Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAE12</td>
<td>Aerodynamics</td>
</tr>
<tr>
<td>2</td>
<td>16MAE422</td>
<td>Missile Aerodynamics</td>
</tr>
<tr>
<td>3</td>
<td>16MAP422</td>
<td>Hypersonic Aerodynamics</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Sub/ Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAP421</td>
<td>Advanced Gas Turbine</td>
</tr>
<tr>
<td>2</td>
<td>16MAE154</td>
<td>Aero Engine Testing &amp; Performance Evaluation</td>
</tr>
<tr>
<td>3</td>
<td>16MAP12</td>
<td>Aerospace Propulsion</td>
</tr>
<tr>
<td>4</td>
<td>16MAE423</td>
<td>Theory of Combustion</td>
</tr>
<tr>
<td>5</td>
<td>16MAE424</td>
<td>Rockets and Space Propulsion</td>
</tr>
<tr>
<td>6</td>
<td>16MAP22</td>
<td>Fuels and Combustion</td>
</tr>
<tr>
<td>7</td>
<td>16MAP23</td>
<td>Heat Transfer in Propulsion Systems</td>
</tr>
<tr>
<td>8</td>
<td>16MAP24</td>
<td>Gas Turbine and Rocket Propulsion</td>
</tr>
<tr>
<td>9</td>
<td>16MAP253</td>
<td>Ramjet and Scramjet</td>
</tr>
<tr>
<td>10</td>
<td>16MAP424</td>
<td>Advanced Propulsion</td>
</tr>
</tbody>
</table>
### Group: 3

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAE23</td>
<td>Airframe Structures and Structural Design</td>
</tr>
<tr>
<td>2</td>
<td>16MAE252</td>
<td>Theory of Aero-elasticity</td>
</tr>
<tr>
<td>3</td>
<td>16MAE421</td>
<td>Fatigue and Fracture Mechanics</td>
</tr>
<tr>
<td>4</td>
<td>16MAE24</td>
<td>Flight Vehicle Design</td>
</tr>
<tr>
<td>5</td>
<td>16MAP154</td>
<td>Aerospace Structures</td>
</tr>
<tr>
<td>6</td>
<td>16MAP423</td>
<td>Advanced Bearings and Rotor Dynamics</td>
</tr>
</tbody>
</table>

### Group: 4

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Sub/ Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAE13</td>
<td>Introduction to Aerospace Vehicles and Systems</td>
</tr>
<tr>
<td>2</td>
<td>16MAE21</td>
<td>Aircraft Performance and Flight Mechanics</td>
</tr>
<tr>
<td>3</td>
<td>16MAE251</td>
<td>Aircraft Navigation Systems</td>
</tr>
<tr>
<td>4</td>
<td>16MAE253</td>
<td>Flight Testing</td>
</tr>
<tr>
<td>5</td>
<td>16MAE41</td>
<td>Aircraft Flight Dynamics and Automatic Flight Control</td>
</tr>
<tr>
<td>6</td>
<td>16MAP13</td>
<td>Introduction to Space Technology</td>
</tr>
<tr>
<td>7</td>
<td>16MAP252</td>
<td>Engine Performance Control &amp; Simulation</td>
</tr>
<tr>
<td>8</td>
<td>16MAP254</td>
<td>Space Transportation Systems</td>
</tr>
<tr>
<td>9</td>
<td>16MAP41</td>
<td>Aerospace Instrumentation and controls</td>
</tr>
</tbody>
</table>
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

### Group: 5

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAP21</td>
<td>Computational Fluid Dynamics</td>
</tr>
<tr>
<td>2</td>
<td>16MAP14</td>
<td>Finite Element Methods</td>
</tr>
<tr>
<td>3</td>
<td>16MAE254</td>
<td>State Space Methods</td>
</tr>
<tr>
<td>4</td>
<td>16MAP152</td>
<td>Continuum Mechanics</td>
</tr>
</tbody>
</table>

### Group: 6

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Course Code</th>
<th>Course Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>16MAE151</td>
<td>Introduction to Advanced Composites</td>
</tr>
<tr>
<td>2</td>
<td>16MAP151</td>
<td>Aerospace Materials and Processes</td>
</tr>
<tr>
<td>3</td>
<td>16MAP153</td>
<td>Advanced Composite Materials</td>
</tr>
</tbody>
</table>
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>01</th>
<th>16MAE12</th>
<th>Group-1</th>
<th>AERODYNAMICS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modules**

**Module -1 Basics of Aerodynamics:** Properties of fluids, Characteristics of Atmosphere, Type of fluid flows, Generation of Lift, Drag and Moment, Incompressible flows over airfoils, calculation of lift and drag from measured pressure distribution, Streamlined and bluff-body, Reynolds number and Mach number, Conservation law of mass and momentum, Euler and Bernoulli’s equations, pitot-tube measurement of airspeed. Pressure coefficient. Streamlines, path lines and streak lines. Angular velocity, vorticity, circulation Stream function, velocity potential and their relationship. Governing equation for irrotational and incompressible fluid flow.

**Module -2 Aerodynamics of airfoils and wings:** Airfoil nomenclature and classification, Low speed aerodynamic characteristics of symmetric and cambered airfoils, Centre of pressure, aerodynamic centre and aerodynamic moment, Concept of point vortex, line vortex and vortex sheet, Kutta condition, Kelvins circulation theorem and starting vortex, Classical thin airfoil theory and symmetric airfoil. Finite wing nomenclature. Incompressible flow over wing, vortex filament, bound vortex, horse shoe vortex, downwash, induce angle of attack and drag. Type of drag. Biot-Savart law and Helmholtzs vortex theorem. Prandtts lifting line theory and limitations. Elliptic lift distributions, expression for induced angle of attack and induce drag. Two dimensional and three dimensional wings lift curve slope and effect of aspect ratio. High lift devices.


**Module -4 Compressible flow over airfoil:** Full velocity potential equation. Small perturbation theory. Linearized velocity potential equation and boundary conditions. Pressure coefficient for small perturbation. Prandtl- Glauret compressibility correction. Critical Mach number, Drag Divergence Mach Number, Sound barrier. Transonic area rule, supercritical airfoil, swept wing and delta wing.

**Module -5 One dimensional flow through constant area duct:** Fanno flow and fanno line, Rayleigh flow and Rayleigh line. Method of characteristics and its application. Flow past Wedge and cone.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
## Modules

### Module -1 Introduction:
- Theory of bodies of revolution. Lift and moment of slender bodies of revolution. Planar W-B Interference. Classes of missiles, Types of design and control; Wing, Canard, Tail, Tailless control; Dorsal, Jet control, Monowing, Triform, and Cruciform.

### Module -2 Aerodynamic Characteristics of Airframe Components & Missile Performance:

### Module -3 Longitudinal Stability and Control, Maneuvering Flight:
- Introduction, Two-degree of freedom analysis, Complete missile aerodynamics: static stability margin, load factor capability for forward control and rear control, Flat turn: Cruciform, Triform, Pull ups; Relation between Maneuverability and load factor. Stability margin.

### Module -4 Directional & Lateral Stability and Control:
- Introduction, Cruciform configuration: wing, body and tail contribution, Directional Control. Introduction to lateral stability and control, Induced roll - cruciform, Lateral Control cruciform, Special design consideration, Damping in roll. Induced roll; Mono wing, Lateral Control- Mono wing.

### Module -5 Air loads: Design criteria:

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### Reference Books:
### Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)**  
**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>03</th>
<th>16MAP422</th>
<th>Group-1</th>
<th>HYPERSONIC AERODYNAMICS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exam Hours:</strong> 03</td>
<td><strong>Exam Marks:</strong> 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Modules


**Module -5 Hypersonic Testing.** Hypersonic Scaling, high enthalpy & high speed, types of hypersonic facilities. Shock tunnels & expansion tubes. Features of Hypersonic wind tunnel design. Instrumentation to hypersonic vehicle testing. Test model similarity laws.

#### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

#### Text Books:

#### Reference Books:
Visvesvaraya Technological University, Belagavi.  
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)  
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Modules</th>
<th>16MAP421</th>
<th>Grop-2</th>
<th>ADVANCED GAS TURBINE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td></td>
<td></td>
<td>Exam Marks: 100</td>
</tr>
</tbody>
</table>

**Module 1**  
**JET PROPULSION CYCLES AND ANALYSIS:** Introduction, Prime movers, simple gas turbine, energy equation, dimensional analysis of rotating machine, Ram jet engine, pulse jet engine, turboprop engine, turbojet engine, thrust and thrust equation, specific thrust of turbojet engine, efficiencies, parameters affecting performance, thrust augmentation, problems.

**Module 2**  
**Ideal cycles and their analysis:** Introduction, assumptions, Brayton Cycle, reheat cycle, reheat and regenerator, intercooled cycle with heat exchanger, inter cooled and reheat cycle, comparison of varies cycles, ericsson cycle, compressor and turbine efficiency, performance of actual cycle.

**Module 3**  
**Centrifugal and axial flow compressors:** essential parts of centrifugal and axial flow compressors, principles of operation, blade shape and velocity triangles, performance characteristics, surging and chocking, degree of reaction, compressor stage efficiency, and mechanical loses, problems.

**Module 4**  
**Impulse and reaction turbine:** single impulse stage and reaction stage, velocity triangles of a single stage machines, expression for work output, blade and stage efficiencies, velocity and pressure compounding, multi stage reaction turbines, performance graphs, losses and efficiencies.

**Module 5**  
**Blade materials, cooling and environmental consideration:** Blade materials, manufacturing techniques, blade fixing, blade cooling, liquid cooling, air cooling, practical air cooled blades, NOX formation, noise standards, noise reduction, aircraft emission standards.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
3. Aircraft Gas
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>02</th>
<th>16MAE154</th>
<th>Group-2</th>
<th>AERO-ENGINE TESTING AND PERFORMANCE EVALUATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:03</td>
<td>Exam Marks:100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modules**


**Aero Thermodynamic Tests: Compressor:** Compressor scaling parameter Groups, Compressor MAP. Inlet distortions. Surge margin stack up. Testing and Performance Evaluation, Test rig.

**Module -2 Combustor:** Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation.


**Module -4 Qualification Tests:** Tests used to evaluate a design. Environment ingestion capability. Preliminary flight rating tests, Qualification testing, acceptance tests, Reliability figure of merit. Structural integrity tests: Design Verification Tests, Durability and Life Assessment Tests, Reliability Tests, Failure Simulation Tests, Functional And Operability Tests.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
1. Advance Aero-Engine Testing, AGARD-59 Publication
<table>
<thead>
<tr>
<th>03</th>
<th>16MAP12</th>
<th>Group-2</th>
<th>AEROSPACE PROPULSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:</td>
<td>Exam Marks:</td>
<td></td>
<td></td>
</tr>
<tr>
<td>03</td>
<td>100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modules**

**Module -1 Introduction to Propulsive Devices and Gas Turbine Engines:** Atmospheric Properties. Turbojet, Turbofan, Turboprop, Turbo-shaft Engine Construction and Nomenclature, theory and performance, introduction to compressors, turbines, combustors and after burners for aircraft engines.


**Module -3 Engine Performance and Health Monitoring:** Performance and Matching of modules of gas turbines-turbomachine aerothermodynamics, aerothermal equations, efficiencies, dimensional analysis, compressor performance characteristic, turbine performance characteristics, Engine health monitoring techniques.

**Module -4 Engine Air Frame Integration:** Engine Performance theory, Propeller theory – pusher and tractor mode. Thrust vectoring nozzles.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
1. Dennis G Shepherd, —Aerospace Propulsionl AmericanElsovier Publishing Co Inc NY.
3. George P Sutton and Donald M Ross, —Rocket Propulsion Elementsl, John Wiley & Sons NY.

**Reference Books:**
5. Williams F A. et al., —Fundamental Aspects of Solid Propellant Rocketsl, Agardograph, 116
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>04</th>
<th>16MAE423</th>
<th>Group-2</th>
<th>THEORY OF COMBUSTION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Exam Hours :03</td>
<td>Exam Marks:100</td>
</tr>
</tbody>
</table>

**Modules**


**Module -2 Pre-Mixed Flames:** Description of premixed flames, Burning velocity and parametric dependences, Experimental methods of measuring burning velocity, Simple one-dimensional thermal theory of flame, concepts of minimum ignition energy, quenching distance, stability limits and flame stabilization. Turbulent premixed flame.

**Module -3 Diffusion Flame:** Jet flame physical description, theoretical analysis-Burke-Schumann’s analysis, mechanism of soot formation, Difference between premixed and diffusion flames, Liquid fuel combustion. Difference between premixed and diffusion flames, Liquid fuel combustion, Difference between premixed and diffusion flames, Liquid fuel combustion- Conservation equations, calculation of mass burning rate, Droplet burning time, Droplet combustion in convective environment.

**Module -4 Combustion in Reciprocating and Gas- Turbine Engines:** Description of the combustion process in piston engines, Combustion efficiency and factors affecting it, Rankine-Hugoniot curves, Deflagration and Detonation in reciprocating engines and preventive methods. Description of different types of combustion chambers in gas-turbine engines, primary requirements of the combustor, Flow structure, recirculation and flame stabilization in main combustion chamber, afterburners.

**Module -5 Combustion in Rocket Engines and Emission:** Types of Rockets based on combustion, Solid fuel combustion, combustion of carbon particle-simplified analysis, boundary layer combustion, combustion of carbon sphere with CO burning gas phase. Chemical Emission from combustion and its effects, Exhaust gas analysis, Emission control methods.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
1. An Introduction to combustion Concepts and Application, Stephen R Turns, TMH Publication
2. Fundamentals and Technology of combustion, Fawzy El-Mahallawy, Saad El-Din Habik,Elsevier

**Reference Books:**
1. Industrial Combustion by Charles E. Baukal.
2. Fundamentals of combustion, D P Mishra, PHI Publication
05 16MAE424 Group-2  ROCKET AND SPACE PROULSION

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module -1 Introduction:</strong> Types of rocket engines, Liquid and Solid Propellant rocket engines, Rocket Propulsion theory, Rocket dynamics- Vertical flight of rocket, the rocket equation, Altitude gain during vertical flight, Escape velocity.</td>
</tr>
<tr>
<td><strong>Module -2 Thermodynamics and Heat Transfer in Rocket Engines:</strong> Thermodynamics of Rocket Propulsion, Nozzle Theory, Over and Underexpanded Nozzles, two-phase flow, variable thrust, High velocity flow with heating in the chamber. General steady state Heat transfer relation, Rocket thrust chamber heat transfer, uncooled combustion devices, Heat transfer to flying vehicles, Exhaust jet and atmospheric interaction.</td>
</tr>
<tr>
<td><strong>Module -3 Solid propellant and Liquid propellant rocket Engines:</strong> Properties and design of solid motors, Integrity of the combustion chamber, Ignition, Hybrid rocket motors, modern solid booster motors Basic configuration and types of liquid propellant rocket engines, Combustion chamber and nozzle, Cooling of liquid-fuelled rocket engines, Choice of propellant and performance of Liquid fuelled rocket engines.</td>
</tr>
<tr>
<td><strong>Module -4 Combustion in Rocket Engines and launch vehicle dynamics:</strong> Combustion of carbon particle-simplified analysis, boundary layer combustion, combustion of carbon sphere with CO burning gas phase. Problems. Vertical motion in earth’s gravity field, inclined motion in earth’s gravity field, motion in atmosphere, Gravity turn, typical earth-launch trajectories.</td>
</tr>
<tr>
<td><strong>Module -5 Electric and Nuclear Propulsion:</strong> Principles of electric propulsion, electric, electromagnetic, and plasma thrusters, Electrical power generation, Nuclear reactor fundamentals, nuclear fission and chain reaction, Typical nuclear rocket system and Operational issues with the nuclear rocket engine.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Question paper pattern:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• The question paper will have ten questions.</td>
</tr>
<tr>
<td>• Each full question consists of 20 marks.</td>
</tr>
<tr>
<td>• There will be 2 full questions (with a maximum of four sub questions) from each module.</td>
</tr>
<tr>
<td>• Each full question will have sub questions covering all the topics under a module.</td>
</tr>
<tr>
<td>• The students will have to answer 5 full questions, selecting one full question from each module.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Text Books:</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Reference Books:</th>
</tr>
</thead>
</table>


Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

Reference Books:
### Modules

#### Module -1
**Fundamentals:** Conduction, Convection, Radiation, Concept of boundary layers - velocity / thermal. Need for turbine blade cooling, turbine cooling technology, turbine heat transfer and cooling issues. **Turbine-Stage Heat Transfer:** Introduction, Real engine turbine stage, simulated turbine stage, time-resolved heat-transfer measurement on a rotor blade. Cascade blade heat transfer. Airfoil end wall heat transfer. Turbine rotor blade tip heat transfer. Leading edge region heat transfer. Flat surface heat transfer.

#### Module -2
**Turbine Film Cooling:** Fundamentals of film cooling. Film cooling on rotating turbine blades. Film cooling on cascade vane simulations, Film cooling on cascade blade simulations, Film cooling on airfoil endwalls. Turbine blade tip film cooling. Leading edge region film cooling. Flat surface film cooling. Film cooling effectiveness. Discharge coefficient of turbine cooling holes. Film cooling effect on aerodynamic losses. **Jet Impingement Cooling:** Heat transfer enhancement by a single jet, Impingement heat transfer in the mid-chord region by jet array, Impingement cooling of leading edge.

#### Module -3
**Rib Turbulated Cooling:** Effect of rib layouts and flow parameters on ribbed channel heat transfer, heat transfer coefficient and friction factor correlation, high performance ribs, effect of surface heating conditions, nonrectangular cross section channels, effect of high blockage ratio ribs, effect of rib profile effect of number of ribbed walls, effect of a 180o sharp turn, detailed heat transfer coefficient measurements in ribbed channel, effect of film cooling hole on ribbed channel heat transfer.

#### Module -4
**Pin Fin Cooling:** Flow and heat transfer analysis with single pin, pin array and correlation, effect of pin shape on heat transfer, effect of nonuniform array and flow convergence, effect of skewed pin array, partial pin arrangements, effect of turning flow, pin fin cooling with ejection, effect of missing pin on heat transfer coefficient. **Temperature Measurement Techniques:** Infrared thermography, Thermocouples, Heat flux gauges, Liquid crystal thermography, Temperature sensitive paints. Engine Temperature and Health Monitoring- Thermal barrier coatings, Engine temperature monitoring, Engine safety and health monitoring.

#### Module -5
**Compound and new cooling techniques:** Impingement on ribbed walls, impingement on pinned and dimpled walls, combined effect of ribbed wall with grooves, combined effect of ribbed walls with pins and impingement inlet conditions, combined effect of swirl flow and ribs, impingement heat transfer with perforated baffles, combined effect of swirl and impingement. Concept of heat pipe for turbine cooling, new cooling concepts.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 16 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:
2. JP Holman, —Heat Transfer, McGraw – Hill Book Company
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>08</th>
<th>16MAP24</th>
<th>Group-2</th>
<th>GAS TURBINES AND ROCKET PROPULSION</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours: 03</td>
<td>Exam Marks (Maximum): 100</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Modules</th>
</tr>
</thead>
</table>
| **Module -1**  
Categories of propulsion system, air breathing engines, non-air breathing engines, thrust of turbojet, turbofan, ramjet and rockets, Performance parameters of propulsion systems. |
| **Module -2**  
Gas turbine components, flow through gas turbine components like inlets, compressor, combustor, turbine and nozzles, Gas turbine component characteristics, propeller, propeller performance. |
| **Module -3**  
Gas turbine engine basic cycle, ideal and real cycle, T-S diagram, turbojet, turbofan and turboprop engines, turbofan with mixed and unmixed jets, Concept of spooling, Engine rating, concept of flat rating Thrust and SFC variation with flight Mach number and altitude, Commercial gas turbine engines. Single and two spool engine matching, matching of turbojet and turbofan engines, Design point optimization of gas turbine engine, Engine sizing, Installed performance and uninstalled performance, Gas turbine engine evaluation in test beds. |
| **Module -4**  
Velocity increment and mass ratio, burnout velocity and distance, specific impulse, trajectory and gravity turn, coasting height, multi staging, satellite and escape velocity. Aero-thermo chemistry, Chemical rockets, internal ballistics of solid propellant rockets, performance parameters, Liquid propellant rockets, components and its performance, propellant-general, liquid and solid propellant. |
| **Module -5**  
Hybrid rockets, status and development of chemical rockets, Electro thermal rocket engines, performance parameters, propellants, resistance heating, arc heating, electrode less discharge, Electromagnetic propulsion, principle of operation, pulse plasma accelerators, travelling wave accelerators, propellants, performance of E-M accelerators. Ion Propulsion, Performance parameters, efficiency of ions, acceleration of the beam, beam neutralization, optimum specific impulse, acceleration-deceleration system, heavy ion. |

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
<table>
<thead>
<tr>
<th>Modules</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module -1</strong></td>
<td>Introduction, Background Description, Fundamentals of Propulsion, Motivation to Study Ramjet and Scramjet, Thrust, Modes of Thrust Generation, Hypersonic Air breathing propulsion Ramjet. Basics of compressible one dimensional flows, Compressibility of Fluid, Mach number, T-S diagram of Compressible flow, Types of Ramjet Engines, Analysis of Ramjet Engines, performance, Thrust Equation.</td>
<td></td>
</tr>
<tr>
<td><strong>Module -4</strong></td>
<td>Scramjet Propulsion: Practical Progress, Heat addition in duct with Area variations, Isolators, Aerothermodynamics of dual mode combustion system, Real H-K diagram, Interoperation of Experimental Data, Fuel-air mixing processes, Measures of local goodness of mixing, Mixing in a Turbulent shear layer.</td>
<td></td>
</tr>
<tr>
<td><strong>Module -5</strong></td>
<td>Hypersonic Air breathing Engine Performance Analysis, Thermodynamics Closed Cycle Analysis, Maximum Allowable Compression Temperature, First Law Analysis Results, Stream Thrust Analysis, Compression Components, Influence of Boundary Layer Friction, Burner Entry Pressure, Leading-Edge Oblique Shock Wave geometry.</td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
1. Hypersonic airbreathing propulsion by William H. Heiser, David T. Pratt
3. Ramjet Technology, EA Bunt and others
4. RAMJETS, AIAA

**Reference Books:**
1. AGARD, Advisory Group For Aerospace Research and Development.
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Exam Hours:03</th>
<th>Group-2</th>
<th>ADVANCED PROPULSION</th>
</tr>
</thead>
</table>

Modules

**Module -1 Advanced Cryogenic & LOX-HC Engines** - Introduction to cryogenics and its applications, Properties of Cryogenic fluids, Engine cycles, system level analysis, testing, thrust chamber, turbo pumps, cryotanks. HC Engines. Engines for booster and upper stages. LOX Kerosene & LOX-Methane engines. Liquid Oxygen and Hydrocarbon, liquid rocket engine (LRE) for application as main engines & booster stages of Launchers- Different LRE cycles.

**Module -2 Green Propellants Propellant-less Propulsion**. Environmental effects of space propellants (toxicity, pollution, performance aspects). Liquid bio-propellant (H2-O2, N2O4-, etc.) for main engines. Solid propellant (NH4ClO4) for the booster. Momentum exchange tether, electro-dynamic tether, Solar thermal propulsion for upper stages, solar sails, magnetic sails. Beamed energy -Earth to Orbit Propulsion.

