Innovent
PROPELLING ENGINEERING DREAMS

An Upskilling Program for New Product Design, Innovation & Research

HOLISTIC
ENGINEERING FINISHING SCHOOL

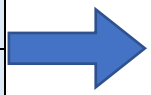
For Industries and Academic Avenues

Course evaluated by AICTE
implemented by

N·E·A·T
प्रौद्योगिकी के लिए राष्ट्रीय शैक्षणिक सहयोग
National Educational Alliance for Technology

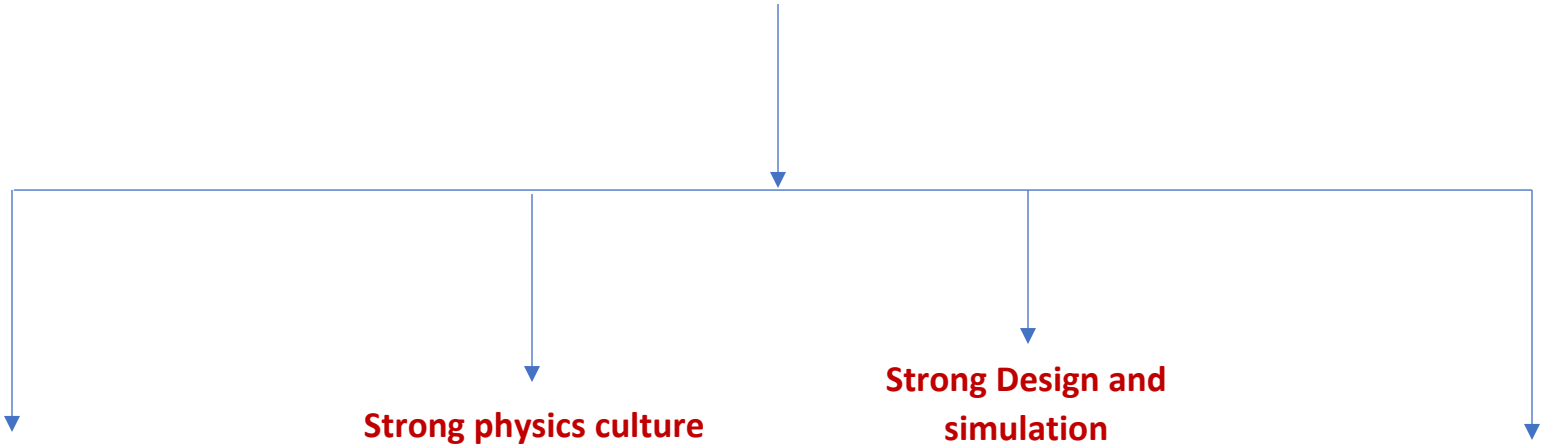
Objective of the course is to achieve the competency to **16 Industry trades:**

OEM Industry trades	
1	Component design engineer
2	System design engineer
3	Structural analyst
4	Product integration engineer
5	Integrated product team lead
6	Process designer
7	Risk/FMEA facilitator
8	Design Laison engineer
9	Testing engineer
10	Quality control engineer
11	Methods/process engineer
12	Production engineer
13	Assembly engineer
14	Component/product definition engineer
15	Repair and concessions engineer
16	Technical documentation author



- Strong foundation in physics and mathematics relevant to mechanical engineering and data science
- A foundational understanding of electro-mechanical A strong foundation in manufacture, GD and T, buildability, tolerance-stackup quality control, heat –treatment and surface engineering.
- Many other incidentals such as quality control cost-modelling, repair/salvage, heat-treatment failures: left austenite , case-depth variation, NDT, CMM vs first principle measurement etc.
- Engineering design (accounting for fluid, thermal, mechanical and electromagnetic aspects), design liaison, Concessions, design best practices, design process and contemporary best practices such as probability approaches, sensitivity analysis etc.
- Strong simulation culture, material and geometric modelling, understanding and replicating idealised boundary conditions, engineering hand-calculations, conceiving worst performance and operating envelopes, interpreting results and conceiving scope for optimisation.

