Function Generator
13. Data acquisition modules
14. Impact hammer and Tri axial accelerometers



Intel RealSense D435i Depth Camera



ZED 2i Stereo Camera



Boards



Digital Electronic Microscope



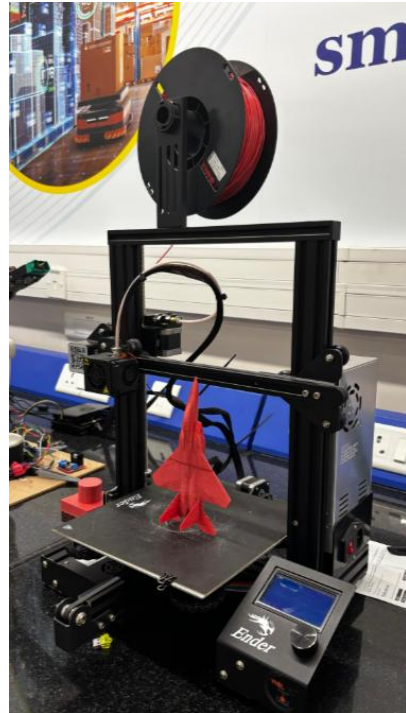
Magic Leap 2 Developer Pro Edition



Basler ace acA3800-10gm Camera



Collaborative Robot



Creality Ender 3 DIY 3D Printer



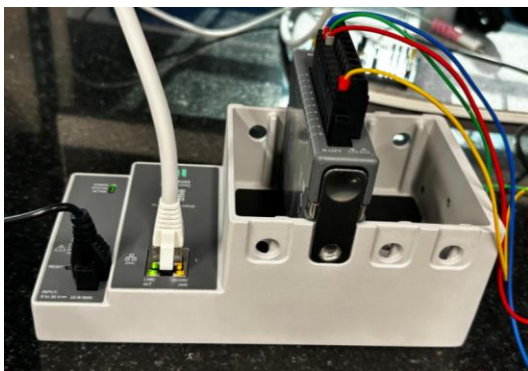
Speed-Adjustable Belt Conveyor



Digital Oscilloscope



Arbitrary/Function Generator



Data acquisition modules



Impact hammer



Tri axial accelerometers

22. Field Robotics Laboratory

The Field Robotics Laboratory focuses on research and development in underwater robotics, soft robotics, and bio-inspired robotic systems. The laboratory provides advanced facilities for robotic design, rapid prototyping, electronics development, testing, and experimental validation. It supports interdisciplinary research involving mechanical design, embedded systems, control engineering, and additive manufacturing.

The following instruments and facilities are available in this laboratory:

1. Keysight DSOX1202G Digital Storage Oscilloscope (200 MHz)
2. Keysight E36323A Programmable DC Power Supply
3. Siglent SPD3303X-E Programmable DC Power Supply
4. FlashForge Adventurer 5M Pro 3D Printer
5. FlashForge Guider 3



FlashForge Adventurer 5M ProFlashForge Guider 3



Programmable DC Power Supply



Digital Storage Oscilloscope