**Module -3 Miniaturised Propulsion & Electrical Propulsion Systems.** Classification of mission requirement. Micro-propulsion technologies; solid micro thruster, micro bi-propellant thruster, cold gas thruster, Integration aspects in micro-spacecraft. Electrical Propulsion Systems. State-of-the-art in electrical propulsion system, high-power gridded ion thruster (GIT), high – power Hall Effect thruster (HET), high- power applied-field magneto plasma dynamic thruster (MPDT), and double stage HET. Micro Ion thruster, Microchip laser thruster. Colloid thruster. Fundamentals of ion propulsion.

**Module -4 Nuclear Propulsion.** Nuclear rocket engine design and performance, nuclear rocket reactors, nuclear rocket nozzles, nuclear rocket engine control, radioisotope propulsion, basic thrusters configuration, thrusters technology, heat source development, nozzle development, nozzle performance of radio isotope propulsion systems. Testing of Nuclear rocket engines.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
## Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018** (Aerospace and Aeronautical Engineering)

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Module</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>AIRFRAME STRUCTURES AND STRUCTURAL DESIGN</strong></td>
<td><strong>Group-3</strong></td>
<td><strong>16MAE23</strong></td>
</tr>
</tbody>
</table>

### Modules

<table>
<thead>
<tr>
<th>Module</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module -1</strong></td>
<td><strong>Fundamentals of structural analysis and structural components of aircraft</strong>: Basic elasticity, Two dimensional problems in elasticity, Loads on structural components, function of structural components, fabrication of structural components, connections, numerical <strong>Sparily determinate and indeterminate structures as applied to aircraft structures</strong>: Statically determinate: Equilibrium of force systems, truss structures, externally braced wings, landing gear, beams – shear and moments, torsion-stresses and deflection. Statically indeterminate structures: Bending moment in frames and rings by elastic centre method, Continuous structure – moment distribution method. Numerical problems.</td>
<td></td>
</tr>
<tr>
<td><strong>Module -2</strong></td>
<td><strong>Introduction to practical aircraft stress analysis</strong>: Introduction to wing stress analysis by modifies beam theory, Introduction to fuselage stress analysis by modified beam theory, Loads and stresses on ribs and frames. numerical problems.</td>
<td></td>
</tr>
<tr>
<td><strong>Module -3</strong></td>
<td><strong>Buckling and stability as applied to aircraft structures</strong>: Introduction, columns and beam columns, crippling stress, buckling of this sheets, Thin skin-stringer panels, skin-stringer panels, Integrally stiffened panels, numerical problems, <strong>Overview of structural design process</strong>: Structural integrity, Material and mechanical properties, failure theories, Design criteria- safe life and fail safe, Designing against fatigue, prediction of aircraft fatigue life.</td>
<td></td>
</tr>
<tr>
<td><strong>Module -4</strong></td>
<td><strong>Wing box structure and Fuselage</strong>: Introduction, wing box design, wing covers, spars, Ribs and bulkheads, wing root joints, variable swept wings, wing fuel tank design. Fuselage: Introduction, fuselage configuration, fuselage detail design, forward fuselage, wing and fuselage intersection, stabilizer and aft fuselage intersection, fuselage opening.</td>
<td></td>
</tr>
</tbody>
</table>

### Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:


### Reference Books:

1. Aircraft structures by David Perry, McGraw Hill, 1982
<table>
<thead>
<tr>
<th>Modules</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 16MAE252 Group-3 THEORY OF AEROELASTICITY</td>
</tr>
<tr>
<td><strong>Exam Hours:</strong> 03  <strong>Exam Marks:</strong> 100</td>
</tr>
<tr>
<td><strong>Module -1</strong></td>
</tr>
<tr>
<td>INTRODUCTION Aeroelasticity - Aeroelastic phenomenon: flutter, buffeting, dynamic loads problems, load</td>
</tr>
<tr>
<td>distribution, divergence, control effectiveness &amp; reversal. Deformation of airplane structures under static loads:</td>
</tr>
<tr>
<td>Forces acting on aeroplane, Influence coefficients. Properties of influence coefficients. Deformation under</td>
</tr>
<tr>
<td>distributed forces. Simplified elastic airplane. Bending, torsional and shear stiffness curves.</td>
</tr>
<tr>
<td><strong>Module -2</strong></td>
</tr>
<tr>
<td>Static aeroelastic phenomena: Load distribution and divergence-wing torsional divergence (two-dimensional case, &amp;</td>
</tr>
<tr>
<td>effectiveness and reversal -2 dimensional case, and finite wing case. Strip theory. Aileron effectiveness in</td>
</tr>
<tr>
<td>terms of wing -tip helix angle. Critical aileron reversal speed. Rate of change of local pitching moment</td>
</tr>
<tr>
<td>coefficient with aileron angle.</td>
</tr>
<tr>
<td><strong>Module -3</strong></td>
</tr>
<tr>
<td>Deformation of airplane structures under dynamic loads: Differential and Integral forms of equations of motions of</td>
</tr>
<tr>
<td>vibrations. Natural modes and frequencies of complex airplane structures - introduction. Dynamic response</td>
</tr>
<tr>
<td>Wing bending and torsion flutter. Coupling of bending and torsion oscillations and destabilizing effects of</td>
</tr>
<tr>
<td>geometric incidences, Flutter prevention and control.</td>
</tr>
<tr>
<td><strong>Module -4</strong></td>
</tr>
<tr>
<td>Test model similarities: Dimensional concepts. Vibration model similarity laws. Dimensionless form of equation of</td>
</tr>
<tr>
<td>motion. Mode shapes and natural frequencies in dimensionless forms. Model scale factors. Flutter model similarity</td>
</tr>
<tr>
<td>law. Scale factors. Structural simulation:-shape, mass and stiffness.</td>
</tr>
<tr>
<td><strong>Module -5</strong></td>
</tr>
<tr>
<td>Testing techniques: Measurement of structural flexibility, natural frequencies and mode shapes. Polar plot of the</td>
</tr>
<tr>
<td>damped response. Identification and measurement of normal modes. Steady state and dynamic Aeroelastic model</td>
</tr>
<tr>
<td>testing.</td>
</tr>
<tr>
<td><strong>Question paper pattern:</strong></td>
</tr>
<tr>
<td>• The question paper will have ten questions.</td>
</tr>
<tr>
<td>• Each full question consists of 20 marks.</td>
</tr>
<tr>
<td>• There will be 2 full questions (with a maximum of four sub questions) from each module.</td>
</tr>
<tr>
<td>• Each full question will have sub questions covering all the topics under a module.</td>
</tr>
<tr>
<td>• The students will have to answer 5 full questions, selecting one full question from each module.</td>
</tr>
<tr>
<td><strong>Text Books:</strong></td>
</tr>
<tr>
<td>1. Dowell, E. H., Crawley, E. F., Curtiss Jr., H. C., Peters, D. A., Scanlan, R. H., and Sisto, F., A Modern Course</td>
</tr>
<tr>
<td><strong>Reference Books:</strong></td>
</tr>
</tbody>
</table>
V. Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>03</th>
<th>16MAE421</th>
<th>Group-3</th>
<th>FATIGUE AND FRACTURE MECHANICS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Exam Hours:03</td>
<td>Exams Marks:100</td>
<td></td>
</tr>
</tbody>
</table>

**Modules**

**Module -1**
Fracture Mechanics Principles: Introduction, Mechanisms of Fracture, a crack in a structure, the Graffity’s criterion, modern design, - strength, stiffness and toughness. Stress intensity approach. **Stress Analysis for Members with Cracks:** Linear elastic fracture mechanics, Crack tip stress and deformations; Relation between stress intensity factor and fracture toughness, Stress intensity based solutions. Crack tip plastic zone estimation, Plane stress and plane strain concepts. The Dugdale approach, the thickness effect.