Engineering Skill Tree



Strong Maths Culture

- Generalised application of transformation matrix
- Transducers data analysis (could be strain gauge data)
- Curve fitting and Sensitivity analysis
- Data Sampling and data verification
- Gradient based optimisation etc
- Probabilistic methods
- Operations research

Strong physics culture (Mapped to product design)

- Mechanics
- Material mechanics
- Vibrations
- TOM
- Fluid mechanics
- Heat transfer
- Thermodynamics
- Applications of Fluid and thermal sciences
- Material science
- Science of manufacture

Strong Design and simulation (Mapped to product design)

- Engineering Materials
- Engineering failures
- Design process
- Design margins
- Lifing methods
- Reliability analysis
- Probabilistic approaches
- Sensitivity analysis
- Risk review
- Design tools
- Design best practices
- Simulation
- Result interpretation
- Conceiving scope for optimisation culture

Production

- Methods (raw material to component)
- Heat treatment and surface engineering
- Quality control and measurement
- NDT
- GD and T and tolerance stackup
- Production economics
- Buildability and assembly failures
- Component physical testing and validation
- Repair and concessions
- Material testing and standards
- Microstructure and alloying

Holistic Engineering Finishing School

1st Year Modules and Course Details

Vital statistics

1. 45 hours of video content
2. 50 GATE assessments
3. 30 Higher Order Thinking and Research assessments
4. 200 concept registrations
5. 20 Gamified assessments
6. 75 summative assessments
7. 100 concept mapping
8. 14 case studies

35 Mock interviews for structural mechanics. This is done to expose the students to OEM and Research lab expectations.

Modules and Course Details

Modules and Product Definition	Course Description	Tools for skill assessment	Skill summary achieved	Value addition
Math's: Linear algebra, calculus, and vector calculus. **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Ability to carry out engineering hand calculations. • Comprehensive appreciation for Eigen vectors and Eigen values with graphical intuition. • Vector and Tensor transformation. • Transformation of circle to ellipse and other simple geometric figures. • Transformation of circle to ellipse and other simple geometric figures • Solution of simultaneous equations (3 variables) various approaches and graphical intuition. • Application of concept of linearly independent vectors • Physical meaning of gradient, curl and divergence and applications. • Vector integrations and applications • Application of calculus for engineering hand calculations. • Total derivative and chain rule • Basic optimisation and use of Hessian matrix.	Math's: 3 levels of assessment: • GATE • Higher Order Thinking • Research	• Transformation in general • Geomatic figure transformation • Appreciating scalar and vector field and application of vector integration • Engineering hand calculations • Hessian matrix for optimisation	• Advanced tensor transformation • applying calculus to carry out engineering hand calculations. • carrying out gradient-based optimisation. • **Case studies on transformations and Hessian matrix**

Engineering mechanics **15 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Conceiving loads for various product lines • Significance of load path and design of load paths for failure • Application of conservation laws • Inertia and inertia tensor construction	• Concept registration • Gamified assessment • Summative assessment • Concept mapping • 3 levels of assessment: ○ GATE ○ Higher Order Thinking ○ Research	• Ability sketch FBD for various product lines • Apply conservation laws to dynamic systems.	• Mechanics applied to product lines. • **Case studies on satellite stability, turbo machinery, basic vehicle dynamics**
Strength of materials **18 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Appreciating the critical facets of stress and strain analysis • Components subjected to combined loading of bending, torsion, shear and axial loads. • Effect of temperature on material • stiffness and buckling and optimising stiffness with minimum weight. • Axisymmetric components • Failure theories and interpretations • Material testing and standardisation • Contact stresses. • Elements of components of composite mechanics	• Conceiving loads for various product lines • Significance of load path and design of load paths for failure • Application of conservation laws • Inertia and inertia tensor construction	• Computing stress and stability margin • Understanding stress pattern in many standard components	• Adding stresses owing to various loads applying calculus to carry out engineering hand calculations. • Stress measures and interpretation • Extending ideas to composite mechanics • Understanding contact situations • **Case studies on bolted joint design, riveted joint, chasis analysis wing and ladder analysis**

2nd Year Modules and Course Details

Vital statistics

1. 51 hours of video content
2. 80 GATE assessments
3. 40 Higher Order Thinking and Research assessments
4. 25 questions on control engineering and electromechanically systems
5. 5 case studies

14 Mock interviews for FEM and Vibration This is done to expose the students to OEM and Research lab expectations.

Modules and Course Details

Modules and Product Definition	Course Description	Tools for skill assessment	Skill summary achieved	Value addition
Math's: Differential equations Complex variables Statistics and probability Numerical methods **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research 5 case-studies	• Ability to model systems mathematically. • Application of complex analysis • Application of probability and statics in mechanical engineering • Need for numerical solution of differential equations.	Math's 3 levels of assessment (GATE, Higher Order Thinking and Research) with emphasis on differential equation and probability and statistics	1D modelling of systems and apply principles of probability and statistics to engineering and	• System modelling using mathematics. • **Case studies on 1D modelling of a fluid system and probabilistic fracture mechanics.**
1. Theory of machines. **10 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Ability to apply kinematics and dynamics to planar mechanisms. • synthesis of mechanisms. Utilising Gyroscopic effect for stabilisation and damping across product lines • Understanding of motion and power transmission • Appreciation of balancing in a generalised and specific situation. • Flywheel design and applications	TOM 3 levels of assessment (GATE, Higher Order Thinking and Research) with emphasis on mechanisms and balancing	Ability to synthesis and analyse mechanisms	• Generalised understanding of balancing • Utilising gyroscopic effect. • **Case-study on balancing**