**Module -2**
Elastic - Plastic Fracture Mechanics: Introduction, Elasto-plastic factor criteria, crack resistance curve, I-integral, Crack opening displacement, crack tip opening displacement. Importance of R-curve in fracture mechanics, Experimental determination of I-integral, COD and CTOD.

**Module -3 Dynamic and Crack Arrest:** Introduction, the dynamic stress intensity and elastic energy release rate, crack branching, the principles of crack arrest, and the dynamic fracture toughness.

**Module -4 Fatigue and Fatigue Crack Growth Rate:** Fatigue loading, Various stages of crack propagation, the load spectrum, approximation of the stress spectrum, the crack growth integration, fatigue crack growth laws. Fracture Resistance of Materials: Fracture criteria, fatigue cracking criteria, effect of alloying and second phase particles, effect of processing and anisotropy, effect of temperature, closure.

**Module -5 Computational Fracture Mechanics:** Overview of numerical methods, traditional methods in computational fracture mechanics – stress and displacement marching, elemental crack advance, virtual crack extension, the energy domain integral, finite element implementation. Limitations of numerical fracture analysis **Fracture Toughness testing of metals:** Specimen size requirements, various test procedures, effects of temperature, loading rate and plate thickness on fracture toughness. Fracture testing in shear modes, fatigue testing, NDT methods.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
### Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>04</th>
<th>16MAE24</th>
<th>Group-3</th>
<th>FLIGHT VEHICLE DESIGN</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03</td>
</tr>
</tbody>
</table>

#### Modules

**Module -1**: Overview of Design Process: Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take-off weight calculation, **Thrust to Weight Ratio & Wing Loading**: Thrust to Weight Definitions, Statistical Estimate of T/W, Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.


#### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

#### Text Books:

#### Reference Books:
1. Aeroplane Design -VOL 1 to 9 - J Roskam
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>05</th>
<th>16MAP154</th>
<th>Group-3</th>
<th>AEROSPACE STRUCTURES</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

Modules

**Module -1 Structural Components and Loads of Aerospace components:** Loads on Structural components, Function of structural components, Fabrication of structural components, Connections; Airworthiness: Factors of Safety- flight envelope, Load factor determination, Airframe loads: Aircraft inertia loads, Symmetric maneuver loads, Normal accelerations associated with various types of maneuvers, Gust loads.

**Module -2 Shear Flow and Shear Center in Open and Closed Thin Wall Sections:** Open Sections: Shear center and elastic axis, Concept of shear flow, Beams with one axis of symmetry; Closed Sections: Bradt-Batho formula, Single and multi-cell closed box structures, Semimonocoque and monococque structures, Shear flow in single and multi-cell monocoque and semimonocoque box beams subject to torsion.

**Module -3 Thin Plate Theory:** Bending of thin plates: Pure bending of thin plates, Plates subjected to bending and twisting, Plates subject to distributed transverse load, Combined bending and in-plane loading of a thin rectangular plate, Bending of thin plates having a small initial curvature, Energy method for bending of thin plates structural instability in thin plates Buckling of thin plates, Inelastic buckling of plates, Experimental determination of critical loads for a flat plate, Local instability, Instability of stiffened panels, Failure stress in plates and stiffened panels, Tension field beams.

**Module -4 Bending, Shear and Torsion of Thin-Walled Beams-I:** Symmetrical bending, Unsymmetrical bending, Deflections due to bending, Calculation of section properties, Applicability of bending theory, Temperature effects bending, shear and torsion of thin-walled beams-II Shear of Beams: General stress, strain and displacement relationships for open and single cell closed section thin-walled beams, Shear of open and closed section beams; Torsion of Beams: Torsion of closed and open section beams; Combined Open and Closed Section Beams: Bending, Shear, Torsion.


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
### Modules

**Module - 1**

**Module - 2**

**Module - 3**
Torsional vibrations in rotating machinery, modeling of rotating machinery shafting, Transfer matrix analysis for free vibration, equivalent discrete system, transient response in torsional vibration. Hydrodynamic Bearings, Viscosity, mechanism of pressure development in the film, a simple rotor in fluid film bearing, optimum design of bearings, Shafts with dissimilar moment of inertia.

**Module - 4**
Introduction to Smart Materials, Structures and Products Technologies. Overview of application of smart materials to rotor dynamics. Shape Memory Materials, Fiber-Optic Sensors.

**Module - 5**
Case study, Ball and Rolling element bearing, Bearing support design for a typical aero engine, FEM methods, Different Types of Models, Bearing and Seal Metrics, Torsional and Axial Models, Transient response using FEM software.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:
1. Rotor dynamics by JS Rao, New Age International Publishers
2. Machinery Vibration and rotor Dynamics by John Vance, Fouad Zeidan and Brian Murphy

### Reference Books:
1. Rotor Dynamics by Agnieszka Muszyńska
2. Rotor Dynamics of Turbo machinery by John M. Vance
## Visvesvaraya Technological University, Belagavi.

### PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)

As per 2017 Regulation

<table>
<thead>
<tr>
<th>01</th>
<th>16MAE13</th>
<th>Group-4</th>
<th>INTRODUCTION TO AEROSPACE VEHICLES AND SYSTEMS</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
</table>

### Modules

#### Module -1 General introduction to aeronautics:
- Fixed wing & Rotary wing aircraft: Light aircraft, Fighter aircraft, Passenger aircraft, and Cargo aircraft; Light helicopter, Large passenger and cargo helicopters
- Exploded views of various types of aircraft, identification of various structural parts and their functions and materials used.

#### Aircraft Systems:
- System design and development processes;
- Mechanical systems: Components and functions of Hydraulics & Landing Gear systems.

#### Module -2 Aircraft Electrical Systems:
- Generation, distribution and typical aircraft electrical systems and recent trends;
- Avionic systems: Flight control systems; Navigation system, Communication and radar systems their components and functions; Emergency systems and advanced systems.
- Satellites & orbital dynamics: Satellite missions, Different types of satellites and their applications, Spacecraft configurations.

#### Module -3 Spacecraft Launch Vehicles:
- Rocket propulsion principles and types and propellants; Sounding Rockets, Staging of rockets; major subsystems of launch vehicles and their functions; Different types of satellite launch vehicles.
- General description about Launch Vehicles of Indian origin.

#### Module -4 Standards & Specifications and Testing & Certification Aspects:
- Introduction to aircraft international and standards specifications for Military and Civil aircraft, Company standards; Airworthiness certification aspects aircraft; Ground testing and qualification testing.
- Flight testing: Purpose and scope, Test plans and procedures; flight test instrumentation; general flying and handling characteristics of aircraft; Preparation, and conduct of tests, fault reporting.

#### Module -5 Introduction to aerospace industries and institutions and their roles:
- Aircraft design and production industries; Components and systems manufactures, Service industries, Research and Development organizations and Academic institutions.
- Introduction to Airport Engineering: Development of air transportation, ICAO, IAAI,AAI, Aircraft characteristics which affect airport planning; Airport planning: Airport Master Plan, Regional Plan, Site selection; Terminal area and airport layout, Visual aids and ATC.

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### Reference Books:
3. Jane’s All The World Aircraft
### Modules


**Module -2 Steady Performance:** Airplane Steady Performance: General equation of motion, Steady level flight performance, Steady Climbing, Gliding Flights ; Minimum rate of sink and range in a glide. Range and Endurance of jet and piston prop airplanes. **Accelerated Performance:** Estimation of take-off and landing distances. Ground effect, Balanced Field Length. Turn performance; Bank angle, load factor, pull-up & pull-down maneuver; accelerated climbing, V-n diagram.

**Module -3 Static Longitudinal Stability and Control:** Equilibrium conditions, Definition of static stability, Definition of longitudinal static stability, stability criteria. Contribution of airframe components: Wing contribution, Tail contribution, Fuselage contribution. Power effects- Propeller airplane and Jet airplane. Trim condition. Static margin.stick fixed neutral points. Longitudinal control, Elevator power, Elevator angle versus equilibrium lift coefficient, Elevator required for landing. Restriction on forward C.G. range, Hinge moment parameters, Stick-free Neutral point, Stick force gradient in unaccelerated flight, Restriction on aft C.G.

**Module -4 Static Directional Stability and Control:** Introduction, Definition of directional stability, Static directional stability rudder fixed, Contribution of airframe components, Directional control. Rudder power, Stick-free directional stability. Requirements for directional control, Rudder lock, Dorsal fin. One engine inoperative condition. Weather cocking effect. **Static Lateral Stability And Control:** Introduction, definition of Roll stability. Estimation of dihedral effect., Effect of wing sweep, flaps, and power, Lateral control, Estimation of lateral control power, Aileron control forces, Balancing the aileron.


### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:

### Reference Books:
### Visvesvaraya Technological University, Belagavi.
### PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
### As per 2017 Regulation

**03 16MAE251**

### AIRCRAFT NAVIGATION SYSTEMS

<table>
<thead>
<tr>
<th>Exam Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Modules</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Module -1 Introduction:</strong> Guidance versus Navigation, categories of navigation, the vehicle, phases of flight, design trade-offs; Evolution of Air navigation, integrated avionics. The Navigation equations: Geometry of earth, coordinate frames, dead-reckoning computations, positioning, terrain-matching, course computation, errors, digital charts, software aspects and future trends.</td>
</tr>
<tr>
<td><strong>Module -3 Inertial Navigation:</strong> The system, Instruments, Platforms, Mechanization equations, error analysis, alignment. Satellite Radio Navigation: Basics, orbital mechanics and clock characteristics, atmospheric effects on satellite signals, NAVSTAR GPS, GLONASS, GNSS, future trends.</td>
</tr>
<tr>
<td><strong>Module -4 Air data Systems:</strong> Air-data measurements, equations, systems, specialty designs, calibration and system test, future trends. Attitude and Heading References: basic instruments, vertical references, heading references, initial alignment of heading references, future trends. <strong>Doppler and Altimeter Radars:</strong> Doppler radars, radar altimeters, future trends.</td>
</tr>
<tr>
<td><strong>Mapping and Multimode Radars:</strong> radar pilot age, semiautomatic position fixing, semiautomatic position fixing with synthetic, precision velocity update, terrain following and avoidance, multimode radars, signal processing, airborne weather radar, future trends.</td>
</tr>
<tr>
<td><strong>Module -5 Celestial Navigation:</strong> star observation geometry, theory of stellar-inertial navigation, stellar sensor design characteristics, Celestial Navigation system design, catalog characteristics, system calibration and alignment, future trends. <strong>Landing Systems:</strong> the mechanics of landing; low-visibility operations, automatic landing systems: ILS, microwave-landing system, carrier-landing system, future trends.</td>
</tr>
<tr>
<td><strong>Air Traffic Management:</strong> flight rules and procedures, phases of flight, subsystems, facilities and operations, system capacity, airborne collision avoidance systems.</td>
</tr>
</tbody>
</table>

#### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

#### Text Books:

#### Reference Books:
<table>
<thead>
<tr>
<th>Modules</th>
<th>FLIGHT TESTING</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module 1</td>
<td>Introduction: Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Method of reducing data uncertainty in flight test data - sources and magnitudes of error, avoiding and minimizing errors. <strong>Flight test instrumentation:</strong> Planning flight test instrumentation, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>05</th>
<th>16MAE41</th>
<th>Group-4</th>
<th>AIRCRAFT FLIGHT DYNAMICS AND AUTOMATIC FLIGHT CONTROL</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours: 03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Marks: 100</td>
</tr>
</tbody>
</table>

Modules

**Module -1**
**Review of feedback system analysis and aerodynamic fundamentals:** Mathematical models of linear open loop and closed loop systems, Transfer functions and Bode plot and root locus methods of analysis, analysis of multi-loop vehicular control systems; Definition of airframe parameters, coefficients and reference geometries, aerodynamic characteristics of plan forms and fuselage and effectiveness of control surfaces.

**Module -2**
**Vehicle equations of motion and axis systems:** Newton”s Second Law and reference frames Expansion of inertial forces and moments, gravity forces and their linearization, Expansion of aerodynamic forces and moments and direct thrust forces, Complete linearized equations of motion, description of dimensional and non-dimensional stability axis derivatives.

**Module -3**
**Longitudinal dynamics:** Review of simplifying assumptions and derivation of simplified longitudinal equations of motion, longitudinal controls and control input transfer functions, two degrees of freedom short period approximations and typical example transfer functions of conventional aircraft and their responses Lateral dynamics: Simplified lateral equations of motion, lateral controls and control input transfer functions, two degrees of freedom Dutch roll approximations, typical example transfer functions of conventional aircraft and their responses.

**Module -4**
**Longitudinal and lateral feedback control:** Longitudinal Feedback Control: Feedback of pitch angle and pitch rate to the elevator, feedback of speed error to elevator, feedback of angle of attack and normal acceleration to elevator, feedback of altitude to the elevator Lateral Feedback Control: Feedback of bank angle and rolling velocity to ailerons, feedback of other quantities to ailerons, feedback of heading angle to rudder, feedback of yawing velocity to rudder, feedback of sideslip to rudder, feedback of lateral acceleration to rudder.

**Module -5**
**Longitudinal and lateral autopilots:** Longitudinal Autopilots: Displacement autopilot, pitch orientational control system, acceleration control system, glide slope coupler and automatic flare control, flight path stabilization, attitude reference systems, effect of nonlinearities. Lateral Autopilots: Damping of Dutch roll, discussion on coordination techniques and methods of obtaining coordination, yaw orientational control system and other lateral autopilot configurations, automatic lateral beam guidance.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
1. Jan Roskam: Airplane flight dynamics and automatic flight controls, Part I & II, Published by Design Analysis and Research Corporation (DAR Corporation), 2003, USA.

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>06</th>
<th>16MAP13</th>
<th>Group-4</th>
<th>INTRODUCTION TO SPACE TECHNOLOGY</th>
<th>Exam Hours:03</th>
<th>Exam Marks:100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Modules</strong></td>
<td></td>
<td></td>
<td><strong>Introduction to Rocket Propulsion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module -2 Atmospheric Reentry</strong></td>
<td>Introduction-Steep Ballistic Reentry-Ballistic Orbital Reentry-Skip Reentry-&quot;Double-Dip&quot; Reentry - Aero-braking - Lifting Body Reentry.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module -3 Fundamentals of Orbit Mechanics, Orbit Maneuvers</strong></td>
<td>Two-body motion-Circular, elliptic, hyperbolic, and parabolic orbits-Basic Orbital Elements-Ground trace In-Plane Orbit changes-Hohmann Transfer-Bielliptical Transfer-Plane Changes - Combined Maneuvers - Propulsion for Maneuvers.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Module -4 Satellite Attitude Dynamics</strong></td>
<td>Torque free Axi-symmetric rigid body-Attitude Control for Spining Spacecraft - Attitude Control for Non-spinning Spacecraft - The Yo-Yo Mechanism - Gravity - Gradient Satellite-Dual Spin Spacecraft- Attitude Determination. <strong>10 Hours</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>07</th>
<th>16MAP252</th>
<th>Group-4</th>
<th>ENGINE PERFORMANCE, CONTROL AND SIMULATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours:30</td>
<td>Exam Marks:100</td>
<td>Modules</td>
<td></td>
</tr>
<tr>
<td>Module -1</td>
<td>Gas turbine engine, Turbojet, turbofan, turboprop schematic, identification of components flow properties along gas path, Definition of Engine Performance parameters specific thrust and specific fuel consumption, installed and uninstalled performance, Importance of by-pass ratio and after burning, concept of multi spooling, importance of bleed and power off-take, engine systems and accessories. Component performance, atmospheric model, correlations for variation of gas properties, inlet and diffuser pressure recovery, compressor and turbine isentropic and polytrophic efficiencies, Burner efficiency, pressure loss and pattern factor. Exit nozzle loss, propeller performance parameters, variable and constant pitch propellers, component performance with variable gas properties.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module -2</td>
<td>Parametric cycle analysis of real engine, turbojet, turbojet with after burner, turbofan with separate exhaust streams, turbofan with after burning separate exhaust streams, turbofan with afterburning mixed exhaust streams, turbo prop engine. Engine operating line on compressor characteristics, Equilibrium running of gas generator, matching procedure for twin spool engines, behaviour of twin spool engines, Method of displacing equilibrium running line, matching procedure for turbofan engine, performance deterioration.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module -3</td>
<td>Aero engine evaluation, engine test bed types, schematic layout of test beds, instrumentation on test beds, engine and component performance from gas path data, engine health monitoring parameters, sensors, analysis of vibration and blade tip gap signals, high temperature sensors, oil debris monitoring, engine trend analysis for engine diagnostics and prognostics. Noise characterization, Measurement of noise, sources of noise generation in aero engine components, noise propagation due to propellers, comparative noise characteristics for turbojet, turbofan, turbo shaft and turbo prop, active and passive methods for noise reduction, International standards for aero engine noise.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Module -5</td>
<td>Aero engine control, FADEC architecture, Digital electronic control unit for aero engine, Gas generator control, engine limit protection, engine automatic and manual starting, power management, engine data for cockpit indication, engine condition parameters display in the cockpit, thrust reverser control and feedback, fuel control and computation, fuel recirculation control, cooling of FADEC, management of engine subsystems like lubrication, on board power, fuel scavenge, starting system, Engine gas path data in FADEC, Engine health management from flight data recorder.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:

Reference Books:
3. SaeedFarokhi, Aircraft Propulsion, John Wiley & Sons, Inc
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module</th>
<th>Module Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Module -2</td>
<td><strong>Transportation System Architecture, Infrastructures and U.S. Space Shuttle:</strong> Introduction, Historical drivers for space infrastructure, Political considerations, National mission model, Private sector and commercialization, Development of commercial space transportation architecture and system concepts, Cost drivers for space transportation architecture options, Recommended improvements to space transportation architectures, Planning for future space infrastructure, Transportation Infrastructure for moon and mars missions U.S. Space Shuttle: Introduction, Historical background, Development of shuttle system, Orbiter development, Current shuttle vehicle and operations, Shuttle evolution and future growth.</td>
</tr>
<tr>
<td>Module -3</td>
<td><strong>Expendable Space Transportation Systems and Reusable Space Launch Vehicles:</strong> Introduction, Expendable launch vehicle design, History behind existing Expendable Launch Vehicles, Evolving the expendable launch vehicle, Reusable space launch vehicles: Background—Previous efforts at hypersonic flight, Early aerospace plane conceptual studies, The X-series of research aircraft, Challenges facing manned aerospace planes, Manned reusable systems development programs-Past and Ongoing., NASA reusable launch vehicle studies in 1990s., Hypersonic wave riders, Importance of vehicle health management, Future reusable space launch vehicles Operations and Support Systems: Introduction, Launch operations definition, Shuttle mission operations, Facility requirements for launch operations, Obstacles to streamlining launch operations, Evolutionary launch operations strategies, Designing for future expendable launch vehicle launch operations, Improving Existing Launch Operations, Future launch operations.</td>
</tr>
</tbody>
</table>

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**
2. Integrated Design for Space Transportation System., BN Suresh and K Sivan, Springer
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

Reference Books:
1. Design Methodologies for space transportation systems, Walter Hammond, AIAA Education Series, American Institute of Aeronautics and Astronautics, Inc

<table>
<thead>
<tr>
<th>09</th>
<th>16MAP41</th>
<th>Group-4</th>
<th>AEROSPACE INSTRUMENTATION AND CONTROLS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Modules

Module - 1
Motion - Force - Torque - Power - Pressure Measurements: Relative and absolute motion measurement. Force measurement- balance, hydraulic and pneumatic load cell, elastic force device. Torque and Power measurement- transmission, driving, absorption dynamometers. Pressure measurement- Low, moderate and high pressure measurement
Temperature – Flow- Acoustics measurement: Temperature measurement – non electrical, electrical, radiation method. Flow measurement- primary, positive displacement, secondary or rate meter. Acoustics measurement- characteristics of sound, sound pressure, power and intensity levels, loudness, typical sound measuring systems, microphones.

Module - 2

Module - 3

Module - 4
Introduction to Automatic Controls: Introduction, closed loop and open loop control systems, mathematical modeling of mechanical, electrical, hydraulic and pneumatic systems, Types of control actions. State-Space Methods - Introduction, Vector matrix representation of State-Space equations, State Transition Matrix and equations, Characteristics equations, eigen values and eigen vectors, similarities transformations, decomposition of transfer functions. Controllability and observe ability of control systems: General concept of control ability, definition of state controllability, alternate tests on control ability, Definition of observability, alternate tests on observability, relationship among controllability, observability and transfer functions.

Module - 5
Design of control systems in state space: Pole placement, Design of servo systems, state observers, design of regulator systems with observers, design of control systems with observers, quadratic optimal regulator systems. Design of discrete data control systems: Digital implementation of analog controllers, digital controllers, design in frequency domain and z plane.

Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

Text Books:
4. K. Ogata, —Modern Control Engineering! Prentice Hall Inc.

Reference Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

## Visvesvaraya Technological University, Belagavi.

**PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)**

As per 2017 Regulation

<table>
<thead>
<tr>
<th>Exam Hours</th>
<th>Group-5</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COMPUTATIONAL FLUID DYNAMICS</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Modules

#### Module -1 Introduction:
- CFD ideas to understand, CFD Application, Governing Equations (no derivation) of flow; continuity, momentum, energy. Conservative & Non-conservative forms of equations, Integral vs Differential Forms of Equations. Form of Equations particularly suitable for CFD work. Shock capturing, Shock fitting, Physical Boundary conditions.

**Mathematical Behavior of Partial Differential Equations and Discretization:** Classification of partial differential equations and its Impact on computational fluid dynamics; case studies. Essence of discretization, order of accuracy and consistency of numerical schemes, Lax’s Theorem, convergence, Reflection Boundary condition.

#### Module -2 Mathematical Behavior of Partial Differential Equations and Discretization:

#### Module -3 Grid Generation:

#### Module -4 Adaptive Grid Methods:


#### Module -5 Finite Volume Techniques:


**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation

<table>
<thead>
<tr>
<th>02</th>
<th>16MAP14</th>
<th>Group-5</th>
<th>FINITE ELEMENT METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exam Hours: 03</td>
<td>Exam Marks: 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modules**

**Module -1**
Introduction to Finite Element Method, One-Dimensional Elements-Analysis of Bars:
- Engineering Analysis, History, Advantages, Classification, Basic steps, Convergence criteria, Role of finite element analysis in computer-aided design.
- Mathematical Preliminaries, Differential equations formulations, Variational formulations, weighted residual methods.

**Module -2**
Two-Dimensional Elements-Analysis, Three-Dimensional Elements-Applications and Problems:
- Three-Noded Triangular Element (TRIA 3), Four-Noded Quadrilateral Element (QUAD 4), Shape functions for Higher Order Elements (TRIA 6, QUAD 8).

**Module -3**
Aero Structural analysis through FEM for Beams and Trusses:
- 1–D Beam Element, 2–D Beam Element, shape functions and stiffness matrixes, Problems, trusses with one, two, three and four bar elements.

**Module -4**
FEM analysis of Heat Transfer and Fluid Flow:
- Steady state heat transfer, 1 D heat conduction governing equation, boundary conditions, One dimensional element, Functional approach for heat conduction, Galerkin approach for heat conduction, heat flux boundary condition, 1 D heat transfer in thin fins. Basic differential equation for fluid flow in pipes, around solid bodies, porous media.