2.Vibrations. **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Ability to conceive vibration margin for axial, torsional and flexural vibrations (coupled modes in some cases) against potential resonances. • All factors that influence natural frequencies • Understanding of sources of excitation and order of excitation. • Computing dynamic stress and HCF analysis • Use of Cambell diagram and interpretation • Physical and mathematical damping	vibration 3 levels of assessment (GATE, Higher Order Thinking and Research) with emphasis on natural frequency of systems and vibration margin	Ability to idealise complex systems and boundary conditions to derive natural frequencies and conceive vibration margin	• Best practices to establish vibration margin and analyse vibration loading. • **Interpretation of cambell diagram with Gyro effect**
3.Machine design **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Ability to analyse loads and load path • Material selection • Strength and surface failures in great detail • Design of machine elements for static and dynamic situations • Effect of temperature on component life • Appreciation for Basic lifing philosphies • Analysis of fits and joints (bolted, riveted and welded) • Ability to concieve optimisation	Design 3 levels of assessment (GATE, Higher Order Thinking and Research) with emphasis on strength failures and best practices	Ability to establish reserve margins for various types of loads. Material selection and basic optimisation	• Best practices on component design and optimisation • Best practices on joint design • Material selection and effect of temperature • **A comprehensive Case study on shaft design including aspects of heat treatment.**
4. Extra module electromechanical systems, emag and control engineering **5 hours of video content considering generalized applications.**	• Introduction to electro-mechanical systems and general transducers • Ability analyses dynamics of a system and write basic control circuits. • Open loop and closed loop control systems • Analyse and compute electromagnetic forces in various systems. • Introduction to PID control	Extra module 3 levels of assessment with emphasis on control engineering	Model systems and analyse basic control requirements	• Appreciate and model electro-mechanical and electromagnetic systems. • **A case study on satellite control**

3rd Year Modules and Course Details

Vital statistics

1. 48 hours of video content+2 hours of FEM +100 hours of simulation content
2. 80 GATE assessments
3. 60 Higher Order Thinking and Research assessments
4. 4 Gamified FEM assessments
5. 15 summative FEM assessments
6. 25 plus concept registration in FEM
7. 50 simulation assessments
8. 19 case studies

Modules and Course Details

Modules and Product Definition	Course Description	Tools for skill assessment	Skill summary achieved	Value addition
1.Fluid mechanics **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Hydrostatics and momentum and energy consideration of fluid flow. • Understanding of flow analysis • Detailed understanding of Boundary layer concept • Discussions of classical equations of fluid mechanics • Applications of Turbulent and laminar flows	3 levels of assessments (GATE, Higher Order Thinking and Research) with emphasis on flow dynamics and Boundary layer concept	Understand and interpret any type of low and hand calculate basic parameters using laws of fluid mechanics	• Science of fluid mechanics appreciated from product perspective. • **2 case-studies one from gas turbine and one from aircraft external flow**
2. Heat transfer **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Combined modes of heat transfer and concept of lumping • Radiative heat transfer view factors network analysis and application to satellite industry • Design of heat exchangers • Cooling of large components and electronic cooling	3 levels of assessments (GATE, Higher Order Thinking and Research) with emphasis on combined mode of heat transfer	Model general heat transfer situations with basic equations	• Science of heat transfer with emphasis on combined and radiative heat transfer. • Significant appreciation of cooling challenges • **1 case-study from satellite analysis**

3. Thermodynamics **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Ability to reparent processes on PV and TS diagrams and interpret them. • Ability sketch cycles and interpret efficiencies. • Insight on entropy, irreversibility and availability	3 levels of assessments (GATE, Higher Order Thinking and Research) with emphasis on thermodynamic cycles	Ability to analyse given cycles and apply thermodynamics to product situations	• Ability to Apply thermodynamics to natural and product phenomena. • **Case-study on Gas turbine efficiency calculations**
4. Applications (FM, TD and HT) **12 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Understanding and critical facets of power engineering with detailed appreciation of compressors • Refrigeration and air conditioning and current facets • IC engines emphasis on thermal aspects of design and optimisation • Turbo machinery analysis based on fluid angular momentum. • Gas turbine applications and appreciation for modern gas turbine technology	3 levels of assessments (GATE, Higher Order Thinking and Research) with emphasis on calculations on power, thrust, efficiency and machine characteristics	Ability to apply science of heat transfer to technology	• Ability to Apply principles of thermodynamics to fluid mechanics to technology • **Two case studies one on Blade design and one on thrust bearing load assessment**
5. Extra module: FEM and ANSYS Workbench/Spaceclaim **A comprehensive familiarity with GUI is gained and facilities.** **34 workshops covering stress, vibration, and elastic stability.** **12 case studies** **Voiced over demo of various stress vibration analyses in AN SYS. +2 hours of FEM**	• Ability to take up simulation of components independently for product development. • Understand extreme loads/events, boundary conditions and implement the same for simulation. • Interpret results and conceive scope for optimisation. • understand the system level requirements while simulating for structural responses. • Understand all FEM aspects to exploit the simulation tool better. • Use space claim to model complex geometries.	3 levels of assessments for various phases of simulation and a detailed assessment for FEM	Simulate components for fundamental failure modes and carry out basic optimisation	• Industry relevant simulation • Complete tool familiarity with detailed exposure to all facilities • **12 case-studies in simulation and 1 case study in FEM**

4th Year Modules and Course Details

Vital statistics

1. 27 hours of video content
2. 75 GATE assessments
3. 45 Higher Order Thinking and Research assessments
4. 80 assessments on design and manufacture (Extra module)
5. 7 case studies

Modules and Course Details

Modules and Product Definition	Course Description	Tools for skill assessment	Skill summary achieved	Value addition
1.Engineering Materials **3 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research 5 case-studies	• Awareness about Current and future materials • awareness about tailoring properties as per requirement • Understanding the need for Heat treatment and surface engineering • Failures due to material defects and heat transfer defects	3 levels of assessments with emphasis on material selection for various product lines and heat treatment. These not just test the understanding but critical thinking about unobvious facets.	Appreciation of knowledge of materials in the product design context	• Material selection • Material defects and heat treatment failures. • **2 Industry case-stdies: on Gear failures carburising and phosphating**
2.Casting, Forming and Joining Processes **4 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Detailed process understanding • Casting and welding failures • Process parameters tolerances and quality • NDT techniques • Application of welding for cost reduction and repair • Design aspects fatigue, vibration and stresses	3 levels of assessments with emphasis on process of manufacturing, defects, tolerance, strength failures and applications	Appreciation of process selection, quality aspects, cost modelling and repair design	• weld design • Strength and fatigue analysis of weld • Understanding of Unidirectional solidification and single crystal. • Quality aspects • **2 industry case-studies disc and drive arm welding Single crystal blade.**

3. Machining and Machine Tool Operations **4 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Detailed appreciation for single and mulipoing cutting tools. • Machining aids (Steady rests, collets etc) and impact on quality. • Quality and surface integrity • Economics of machining	3 levels of assessments with emphasis on process of manufacturing, cutting tools, quality and optimizing of matching process and hence quality of component (tolerance definition)	Appreciation for critical tool angles/geometry, machining set up and quality. Machinability and impact of machining on material strength and Quality (tolerance and surface characteristics)	• Tool signature, aching setup, coolant cutting forces and quality • **Case study on titanium machining**
4. Metrology and Inspection **3 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• Measurement and errors and quality control • Tolerance analysis (GD and T) • Tolerance stackup for simple assemblies • First principle method vs CMM	3 levels of assessments with emphasis on GD and T (Drawing reading) and quality control	Detailed appreciation for GD and T, measurement and tolerance stakup	• Interpretation of geometric tolerances • Detailed understading of tolerance stackup • Quality control proces • **Case study: Fuel pipe assembly tolerance stackup**
5. Product on engineering **5 hours of video content.** Sub modules: • GATE • Higher Order Thinking • Research • 5 case-studies	• CIM and current manufacturing trends • Production planning and inventory control • Theory and application of operation research • Digital twin for plant control	3 levels of assessments with emphasis on production facets and employment of operation research	Detailed exposure to production engineering with contemporary and futuristic technologies and practices.	• Exposure to current practices (Life cycle managment , Model based definition, digital twin etc) • **Case study on Project management**
6. EXTRA MODULE on product design and best practices and manufacture **5 hours contemporary design concepts +2 hours 7 design case-studies and 1 hour of manufacture and assembly critical facets**	• Concept sketching to component drawing. • Risk analysis • Unobvious engineering failures • Buildability, heat treatment and effect of clearances on system performance • Sensitivity analysis • Probabilistic approaches	3 levels of assessments with emphasis on design failures, materials and drawing reading	Detailed exposure to contemporary design process and practices. Hands on Engineering hand calculations and detailed understanding of component design	• Sensitivity and probabilistic approaches • Component design • **Case-studies on one centrifugal loading and two disc lifing**