**Module -5**
FEM for Dynamic:
- Formulation for point mass and distributed masses, Consistent element mass matrix of one dimensional bar element, truss element, axisymmetric triangular element, quadrilateral element, beam element.
- Lumped mass matrix, Evaluation of eigen values and eigen vectors, Applications to bars, stepped bars, and beams.

**Question paper pattern:**
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**

**Reference Books:**
<table>
<thead>
<tr>
<th>03</th>
<th>16MAE254</th>
<th>Group -5</th>
<th>STATE SPACE METHODS</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Exam Hours:</strong> 03</td>
<td><strong>Exam Marks:</strong> 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Modules**

**Module -1**


**Module -2**


**Module -3**


**Module -4**


**Module -5**


**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


**Reference Books:**

### Modules

#### Module -1 Analysis of Stress:
- Continuum concept, homogeneity, isotropy, mass density, body force, surface force

#### Module -2 Deformation and Strain:
- Particles and points, continuum configuration-deformation and flow concepts. Position vector, displacement vector-Lagrangian and Eulerian description, deformation gradient, displacement gradient. Deformation tensors, finite strain tensors, small deformation theory, infinitesimal strain tensors. Relative displacement-linear, rotation tensors. Transformation properties of strain tensors. Principal strains, strain invariants, cubical dilatation, spherical and deviator strain tensors, plane strain, Mohr’s circle, and compatibility equations. **Motion and Flow:** Motion, flow, material derivative. Velocity, acceleration, instantaneous velocity field. Path line, stream line, steady motion. Rate of deformation, Vorticity, natural strain –physical interpretation. Material derivatives of volume, area and line element, material derivatives of volume, surface and line integrals.

#### Module -3 Fundamental Laws of Continuum Mechanics:

#### Module -4 Fluids:

#### Module -5 Plasticity:

### Question paper pattern:
- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:
Visvesvaraya Technological University, Belagavi.
PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)
As per 2017 Regulation
**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)**

As per 2017 Regulation

<table>
<thead>
<tr>
<th>01</th>
<th>16MAE151</th>
<th>Group-6</th>
<th><strong>INTRODUCTION TO ADVANCED COMPOSITES</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Hours:03</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Exam Marks:100</td>
</tr>
</tbody>
</table>

**Modules**

<table>
<thead>
<tr>
<th>Module</th>
<th>Description</th>
</tr>
</thead>
</table>
| Module -1 | **Science of composite materials**: Polymer-matrix composites, Carbon-matrix, Metal-matrix, Ceramic-matrix.  
**Advance processing techniques**: Filament winding, pultrusion, pulforming, thermofoming, injection, injection molding, liquid molding, blow molding. Application to aircraft, missiles & spacecraft. |
| Module -2 | **Macro& microbehavior of a lamina**: Stress strain relationship for an orthotropic Lamina-Restriction on elastic constants-Strengths of an orthotropic lamina and failure theories for an orthotropic lamina. Determination of elastic constants-Rule of mixtures, **Macro-mechanical behavior of a laminate**: Classical plate theory-stress and strain variation in laminate. Strength analysis of a laminate. |
| Module -3 | **Composite materials for thermal application, electrical/electromagnetic application**: Materials for high thermal conductivity, thermal interface materials, materials for thermal insulation, materials for heat retention Application to micro-electronics, resistance heating Mechanism behind electromagnetic application, materials for electromagnetic application.  
| Module -5 | **Smart structure application**: Polymer matrix composites for damage sensing, temperatures sensing& vibration reduction. **Introduction to testing**: Environmental effects testing, Design allowable & Damage tolerance Testing. Test Techniques. |

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


**Reference Books:**

Visvesvaraya Technological University, Belagavi.

PhD Coursework Courses – 2018 (Aerospace and Aeronautical Engineering)

As per 2017 Regulation

<table>
<thead>
<tr>
<th>Module</th>
<th>Exam Hours</th>
<th>Exam Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>02 16MAP151 Group-6 AEROSPACE MATERIALS &amp; PROCESSES</td>
<td>03</td>
<td>100</td>
</tr>
</tbody>
</table>

**Modules**

**Module -1**

The Gas Turbine Engine: Major engine components, material trends, component operating environments and material requirements, compressor and turbine discs, blades. Combustion chambers, shafts, bearings. **Steels:** Compressor and turbine discs, processing of steel to billets, future trends in disc materials, compressor and turbine blading, transmission materials-bearings, shafts and gears.

**Module -2**


**Module -3**

Casting Technology: Light alloy casting, moulding practice, melting practice, precision investment casting, effect of casting parameters on properties, techniques for special or small quantity castings, titanium casting, directional solidification, hot isostatic pressing, future trends in casting technology, Processing of ceramics like slip casting, powder metallurgy technique.

**Module -4**

Forging of Gas Turbine components: Historical background, forging equipment, press, recent trends, quality control aspects of thermo mechanical processing, processing to improve mechanical properties, Incoloy 901, titanium 6-4 alloy, 12% chromium steels, super alloy powder metallurgy. Forging of compressor and turbine blades.

**Module -5**

Sheet Materials fabrication and joining: Alloy requirements, sheet materials, steels, titanium alloys, high temperature super alloys, heat treatment and de-scaling, forming, chemical machining, electron beam welding, brazing of super alloys, ultrasonic machining, water jet cutting, electrochemical processing, laser cutting for rotating machinery components, Joining technologies like plasma technique, laser welding, use of rapid prototyping machines in manufacturing components. Surface degradation and protective treatments: Corrosion behavior, coatings and surface treatments, erosion behavior of compressor components, surface degradation and protection of combustor and turbine components, hot corrosion, high temperature coating technology.

**Question paper pattern:**

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

**Text Books:**


**Reference Books:**

**Visvesvaraya Technological University, Belagavi.**

**PhD Coursework Courses – 2018  (Aerospace and Aeronautical Engineering)**

**As per 2017 Regulation**

<table>
<thead>
<tr>
<th>Module</th>
<th>Exam Hours: 03</th>
<th>Exam Marks: 100</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>03</strong></td>
<td>16MAP153</td>
<td>Group-6 ADVANCED COMPOSITES MATERIALS</td>
</tr>
</tbody>
</table>

### Modules

**Module -1 Science of composite materials:** Polymer-matrix composites, Carbon-matrix, Metal-matrix, Ceramic-matrix. Advance processing techniques: Filament winding, pultrusion, pulforming, thermoforming, injection, injection molding, liquid molding, blow molding. Application to aircraft, missiles & spacecraft.

**Module -2 Macro & Microbehavior of a lamina:** Stress strain relationship for an orthotropic Lamina- Restriction on elastic constants-Strengths of an orthotropic lamina and failure theories for an orthotropic lamina. Determination of elastic constants-Rule of mixtures, Macro-mechanical behavior of a laminate: Classical plate theory-stress and strain variation in laminate. Strength analysis of a laminate.

**Module -3 Composite materials for thermal application, electrical/electromagnetic application:** Materials for high thermal conductivity, thermal interface materials, materials for thermal insulation, materials for heat retention Application to micro-electronics, resistance heating Mechanism behind electromagnetic application, materials for electromagnetic application.

**Module -4 Materials for thermoelectric, dielectric application, optical & magnetic application:** Non-structural & Structural composites, dielectric behavior, piezoelectric behavior, Piezoelectric/ferroelectric composite principles. Pyroelectric behavior. Materials for optical wave guide, materials for lasers. Metal-matrix composites for magnetic application.

**Module -5 Smart structure application:** Polymer matrix composites for damage sensing, temperatures Sensing & vibration reduction. Introduction to testing: Environmental effects testing, Design allowable & Damage tolerance Testing. Test Techniques.

### Question paper pattern:

- The question paper will have ten questions.
- Each full question consists of 20 marks.
- There will be 2 full questions (with a maximum of four sub questions) from each module.
- Each full question will have sub questions covering all the topics under a module.
- The students will have to answer 5 full questions, selecting one full question from each module.

### Text Books:


### Reference Books: