MOM II MEETING UDAC ONLINE HELD ON 02122020.pdf

SCHEME AE 2018-19.pdf

UTD_3-8 sem syllabus_AERO 2018.19 .pdf

Approved
Dean, FA & UD

Department of Mechanical Engineering

Scheme & Syllabus

of

Bachelor of Technology

Aeronautical Engineering

From III to VIII Semester

Effective from Academic session 18-19

for B.Tech.- AE Effective for student admitted in 18-19 (First year)

University Teaching Departments

Rajasthan Technical University, Kota

Approved
Dean, FA & UD

Minutes of Meeting
II Meeting (online) of Academic Council, University Departments, RTU, Kota
27 November, 2020, 3:30 pm

Ref. Number: **Date : 28-11-2020**

II Meeting of Academic Council, University Departments, RTU, KOTA was convened through online mode on 27-11-2020 at 3:30 PM using Google Meet under the Chairmanship of Prof. A.K. Mathur, Dean, Faculty Affairs. Following members were present:

1. Prof. B.P. Suneja
2. Prof. Rajiv Gupta
3. Prof. Dinesh Birla
4. Prof. S. R. Kapoor
5. Prof. V.K. Gorana
6. Prof. A.K. Chaturvedi
7. Prof. Vivek Pandey
8. Prof. K.S. Grover
9. Dr. R.K.Bayal
10. Dr S. D. Purohit
11. Dr. Sanju Tanwar
12. Shri Manoj Vaishnav
13. Shri Ashok Patni
14. Dr. Vikas Bansal (Member Secretary)

Following agendas related to academic has been discussed and resolved into the meeting:

Agenda 1: Modifications/ improvement in CBCS regulations for Undergraduate programmes

Looking towards the model curriculum provided by the AICTE and to improve the academics of University Departments, RTU, Kota in the prevailing situations, modifications may be made in the CBCS regulations. A committee was formed for modifications in CBCS regulation as decided in the meeting of Head of Departments held in the month of September 2020. The committee has recommended CBCSUG-2020 after incorporating modifications in CBCSUG-2017. CBCSUG-2020 may be affected from the students admitted in 2020-21 and onwards. Modified regulations (CBCSUG-2020) as enclose in Annexure-1 is submitted herewith for approval. These shall be affected from

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the students admitted in 2020-21 and onwards after approval. Members are requested to approve.

Resolution: The Agenda was approved by the respected members. Following modifications were suggested and approved by the respected members in proposed CBCSUG-2020 by the committee (appointed on September 05, 2020 in the meeting of Head of Departments):

i. Industrial Training (as mentioned in Section 6 and other Sections of the proposed CBCSUG-2020) has been considered as Credit courses in place of non-graded core courses. Therefore, 5 non-graded units have been changed to 5 Credits.

ii. As suggested by HVC, SODECA, which was also non-graded core course (as mentioned in Section 6 and other Sections of the proposed CBCSUG-2020), has also been converted to Credit course. Therefore, 4 non-graded units of SODECA have been changed to 4 Credits of SODECA (Anandam).

iii. Above two changes have been resulted into change in the minimum credit requirement criterion (as mentioned in Section 4 and other Sections of the proposed CBCSUG-2020) for passing the B.Tech. degree. Now, minimum credit requirement is 164 Credits along with 11 non- graded units in place of 155 Credits along with 20 non- graded units as suggested by the committee (appointed on September 05, 2020 in the meeting of Head of Departments).

iv. In ADDITION of grades S and Z (as mentioned in Section 6 and other Sections of the proposed CBCSUG-2020), two more grades V for excellent performance and G for good performance has also been.

v. As mentioned in Appendix-1 and other Sections of the proposed CBCSUG-2020, In first year scheme, Engineering Mechanics and Introduction to Electrical and Electronics Engineering has been replace by Basic Mechanical Engineering, Basic Civil Engineering and Introduction to Electrical and Electronics Engineering. Students of CS, EC, EE, EIC, IT will study Basic Mechanical Engineering and Basic Civil Engineering. Students of CE, PE, PC will study Basic Mechanical Engineering and Introduction to Electrical and Electronics Engineering. Students of AE, ME, PIE will study Basic Civil Engineering and Introduction to Electrical and Electronics Engineering.

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vi. As per the guidelines of AICTE and as suggested and approved in the UDAC meeting, Minor degree or Honours shall be added in the B. Tech. degree on completing courses of extra 20 credits in the inter-disciplinary specialization or Departmental specialization respectively. This provision has been placed in place of the option for both Minor degree and Honours (as mentioned in Section 5, Appendix-3 and other Sections of the proposed CBCSUG-2020) on clearing extra 40 credits as suggested by the committee (appointed on September 05, 2020 in the meeting of Head of Departments).

vii. Therefore, the minimum requirement for obtaining Minor degree or Honours (as mentioned in Section 5, Appendix-3 and other Sections of the proposed CBCSUG-2020) with B. Tech. Degree becomes 184 credit and 11 non-graded units.

viii. List of MOOC courses may also be prepared from the option available to the BOS other than 4 agency prescribed in the proposed CBCSUG-2020 (as mentioned in Section 5 and other Sections of the proposed CBCSUG-2020) by the committee. The list of MOOCS prepared by the BOS shall be approved by Dean UD.

ix. The provision for obtaining the grades in the MOOC COURSES as suggested by the committee and as mentioned in Section 5 and other Sections has been replaced by the following provision as suggested and approved by the Hon'ble members that In House examination / evaluation will be carried out for the MOOC COURSES as held for regular courses. The grading of the MOOC courses will be done on the basis of these examinations/evaluations. A Course Coordinator will be assigned for each MOOC COURSE.

x. Theory and Practical courses will be treated as separate courses.

xi. The provision of 'Self-study course' as mentioned at Sub. Section 4.11 of Section 4 of proposed CBCSUG-2020 has been deferred.

xii. The provision of 'Exit policy' as mentioned at Sub. Section 4.13 of Section 4 of proposed CBCSUG-2020 has been deferred till announced by AICTE and other regulating bodies.

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xiii. Minimum number of students in Departmental Elective has been replaced by 'minimum of 10 or actual number of students admitted' in place of '10' (as mentioned in Section 3.3 and other Sections of the proposed CBCSUG-2020).

Agenda 2: To approve B. Tech. Curriculum applicable for students admitted in 2017-18

In pursuance of the CBCS Regulations, the teaching schemes have been revised form 2017-18 by the concerned BOS, these are placed for kind perusal of members (Annexure 2). Members are requested to approve.

Resolution: The Agenda was approved by the respected members.

Agenda 3: To approve B. Tech. Curriculum applicable for students admitted in 2018-19

In Academic session 2018-19, a revised teaching scheme for I and II semester in line with that in RTU was adopted on recommendation of the BOS and approval of the Vice Chancellor .

In the prevailing market conditions and as per the model curriculum provided by AICTE, it has been discussed in the meeting of Head of Departments held in the month of September 2020 to **include One MOOC courses each in VII and VIII semester aggregating to 7 Credit in the scheme for the students admitted in 2018-19.** 8-10 weeks of MOOC courses shall be considered for 3 credits and 12-16 weeks for MOOC courses shall be considered for 4 credits. A list of the MOOC courses shall be submitted by the respective BOS, two months before the start of the respective semester . The students have to select the MOOC courses from the list provided by the concerned BoS. The MOOCs courses available on the following site/platform will be recognized.

Initiative	Institution Behind Platform	Website Link
NPTEL	IIT Madras	nptel.ac.in/
mooKIT	IIT Kanpur	www.mookit.co/
IITBX	IIT Bombay	iitbombayx.in/
SWAYAM	MHRD and Microsoft	Swayam.gov.in

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Only those MOOCs courses will be considered for fulfilling the requirement of the B.Tech. Degree, which have certification.

The student will inform in writing to respective Head of the Department about the MOOCs courses intended to register from the list provided by concerned BoS at the time of registration of other courses. The HOD shall verify the authenticity of the course as per points mentioned above. The student shall submit the certificate along with the credit earn to the HOD, who will ensure to submit the information about the credit and grade earn by the student during the semester (through the MOOCs courses) at the time of submission of other course grades. Before submitting the grade of MOOC course registered by the student, the HOD shall convert the grade of the MOOC course to the grading system of CBCS of University Departments. For conversion, first the grade of the course shall be converted to equivalent marks using the rules prevalent at the institute offering the MOOC course and then marks shall be converted to equivalent grade of CBCS of University Departments.

In pursuance of the CBCS Regulations, the revised teaching schemes are placed for kind perusal of members (Annexure 3). Members are requested to approve.

Resolution: The Agenda was approved by the respected members after having following modifications:

The provision for obtaining the grades in the MOOC COURSES as suggested above has been replaced by the following provision as suggested and approved by the Hon'ble members that In House examination / evaluation will be carried out for the MOOC COURSES as held for regular courses. The grading of the MOOC courses will be done on the basis of these examinations/evaluations. A Course Coordinator will be assigned for each MOOC COURSE.

Agenda 4: To approve B. Tech. Curriculum applicable for students admitted in 2019-20

In Academic session 2019-20, a revised teaching scheme for I and II semester in line with that in RTU was adopted on recommendation of the BOS.

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In the prevailing market conditions and as per the model curriculum provided by AICTE, it has been discussed in the meeting of Head of Departments held in the month of September 2020 to **include One MOOC courses each in VII and VIII semester aggregating to 7 Credit in the scheme for the students admitted in 2019-20.** 8-10 weeks of MOOC courses shall be considered for 3 credits and 12-16 weeks for MOOC courses shall be considered for 4 credits. A list of the MOOC courses shall be submitted by the respective BoS, two months before the start of the respective semester . The students have to select the MOOC courses from the list provided by the concerned BoS. The MOOCs courses available on the following site/platform will be recognized.

Initiative	Institution Behind Platform	Website Link
NPTEL	IIT Madras	nptel.ac.in/
mooKIT	IIT Kanpur	www.mookit.co/
IITBX	IIT Bombay	iitbombayx.in/
SWAYAM	MHRD and Microsoft	Swayam.gov.in

Only those MOOCs courses will be considered for fulfilling the requirement of the B.Tech. Degree, which have certification.

The student will inform in writing to respective Head of the Department about the MOOCs courses intended to register from the list provided by concerned BoS at the time of registration of other courses. The HOD shall verify the authenticity of the course as per points mentioned above. The student shall submit the certificate along with the credit earn to the HOD, who will ensure to submit the information about the credit and grade earn by the student during the semester (through the MOOCs courses) at the time of submission of other course grades. Before submitting the grade of MOOC course registered by the student, the HOD shall convert the grade of the MOOC course to the grading system of CBCS of University Departments. For conversion, first the grade of the course shall be converted to equivalent marks using the rules prevalent at the institute offering the MOOC course and then marks shall be converted to equivalent grade of CBCS of University Departments.

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In pursuance of the CBCS Regulations, the teaching schemes are placed for kind perusal of members (Annexure 3). In pursuance of the CBCS Regulations, the revised teaching schemes are placed for kind perusal of members (Annexure 4). Members are requested to approve.

Resolution: The Agenda was approved by the respected members after having following modifications:

The provision for obtaining the grades in the MOOC COURSES as suggested above has been replaced by the following provision as suggested and approved by the respected members that In House examination / evaluation will be carried out for the MOOC COURSES as held for regular courses. The grading of the MOOC courses will be done on the basis of these examinations/evaluations. A Course Coordinator will be assigned for each MOOC COURSE.

Agenda 5: To approve B. Tech. Curriculum applicable from 2020-21 and onwards for first year

In pursuance of **the revised** CBCS Regulations, the teaching schemes are placed for kind perusal of members (Annexure 5). Members are requested to approve.

Resolution: The Agenda was approved by the respected members after following modifications:

In first year scheme Engineering Mechanics and Introduction to Electrical and Electronics Engineering has been replaced by Basic Mechanical Engineering, Basic Civil Engineering and Introduction to Electrical and Electronics Engineering. Students of CS, EC, EE, EIC, IT will study Basic Mechanical Engineering and Basic Civil Engineering. Students of CE, PE, PC will study Basic Mechanical Engineering and Introduction to Electrical and Electronics Engineering. Students of AE, ME, PIE will study Basic Civil Engineering and Introduction to Electrical and Electronics Engineering.

Agenda 6: To approve BOS of HEAS department.

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In pursuance of CBCS Regulations, the BOS of HEAS department is placed for kind perusal of members (Annexure 6). Members are requested to approve.

Resolution: The Agenda was approved by the respected members.

Agenda 7: To approve policies and guidelines regarding academics and examination which are not in practice during pre COVID periods (Normal circumstances).

The extra ordinary situation arisen due to COVID-19, forces the administration to adopt some policies regarding academics and examination which are not in practice during pre COVID periods. Govt. of Rajasthan, Office of HVC and COE issued some guidelines for the academics and examination process. Members are requested to approve the same for University Departments, RTU, Kota.

Members are requested to approve.

Resolution: The Agenda was approved by the respected members.

Reporting Item:

There are no guidelines for preparation of grades for back /improvement examinations in the present CBCS regulations. A committee was formed and approved by HVC for addressing this issue. Following provisions were proposed by the committee and approved by HVC in 2019 (note-sheet enclosed):

a. If the back exam is conducted with main exam then the grading may be calculated with the main exam students.
b. In case the back exam is conducted separately, then the grading may be calculated along with the previous main exam. However, the grading of the students (awarded already) will remain unaffected.

Resolution: The Agenda was approved by the respected members.

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The meeting ended with a vote of thanks to The Chair

Dr Vikas Bansal
Member Secretary, UDAC)

Prof Anil Mathur
Chairman, UDAC

Copy to:

1. **PS to HVC for Approval in BOM**
2. **Members of UDAC**

Dr Vikas Bansal
Member Secretary, UDAC)

Prof Anil Mathur
Chairman, UDAC

NOTE SHEET

Agenda 2. List of MOOC courses to be decided by deptt.

Resolution:

As per agenda for VII & VIII semester of 18-19 scheme, a list of possible MOOC courses is to be finalized for students of Aeronautical Engineering. These MOOC's courses are dynamic in nature and changes every semester. As VII sem of the UD 18-19 scheme is likely to start from July 2021. Therefore, it is resolved that BOS of the deptt. will decide and finalize the list of MOOC courses just before 2 months from start of VII sem. Following Mooc Courses agencies may also be included in the ⊛⊛

Meeting ended with vote of thanks to all the members for attending the meeting.

VS 21/10/20

(Dr. V.K.Gorana)

⊛⊛ list provided by academic cell.

(1) Coursera → www.coursera.org.

(2) edx (courses by Harvard & MIT) i.e. www.edx.org.

VS 21/10/20.

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Scheme for B.Tech. Aeronautical Engineering

Effective for students admitted in 2018-19 & 2019-2020 batch

THEORY & PRACTICAL

Sem	Codes	Subject	Internal	External	Total marks	Hours/week			Credits
						L	T	P	
III	3ANU1	Advanced Engineering Mathematics-I	50	100	150	3	1	0	4
	3ANU2	Incompressible Fluid mechanics	50	100	150	3	1	0	4
	3ANU3	Engineering Thermodynamics	50	100	150	3	0	0	3
	3ANU4	Engineering Mechanics	50	100	150	3	0	0	3
	3ANU5	Introduction to Aeronautics	50	100	150	3	0	0	3
	3ANU6	Aircraft Materials Engineering	50	100	150	2	0	0	2
	3ANU11	Object Oriented Programming Lab	50	25	75	0	0	3	2
	3ANU12	Fluid Mechanics Lab	50	25	75	0	0	2	1
	3ANU13	Metrology Lab	50	25	75	0	0	2	1
	3ANU14	Professional Communication Lab	50	25	75	0	0	2	1
	3ANU20	Extra Curricular & Discipline	50		50				1
		Sub- Total	**550**	**700**	**1250**	**17**	**2**	**9**	**25**
IV	4ANU1	Advanced Engineering Mathematics-II	50	100	150	3	1	0	4
	4ANU2	Aerodynamics-I	50	100	150	3	1	0	4
	4ANU3	Mechanics of Solids	50	100	150	3	0	0	3
	4ANU4	Heat Transfer	50	100	150	3	0	0	3
	4ANU5	Elements of Vibration	50	100	150	3	0	0	3
	4ANU6	Manufacturing Process	50	100	150	2	0	0	2
	4ANU11	Aerodynamics Lab	50	25	75	0	0	3	2
	4ANU12	Manufacturing Process Lab	50	25	75	0	0	3	2
	4ANU13	Heat Transfer Lab	50	25	75	0	0	2	1
	4ANU14	Programming in MATLAB	50	25	75	0	0	2	1
	4ANU20	Extra-Curricular & Discipline	50		50	0	0	0	1
		Sub- Total	**550**	**700**	**1250**	**17**	**2**	**10**	**26**
	5ANU1	Aerodynamics - II	50	100	150	3	1	0	4
	5ANU2	Aircraft Structure -I	50	100	150	3	1	0	4

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V	5ANU3	Aircraft Performance	50	100	150	3	0	0	3
	5ANU4	Aircraft Systems	50	100	150	3	0	0	3
	5ANU5.1	Machine Design	50	100	150	3	0	0	3
	5ANU5.2	Experiments in Fluid Mechanics							
	5ANU5.3	Introduction to Robotics							
	5ANU6.1	Digital Electronics	50	100	150	2	0	0	2
	5ANU6.2	Experimental Stress Analysis							
	5ANU6.3	Heat Transfer in Space Applications							
	5ANU11	CAD Lab	50	25	75	0	0	3	2
	5ANU12	Aircraft Systems Lab	50	25	75	0	0	2	1
	5ANU13	Vibration Lab	50	25	75	0	0	2	1
	5ANU14	Mechanics of Solids Lab	50	25	75	0	0	2	1
	5ANU20	Extra Curricular & Discipline	50		50	0	0	0	1
		Sub- Total	**550**	**700**	**1250**	**17**	**2**	**9**	**25**
VI	6ANU1	Aerospace Propulsion – I	50	100	150	3	1	0	4
	6ANU2	Aircraft Structure – II	50	100	150	3	1	0	4
	6ANU3	Aircraft Stability and Control	50	100	150	3	0	0	3
	6ANU4	Computational Fluid Dynamics	50	100	150	3	0	0	3
	6ANU5.1	Mechanics of Composites	50	100	150	3	0	0	3
	6ANU5.2	Introduction to Aeroelasticity							
	6ANU5.3	Internal Combustion Engines							
	6ANU6.1	Unmanned Aerial Systems	50	100	150	2	0	0	2
	6ANU6.2	Fuels & Propellant Technology							
	6ANU6.3	Theory of Machines							
	6ANU11	Computational Fluid Dynamics Lab	50	25	75	0	0	3	2

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	6ANU12	Aeromodelling Lab	50	25	75	0	0	3	2
	6ANU13	Aircraft Structures Lab	50	25	75	0	0	2	1
	6ANU14	Composite Materials Lab	50	25	75	0	0	2	1
	6ANU20	Extra Curricular & Discipline	50		50	0	0	0	1
		Sub- Total	**550**	**700**	**1250**	**17**	**2**	**10**	**26**
VII	7ANU1	Aerospace Propulsion – II	50	100	150	3	1	0	4
	7ANU2	Aircraft Design	50	100	150	3	1	0	4
	7ANU3	Finite Element Methods	50	100	150	3	0	0	3
	7ANU4	Space Dynamics	50	100	150	3	0	0	3
	7ANU5.1	Automatic Control Systems							
	7ANU5.2	Structural Health Monitoring	50	100	150	3	0	0	3
	7ANU5.3	Operation Research							
	7ANU6X	MOOC							4
	7ANU11	Aircraft Design Lab	50	25	75	0	0	3	2
	7ANU12	Finite Element Methods Lab	50	25	75	0	0	2	2
	7ANU13	Minor Project	50	25	75	0	0	2	2
	7ANU14	Practical Training	150	75	225	0	0	4	4
	7ANU20	Extra Curricular & Discipline	50		50	0	0	0	1
		Sub- Total	**600**	**650**	**1250**	**15**	**2**	**11**	**26**
VIII		**Option-A**							
	8ANU1.1	Aircraft Maintenance and Airport Management							
	8ANU1.2	Helicopter Engineering	50	100	150	3	0	0	3
	8ANU1.3	Turbomachinery							
	8ANU2.1	Rockets and Missiles							
	8ANU2.2	Non-destructive Testing	50	100	150	3	0	0	3
	8ANU2.3	Artificial Intelligence							
	8ANU3.1	Introduction to Avionics							
	8ANU3.2	Refrigeration and Air-Conditioning	50	100	150	3	0	0	3
	8ANU3.3	Viscous Flows							
	8ANU4X	MOOC							3
	8ANU13	Seminar	150	75	225	0	0	4	4
	8ANU14	Major Project	350	175	525	0	0	18	12

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8ANU20	Extra Curricular & Discipline	50		50	0	0	0	1
	Sub- Total	**700**	**550**	**1250**	**9**	**0**	**22**	**26**
	Option-B							(3)
8ANU4X	MOOC							
8ANU13	Seminar	150	75	225	0	0	4	4
8ANU14	Project-cum-Internship	500	475	975	0	0	36	21
8ANU20	Extra Curricular & Discipline	50		50	0	0		1
	Sub- Total	**700**	**550**	**1250**	**0**	**0**	**40**	**26**

(2)

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Syllabus of B. Tech. Aeronautical Engineering, 3rd Semester

Codes	Syllabus
3ANU1	**Advanced Engineering Mathematics-I**
	Laplace Transform: Definition and existence of Laplace transform, properties and formulae, unit step function, Dirac Delta function, Heaviside function; Inverse Laplace transform; Convolution theorem; Application of Laplace transform to ordinary differential equation. **Fourier Transform:** Fourier complex, sine and cosine transform, properties and formulae; Inverse Fourier transforms, Convolution theorem; Application of Fourier transforms to partial differential equation (1D heat and wave equations). **Z-Transform:**Definition, properties and formulae; Convolution theorem; Inverse Z-transform, application of Z-transform to difference equation. **Numerical Analysis:** Interpolation; Difference operators: forward, backward, central, shift and average operators; Newton's forward and backward interpolation formulae; Gauss's forward and backward interpolation formulae; Stirling's formula; Lagrange interpolation formula for unequal intervals; Inverse interpolation. **Numerical Differentiation:** Newton's, Gauss's and Stirling's formula. **Numerical Integration:** Trapezoidal Rule; Simpson's 1/3 and 3/8 rule. **Numerical Solution of ODEs of First Order:** Picard's method; Euler's method; Modified Euler's method; Runge-Kutta fourth order method; Milne's method. TEXT BOOKS:- 1. "Advanced Engineering Mathematics", R.K. Jain &S.R.K. Iyengar, Narosa Publications

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	2. "Advanced Engineering Mathematics", O'Neil, Cengage Learning India REFERENCE BOOKS:- 1. "Advanced Engineering Mathematics", E. Kreyszig, Wiley 2. "Advanced Engineering Mathematics", M. Greenberg, Pearson Education 3. "Advanced Engineering Mathematics", D.G.Zill& W.S. Wright, Jones & Bartlett India Private Limited 4. "Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education 5. "Engineering Mathematics", S. Pal & S.C. Bhuria, Oxford University Press
3ANU2	**Incompressible Fluid Mechanics**
	Fluid Properties: Concept of fluid and flow, ideal and real fluids, continuum concept;Pressure, density, temperature, viscosity, compressibility, specific heats,capillarity and surface tension; Newtonian and non-Newtonian fluids. **Fluid Statics:** Pascal's law;Hydrostatic equation, hydrostatic forces on submerged surfaces, barometer, manometer;Buoyancy. **Fluid Kinematics:** Eulerian and Lagrangian description of fluid flow; Streamline, streakline and path line, equation of streamline, different types of flows;Conservation of mass in a control volume;Differential equation of continuity; Acceleration, rotation and strain rate of a fluid particle. **Fluid Dynamics:** Linear and angular momentum conservation equation in integral form; Euler's equation; Bernoulli's equation;Conservation of energy; Flow measuring devices –pitot tube, venturimeter, orificemeter. **Viscous Flow:**Navier-Stokes equation, unidirectional flow between stationary and moving parallel plates, flow through pipes, Hagen-Poiseuillelaw;Reynolds number and its significance, laminar to turbulent transition, description of turbulent flow; Concept of boundary layer,boundary layer equations, displacement, momentum and energy thickness, boundary layer separation. **Dimensional Analysis:** Fundamental and derived units and dimensions;Dimensional homogeneity;Dimensional analysis using

	Rayleigh method andBuckingham-Π theorem,significance of dimensionless groups, important dimensionless numbers;Geometric, kinematic and dynamic similarity, model testing. TEXT BOOKS:- 1. "Fluid Mechanics", F.M. White, McGraw Hill Publishing Company Ltd. 2. "Fluid Mechanics: Fundamentals and Applications", Y.A. Cengel&J.M. Cimbala, McGraw Hill Education REFERENCE BOOKS:- 1. "Mechanics of Fluids", I.H. Shames, McGraw Hill Publishing Company Ltd. 2. "Fluid Mechanics", P.K. Kundu and I.M. Cohen, Academic Press 3. "Fluid Mechanics", J. F. Douglas, Pearson education 4. "Introduction to Fluid Mechanics", J.A. Fay, MIT Press 5. "Introduction to Fluid Dynamics", R.W. Fox, A.T. McDonald, P.J.Pritchand, McGraw Hill
3ANU3	**Engineering Thermodynamics**
	Basic concepts: Thermodynamic system and control volume,open,closed and isolated systems;Thermodynamic properties, state and path variables, processes and cycles; Temperature andzeroth law of thermodynamics;Quasi-static process; Equation of state of perfect gas, difference between gas & vapour. **First Law of Thermodynamics:** First law for a closed system undergoing a change of state, heat and work, mechanical and non-mechanical forms of work; Concept of internal energy of a system;Definitions of enthalpy and specific heats; First law applied to flow processes (control volume systems). **Second Law of Thermodynamics:** Kelvin-Plank andClausius statements, heat engines, refrigerator and heat pump;Reversible and irreversible processes, availability, irreversibility; Thermodynamic temperature scale;Introduction to entropy,principle of increase of entropy,Clausius inequality;Carnot cycle, efficiency of Carnot engine; Maxwell's relations.

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	Properties of Steam: Critical state, sensible heat, latent heat, saturated & superheated steam, wet steam, dryness fraction, internal energy of steam, Mollier chart; Work andheat transfer during various thermodynamics processes with steam as working fluid;Clausius-Clapeyron equation and Joule-Thomson coefficient. **Air Standard Cycles:**Otto cycle; Diesel cycle; Stirling and Ericsson cycles; Brayton cyclewith intercooling, reheat and regeneration. **Vapour Cycles:** Simple &modified Rankine cycle with reheat and regeneration. TEXT BOOKS:- 1. "Thermodynamics: An Engineering Approach", Y.A. Cengel&M.A. Boles, McGraw Hill Education 2. "Engineering Thermodynamics", P.K. Nag, McGraw Hill Education REFERENCE BOOKS:- 1. "Fundamentals of Classical Thermodynamics", G.J. Van Wylen and R.E. Sonntag, John Wiley& Sons 2. "Thermodynamics", W.C. Reynolds & H.C. Perkins, McGraw-Hill 3. "Engineering Thermodynamics: Work and Heat Transfer", G. Rogers and Y.Mayhew, Longman Scientific 4. "Fundamentals of Engineering Thermodynamics", M.J. Moran & H.N. Shapiro, John Wiley & Sons Inc. 5. "Fundamentals of Engineering Thermodynamics", E. Rathakrishnan, Prentice-Hall of India
3ANU4	**Engineering Mechanics**
	Statics of Particles and Rigid Bodies: Fundamental laws of mechanics, concept of particle and rigid body; Principle of transmissibility, system of forces, resultant force, resolution of forces; Moment and couples, Varignon'stheorem, resolution of a force into a force and a couple, free body diagram; Equilibrium, conditions for equilibrium, Lami's theorem. **Friction:** Types of Friction; Laws of friction, angle of friction, angle of repose; Ladder, wedge, belt friction; Belt Drive; Screw jack. **Centroid and Moment of Inertia:** Location of centroid and centre of gravity; Moment of inertia, parallel axis and

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	perpendicular axis theorem, radius of gyration, moment of inertia of composite section; Polar moment of inertia, moment of inertia of solid bodies. **Kinematics of Particles and Rigid Bodies**: Velocity, acceleration, types of motion; Equations of motion, rectangular components of velocity and acceleration, angular velocity and angular acceleration; Projectile motion; Relative motion. **Kinetics of Particles and Rigid Bodies:** Newton's laws, equation of motion in rectangular coordinates, radial and transverse components; Equation of motion in plane for a rigid body. **Work, Energy and Power**: Work done by a forceand couple; Power, efficiency; Energy, kinetic energy of rigid body; Principle of work and energy, conservative and non-conservative force, conservation of energy;D'Alembert principle. **Impulse and Momentum**: Linear and angular momentum; Linear and angular impulse; Principle of momentum conservation for a particle and rigid body; Principle of linear impulse and momentum for a particle and rigid body; Principle of angular momentum and impulse;Angular momentum of particles and rigid body, conservation of angular momentum. TEXT BOOKS:- 1. "Engineering Mechanics", D.P. Sharma. Pearson Education 2. "Engineering Mechanics", S. Timoshenko, D.H. Young, J.V. Rao & S.Pati, McGraw-Hill Education REFERENCE BOOKS:- 1. "Engineering Mechanics", R.C. Hibbeler, Pearson Education 2. "Vector Mechanics for Engineers: Statics & Dynamics", F.P. Beer,E.R. Johnston, P.J. Cornwell, B.P. Self, D.F. Mazurek & S.Sanghi, McGraw-Hill 3. "Engineering Mechanics: Statics and Dynamics", N.H. Dubey, McGraw-Hill Education 4. "Engineering Mechanics: Statics and Dynamics", I.H. Shames& G.K.M. Rao, Pearson Education 5. "Engineering Mechanics: Statics and Dynamics", Vela Murali,Oxford University Press
3ANU5	**Introduction to Aeronautics**
	History of Aviation: Brief history of flight vehicle development; Developments in aerodynamics, materials, structures and

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	propulsion over the years; Indian aerospace activities; Aerospace applications. **Aircraft Configurations:**Classification of aircraft; Functions of major components of airplane; Basic flight instruments, different types of air speeds. **Standard Atmosphere:** Physical properties and structure of atmosphere; Geometric and geopotential altitude; Standard atmosphere, variation of temperature, pressure and density;Pressure, density and temperature altitudes. **Basic Aerodynamics:** Introduction to principle of flight, streamlined and bluff bodies, laminar and turbulent flows,boundary layer separation and control;Lift, drag and moment, non-dimensional coefficients; Airfoil, airfoil geometry, flow over airfoil, centre of pressure and aerodynamic centre, airfoil nomenclature; Wings, wing geometry, flow over finite wing; Propagation of sound, different flight regimes, wave drag; Types of drag, methods to reduce drag. **Aircraft Structures:** Basic functions of aircraft structure; Principle types of construction;Constructional features of conventional aircraft; Use of metallic, non-metallic and composite materials; Introduction to landing gears. **Aerospace Propulsion:** Fundamental gas turbine cycle and propulsion techniques; Mechanism of thrust production in propellers and jet engines, comparative merits; Different types of aircraft engines; Principle of operation of rocket, rocket engine, exploration into space. **Fundamentals of Flight Mechanics:** Forces and moments on airplane, significance of L/D ratio,drag polar; High lift devices; Equations of motion; Steady level flight; Climbing flight,absolute and service ceilings; Gliding flight; Turning flight; Concepts of stability and control; Primary and secondary control surfaces; Longitudinal and lateral-directional stability and control. TEXT BOOKS:- 1. "Introduction to Flight", J.D. Anderson, McGraw Hill Education

	2. "Fundamentals of Flight", R.S.Shevell, Pearson Education REFERENCE BOOKS:- 1. "Flight without Formulae", A.C. Kermode, Pearson Education 2. "Understanding Flight", D. Anderson& S. Eberhardt, McGraw HillEducation 3. "The Airplane: A History of its Technology", J.D. Anderson, AIAA 4. "Flight: The Complete History of Aviation", R.G. Grant, DK Publishing 5. "Introduction to Aerospace Engineering with a Flight Test Perspective", Stephen Corda, Wiley-Blackwell
3ANU6	**Aircraft Materials Engineering**
	Atomic Structure of Metals: Bonding in solids, crystal structure, mechanical properties; Crystal lattice of BCC, FCC and HCP, crystallographic notation of atomic planes and directions (Miller Indices); Polymorphism and allotropy; Imperfections in crystals. **Theories of Plastic Deformation:** Phenomenon of slip, twinning, recovery, recrystallization and grain growth; Iron-carbon equilibrium diagram, phase transformation in the iron carbon diagram, TTT curves. **Heat Treatment Processes of Engineering Materials:** Principles and applications of annealing, normalizing, hardening, and tempering; Chemical heat treatment of steels: carburizing, nitriding, cyaniding, carbo-nitriding of steel. **Broad Classification of Engineering Materials:** Ferrous materials, nonferrous materials and alloys; Classification of steels; Maraging steels and super alloys, effects of alloying element on the structure and properties of steel,distribution of alloying elements (Si, Mn, Ni, Cr, Mo, Co, W, Ti, Al) in steel Ceramic materials; Fibre-reinforced composite materials and polymers.

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	Materials in Aircraft Constructions: Wood, aluminium, titanium, copperand magnesiumbased alloys, steels, composite materials, plastic, rubber; Adhesives; Surface finishes and paints. **Corrosion**: Detection and prevention; Protective coatings. **Testing:** Destructive and non-destructive testing techniques; Crack detection; Inspection of parts by hot oil and chalk, dye-penetrant, fluorescent and magnetic particles, X-ray, ultrasonic, eddy current and acoustic emission methods. TEXT BOOKS:- 1. "Aircraft Materials and Processes", George F. Titterton, Himalayan Books 2. "Materials Science and Engineering", William D. Callister Jr., David G. Rethwisch, John Wiley & Sons REFERENCE BOOKS:- 1. "Aircraft Materials and Analysis", Tariq Siddiqui, McGraw-Hill 2. "Aircraft Materials and Processes", Dorothy Kent, Shroff Publication 3. "Materials Science and Engineering: A First Course", V. Raghavan, PHI Learning Private Limited 4. "Material Science and Engineering", W.F. Smith, J. Hashemi & R. Prakash,McGraw Hill Education 5. "Materials for Engineering", W. Bolton, Newnes
3ANU11	**Object Oriented Programming Lab**
	• Use of functions, arrays, strings etc. • Use of nested loops in applications • Brief introduction to pointers and referencing • Defining class and objects; use of objects as function parameters; friend functions • Different types of inheritance • Constructors and destructors

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	• Function and operator overloading • Introduction to algorithms such as searching algorithms (linear search and binary search) and sorting algorithms TEXT BOOKS:- 1. "Object Oriented Programming with C++", E. Balagurusamy, McGraw Hill Education 2. "Let us C++", Y.P. Kanetkar, BPB Publications REFERENCE BOOKS:- 1. "Computer Science with C++ for Class XI",S. Arora, Dhanpat Rai Publications 2. "C/C++ Programmer's Reference", H.Schildt, McGraw-Hill Professional 3. "C++ Standard Library: A Tutorial and Reference", N.M. Josuttis, Addison-Wesley Professional 4. "C++ Programming Simplified", V.Thada, College Book Centre 5. "Object Oriented Programming in C++", Robert Lafore, Pearson Education India
3ANU12	**Fluid Mechanics Lab**
	• Calculation of meta-centric height for a given body • Verification of Bernoulli's theorem • Velocity measurement using Pitot-static tube • Calibration and flow rate determination using venturimeter and orificemeter • Characterization of flow through notches and weir • Determination of head loss in given length of pipe and calculation of friction factor • Demonstration of laminar, turbulent and transient flow in pipe and calculating the Reynolds number • Calculation of coefficient for minor losses in pipes due to sudden expansion and contraction • Measurement of velocity distribution in a pipe and calculation of discharge • Measurement of boundary layer velocity profile over a flat plate and to determine the boundary layer thickness

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	• Performance characteristics of centrifugal and reciprocating pump • Evaluation of performance of different types of turbines • Calculation of losses due to sudden expansion and contraction • Experiments on potential flow analogy (Hele-Shaw flow) • Smoke flow visualization over streamlined and bluff bodies • Study of features of vortex formed in a tube REFERENCE BOOKS:- 1. "Experiments in Fluid Mechanics", Sarbjit Singh, PHI Learning 2. "Laboratory Experiments in Fluid Mechanics", K.R. Arora, Standard Publications 3. "Fluid Mechanics and Machinery Laboratory Manual", N. Kumara Swamy, Charotar Publishing House Pvt. Ltd.
3ANU13	**Metrology Lab**
	• Study of various measuring tools like dial gauge, micrometer, VernierCalliper and telescopic gauges • Measurement of angle and width of a V-groove by using bevel protector • Measurement of angle by using sine bar • Measurement of gear tooth thickness by using gear tooth Vernier Calliper • To measure a gap by using slip gauges • To check accuracy of gear profile with the help of profile projector • To determine the effective diameter of external thread by using three-wire method • Study and use of surface roughness instrument • To check the accuracy of a ground, machined and lapped surface
3ANU14	**Professional Communication Lab**
	Students should be acquainted with the basic skills of professional communication such as:-

	• Writing formal applications • Email writing • Professional telephonic conversation • Preparing and giving presentations • Resume making • Group discussions • Personal interviews • Importance of body language in communication
3ANU20	**Extra-Curricular and Discipline**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 4th Semester

Codes	Syllabus
4ANU1	**Advanced Engineering Mathematics – II**
	Complex Analysis: Differentiability and Analytic functions; Cauchy-Riemann equations (Cartesian and Polar forms), harmonic functions; Conformal mapping; Complex Line integral, M-L inequality; Cauchy theorem, Cauchy integral formulae; Taylor series and Laurent series, Singularities and Zeros, residues at poles and infinity, residues at isolated essential singular point; Cauchy residue theorem, evaluation of real definite integrals and improper integrals. **Special Functions**: Legendre's function, generating function, simple recurrence relations, orthogonal property; Bessel's functions of first and second kind, generating function, simple recurrence relations, orthogonal property. **Statistics & Probability**: Basic concepts of probability, conditional probability; Baye's theorem; Random variable and distributions: Discrete and continuous random variables, moments, expectation, moment generating function; Binomial, Poisson and normal distribution. TEXT BOOKS:- 1. "Advanced Engineering Mathematics", R.K. Jain & S.R.K. Iyengar, Narosa Publications 2. "Introduction to Probability and Statistics", S. Lipschutz& J.J. Schiller, McGraw Hill Education REFERENCE BOOKS:- 1. "Advanced Engineering Mathematics", I. Kreyszig, Wiley India 2. "Advanced Engineering Mathematics", D. Zill& W. Wright, Jones & Bartlett India Private Limited 3. "Complex Variables and Applications", J.W. Brown & R.V. Churchill, McGraw Hill Education 4. "Probability and Statistics", M. Spiegel, J. Schiller & R.A. Srinivasan, McGraw Hill Education

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	5. "Higher Engineering Mathematics", B.V. Ramana, McGraw Hill Education
4ANU2	**Aerodynamics – I**
	BasicFluid Mechanics Concepts: Streamfunction;Vorticity, circulation, relation between circulation and vorticity; Kelvin's theorem; Helmholtz theorems. **Potential Flow:** Velocity potential; Laplacian flow, principle of superposition; Elementary flows: uniform flow, source, sink, vortex & doublet;Potential flow past stationary and rotating circular cylinder, d'Alembert paradox, Magnus effect;Kutta-Joukowski theorem; Blasius theorem. **Flow overAirfoils:** Airfoil geometry, angle of attack, sectional forces and moment coefficients, centre of pressure and aerodynamic centre;Kutta condition; Introduction to conformal mapping, Kutta-Joukowski transformation; Thin Airfoil Theory, Theodorsen's condition;Real flow effects, effect of angle of attack on pressure distribution, airfoil stall, profile drag. **Flow over Finite Wings:**Wing geometry, forces and moment coefficients;Wingtip vortices, downwash, induced drag; Lifting Line Theory and its limitations, elliptical and general lift distribution;Simplified horseshoe vortex;Qualitative discussion of flow over delta wings. **Experimental Aerodynamics:**Types and components of subsonic wind tunnel, flow quality; Correlation of experimental results to actual prototypes; Flow visualization techniques; Instrumentation for pressure, velocity and force measurement. TEXT BOOKS:- 1. "Fundamentals of Aerodynamics", J.D. Anderson, McGraw-Hill Higher Education 2. "Aerodynamics for Engineering Students", E.L. Houghton, P.W. Carpenter, S. Collicott& D. Valentine, Elsevier REFERENCE BOOKS:-

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	1. "Aerodynamics for Engineers", J.J. Bertin&R.M. Cummings, Pearson Education India 2. "Theoretical Aerodynamics",E. Rathakrishnan, John Wiley & Sons 3. "Basic Aerodynamics: Incompressible Flow", G.A. Randro, H.M. Macmohan&R.L. Roach, Cambridge University Press 4. "Low Speed Aerodynamics", K. Ghosh, PHI Learning 5. "Flight Vehicle Aerodynamics", M. Drela, MIT Press
4ANU3	**Mechanics of Solids**
	Introduction: Concept of stress, normal stress and shear stress, stress tensor; Concept of strain, normal strain and shear strain, strain tensor; Stress-strain diagrams, Hooke's law, Modulus of elasticity, Poisson's ratio, bulk modulus, modulus of rigidity; Different types of loadings and sectional resultants, thermal stresses. **Transformation of Stress and Strain:** Mohr's circle for stress and strain; Principal stresses, maximum shearing stress, plane stress and plane strain; Stresses in thick and thin-walled pressure vessels. **Stresses in Beams:** Shear force and bending moment diagrams for simply supported and cantilever beams with concentrated, uniformly distributed and variable loads; Theory of pure bending, bending stress variation in cross-section; Transverse shear stress and its distribution in different sections; Composite beam. **Deflection of Beams:** Deflection in simply supported beams and cantilever with concentrated loads, uniformly distributed loads and their combination. **Columns:**Buckling of columns, Euler's formula for pin-ended columns and its extension to columns with other end conditions. **Torsion:**Stresses and deformation in circular and hollows shafts, angle of twist; Torsion in composite shafts; Saint-Venant's theorem.

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	TEXT BOOKS:- 1. "An Introduction to the Mechanics of Solids", S.H. Crandall, N.C. Dahl, T.J. Lardner & M.S. Sivakumar, McGraw-Hill 2. "Fundamentals of Solid Mechanics: A Treatise on Strength of Materials", M.L. Gambhir, PHI Learning REFERENCE BOOKS:- 1. "Mechanics of Materials", S.P. Timoshenko & J.M. Gere, CBS Publishers 2. "Mechanics of Materials", Beer, Johnston, Dewolf& Mazurek, Tata McGraw Hill 3. "Strength of Materials", Sadhu Singh, Khanna Publishers 4. "Mechanics of Materials", R.C. Hibbeler, Pearson 5. "Mechanics of Solids", T.J. Lardner & R.R. Archer, McGraw-Hill College
4ANU4	**Heat Transfer**
	Introduction: Definitions of heat and heat transfer, difference between heat transfer and thermodynamics; Basic modes of heat transfer, engineering applications of heat transfer. **Conduction:** Fourier's law of heat conduction, heat conduction equation for homogeneous isotropic materials in different coordinate systems, significance of thermal diffusivity;Simple one-dimensional steady heat conduction, electrical analogy of heat transfer, critical thickness of insulation; Analysis of fins having variable and constant cross-sectional area, fin efficiency and fin effectiveness; Unsteady heat conduction,lumped systems, Biot number and its physical implication. **Convection:**Natural and forced convection, local and average heat transfer coefficients, Nusselt number, Grashof number; Steady laminar free convection from an isothermal vertical plate; Forced convection over a flat plate, momentum and thermal boundary layer, Prandtl number and its range for various fluids. **Thermal Radiation:** Radiation characteristics, Planck's law; Stefan-Boltzmann law; Wien's displacement law; Absorptivity,

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	reflectivity and transmissivity, definition of black, gray& diffuse surfaces; Kirchhoff's law; View Factor, reciprocity theorem. **Boiling and Condensation:** Pool boiling, saturated pool boiling curve, critical heat flux correlation; Dropwise and film condensation, laminar film condensation on a vertical plate. **Heat Exchangers:** Parallel flow & counter-flow heat exchangers; LMTD andNTU method, effectiveness of heat exchangers. TEXT BOOKS:- 1. "Heat Transfer", J.P. Holman & S. Bhattacharyya, McGraw Hill Education 2. "Principles of Heat and Mass Transfer", F.P. Incropera, D.P. Dewitt, T.L. Bergman & A.S. Lavine, Wiley India REFERENCE BOOKS:- 1. "Principles of Heat Transfer", F. Kreith, R.M. Manglik& M.S. Bohn, 2. "Heat and Mass Transfer: Fundamentals and Applications", Y.A Cengel& A.J. Ghajar, McGraw-Hill Education 3. "Heat and Mass Transfer", P.K Nag, McGraw Hill Education 4. "Heat Transfer", P.S. Ghoshdastidar, Oxford University Press 5. "Introduction to Heat Transfer", S.K. Som, Prentice Hall India Learning Private Limited
4ANU5	**Elements of Vibration**
	Basics of Vibration: Scope of vibration, important terminology and classification; Vectorial representation, complex number representation. **Undamped Free Vibrations of Single Degree of Freedom System:** Derivation of equation of motion for one-dimensional longitudinal, transverse and torsional undamped vibrations using Newton's second law; D' Alembert's principle and principle of conservation of energy; Compound pendulum and centre of percussion. **Damped Free Vibrations of Single Degree of Freedom System:** Viscous damping;Underdamped, critically damped and

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	overdamped systems, damping ratio, logarithmic decrement; Vibration characteristics of Coulomb damping and Hysteretic damping. **Forced Vibrations of Single Degree of Freedom System:** Forced vibration with constant harmonic excitation, steady state and transient parts, transmissibility; Frequency response curves and phase response curve. **System with Two Degrees of Freedom:** Principle modes of vibration, mode shapes; Undamped free and forced vibrations of two degrees of freedom system with harmonic excitation; Vibration absorber. **Vibrations of Continuous Systems:** Introduction to multiple degree of freedom systems; Transverse vibration of a string; Longitudinal vibration of a bar; Torsional vibration of a shaft and flexural vibrations of a beam. TEXT BOOKS:- 1. "Mechanical Vibrations", S.S Rao, Pearson Education 2. "Elements of Vibration Analysis", L. Meirovitch, McGraw-Hill REFERENCE BOOKS:- 1. "Mechanical Vibrations", R. Venkatachalam, Prentice Hall India Learning Private Limited 2. "Mechanical Vibrations: Theory and Applications", Kelly, S.G., Cengage Learning 3. "Theory of Vibrations with Applications", W.T. Thomson, M.D. Dahleh& C. Padmanabhan, Pearson Education 4. "Principles of Vibration", B.H Tongue, Oxford Publication 5. "Mechanical Vibrations", W.J. Palm III, Wiley
4ANU6	**Manufacturing Processes**
	Introduction: Importance of manufacturing, survey of manufacturing processes.

	Foundry: Casting process, patterns, moulds,core & core prints; Gating system; Casting defects. **Metal Joining Processes:** Principle of welding, soldering, brazing and adhesive bonding; Arc welding, TIG, MIG; Gas welding and cutting; Thermite welding; Resistance welding; Spot, projection & seam welding; Introduction to atomic hydrogen, ultrasonic, plasma, laser and electron beam welding; Friction and explosive welding; Welding defects. **Forming and Shaping Processes:** Metal working, elastic and plastic deformation, concept of strain hardening, hot and cold working; Rolling principle and operations; Forging; Extrusion; Cold working processes— shearing, drawing, squeezing, blanking, piercing, deep drawing, coining & embossing, riveting, thread rolling, bending; Metal working defects. **Machining:** Classification of metal removal processes, chip formation; Principle of working and common operations on Lathemachine, shaper machine, milling machine, drilling machine, cylindrical grinding machine; Basics of CNC machining; General principles and applications of abrasive jet machining, ultrasonic machining, electric discharge machining, electro-chemical machining, plasma arc machining, electron beam machining and laser beam machining. **Powder Metallurgy:** Methods of powder manufacturing; Properties of metal powders; Compacting; Sintering; Applications of powder manufacturing, advantages and limitations of powder manufacturing. **Rapid Prototyping Operations:** Additive & subtractive processes; Introduction to different additive manufacturing processes; Virtual Prototyping. **Plastic Technology:** General properties of plastics, classification of plastics; Ingredients of moulding compounds; Introduction to different plastic part manufacturing processes. TEXT BOOKS:- 1. "Manufacturing Technology", P.N. Rao, Tata McGraw Hill 2. "Manufacturing Processes for Engineering Materials", S. Kalpakjian& S.R. Schmid, Pearson Education

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	REFERENCE BOOKS:- 1. "Manufacturing Science", A. Ghosh & A.K. Mallik, Pearson India 2. "Introduction to Manufacturing Processes", John A. Schey, McGraw-Hill Education 3. "Elements of Manufacturing Processes", B.S. Nagendra Parashar & R.K. Mittal, PHI Learning Private Limited 4. "Manufacturing Processes", J.P. Kaushish, Prentice Hall India Learning Private Limited 5. "A Textbook of Production Technology", P.C. Sharma, S. Chand
4ANU11	**Aerodynamics Lab**
	• Study of components of subsonic wind tunnel • Calibration of wind tunnel test section • Measurement of pressure distribution over smooth and rough cylinder • Measurement of pressure distribution over symmetric and cambered airfoils • Force measurement using strain gauge balance over models of different shapes • Flow visualization of flow over a delta wing at different incidences • Assessment of effect of streamlining on reduction of drag • Smoke flow visualization over airfoil and cylinder • Boundary layer measurements over flat plate • Calculation of displacement thickness over airfoil at different locations • Calibration of hot wire anemometer and freestream turbulence measurement • Use of pressure sensors for pressure measurement • Study of velocity measurement using LDV & PIV • Characterization of subsonic jets TEXT BOOKS:-

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	1. "Instruments, Measurements and Experiments in Fluids", E. Rathakrishnan 2. "Low-Speed Wind Tunnel Testing", J.W. Barlow, W.H. Rae & Alan Pope, John Wiley & Sons REFERENCE BOOKS:- 1. "Fluid Mechanics Measurements", R. Goldstein, CRC Press 2. "Experimental Aerodynamics", S. Discetti& A. Ianiro, CRC Press 3. "Experiments in Aerodynamics", S.P. Langley, Hardpress Publishing 4. "Aerodynamic Measurements: From Physical Principles to Turnkey Instrumentation", G.P. Russo, Woodhead Publishing 5. "Theoretical and Experimental Aerodynamics", M. Kaushik, Springer
4ANU12	**Manufacturing Process Lab**
	<u>Machine Shop</u> • Study of centre, capstan and automatic lathes and their accessories • Plane turning and step turning • Taper turning, knurling and chamfering • Thread cutting and grooving • Drilling and boring • Study of shaper machine and its mechanism • Study of milling machine, milling cutters, indexing heads and indexing methods and to prepare a gear on milling machine • Study of single point cutting tool geometry and to grind the tool as per given geometry **<u>Foundry Shop</u>** • Preparation of mould using given pattern requiring core and prepare a casting usingaluminium • Moisture test and clay content test • Strength test (compressive, tensile, shear transverse etc. in green and dry conditions)

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	• Permeability test • A.F.S. sieve analysis test **<u>Welding Shop</u>** • Hands-on practice on electric-arc welding • Demonstration of oxy-acetylene gas welding • Study of metal inert gas welding (MIG) and tungsten inert gas welding (TIG) REFERENCE BOOKS:- 1. "Mechanical Workshop Practice", K.C. John, Prentice Hall India Learning Private Limited 2. "Workshop Practice", Swarn Singh, S.K. Kataria& Sons 3. "Elements of Workshop Technology", S.K. Hajra Choudhury &Nirjhar Roy,Media Promoters & Publishers Pvt. Ltd. 4. "A Textbook of Workshop Technology", D. Dhounchak& L.K. Biban, White Falcon Publishing 5. "Workshop Practice",H.S. Bawa, McGraw Hill Education
4ANU13	**Heat Transfer Lab**
	• Calculation of thermal conductivity of insulating powders in spherical cavity • Determination of thermal conductivity of a metal rod • Calculation of total thermal resistance of the given compound resistance in series • To determine the heat transfer rate and temperature distribution for a pin fin • To determine the surface heat transfer coefficient for heated vertical cylinder in natural convection • To find the heat transfer coefficient in forced convection in a tube • Study and comparison of LMTD and effectiveness in parallel and counter flow heat exchangers • Determination of heat transfer coefficient in dropwise and filmwise condensation • Determination of critical heat flux in saturated pool boiling

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	• Measurement of emissivity of the test plate surface • Evaluation of Stefan-Boltzmann constant for radiative heat transfer
4ANU14	**Programming in MATLAB**
	• Basics of MATLAB computer programming • Use of formulae and inbuilt functions • MATLAB scripts and functions (m-files) • Loops and nested loops • Array, vector and matrices • Plotting functions and vector plots • Solving differential equations using MATLAB • Reading and writing data, file handling • Using MATLAB toolboxes • MATLAB graphic functions TEXT BOOKS:- 1. "Getting Started with MATLAB: A Quick Introduction for Scientists & Engineers", R. Pratap, Oxford 2. "MATLAB for Beginners: A Gentle Approach", P.I. Kattan, P.I. Kattan REFERENCE BOOKS:- 1. "MATLAB For Dummies", J. Sizemore, John Wiley & Sons 2. "Modeling and Simulation using MATLAB – Simulink", S. Jain, Wiley 3. "MATLAB Programming for Engineers", S.J. Chapman, Cengage 4. "Essential MATLAB for Engineers and Scientists", B. Hahn, D.T. Valentine, Academic Press

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	5. “MATLAB: An Introduction with Applications”, A. Gilet, Wiley
4ANU20	**Extra-Curricular&Discipline**
	As per UD, RTU norms

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Syllabus of B.Tech. Aeronautical Engineering, 5th Semester

Codes	Syllabus
5ANU1	**Aerodynamics – II**
	Basic Concepts: Compressibility; Laws of thermodynamics, perfect gas; Mach number, shock and Mach waves; Governing equations for compressible flows. **Steady One-Dimensional Isentropic Flow:** Continuity, momentum and energy conservation equations; Stagnation temperature and pressure; Expression for speed of sound; Normal shock, Rayleigh flow, Fanno flow. **QuasiOne-Dimensional Flows:** Governing equations; Area-velocity relations; Isentropic flow through variable-area ducts, convergent-divergent (or De Laval) nozzles, over-expanded and under-expanded nozzles, diffusers. **Two-Dimensional Flows:** Oblique shock wave and its governing equations, θ-B-M relations, attached and detached shock; Expansion waves, Prandtl-Meyer flow and its governing equations, Supersonic flow over convex and concave corners. **Airfoils in Compressible flow:** Critical Mach number and critical pressure coefficient, drag divergence Mach number; Shock boundary layer interaction; Whitecomb area rule, supercritical airfoil, swept and delta wings, supersonic aerofoils, wave drag; Similarity rules. **Experiments in Compressible Flow:** Transonic, supersonic and hypersonic tunnels and their peculiarities; Blowdown, indraft and continuous wind tunnels; Shock tubes; Optical methods of flow visualization. TEXT BOOKS:- 1. "Modern Compressible Flow", John D. Anderson Jr., McGraw Hill 2. "Gas Dynamics", E. Rathakrishnan, Prentice Hall of India Pvt. Ltd.

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	REFERENCE BOOKS:- 1. "Compressible Fluid Dynamics", P. A. Thomson, McGraw-Hill 2. "Elements of Gas Dynamics", H. W. Liepmann & A. Roshko, Wiley & sons 3. "Fundamentals of Compressible Flow with Aircraft and Rocket Propulsion", S. M. Yahya, Wiley Eastern Ltd. 4. "Compressible Fluid Flow", P. H. Oosthuizen & W.E. Carscallen, McGraw-Hill 5. "Instruments, Measurements and Experiments in Fluids", E. Rathakrishnan
5ANU2	**Aircraft Structure - I**
	Introduction: Features of aircraft structures, monocoque and semi-monocoque structures, idealization, nomenclature & layout, functions; Static equilibrium, statically determinate and indeterminate structures; Concept of static stability. **Statically Determinate Structures:** Analysis of framed structures; Planar truss analysis: method of joints, method of sections, method of moments; Space truss analysis: 3d truss tension coefficients. **Statically Indeterminate Structures:** Degree of indeterminacy; Bending & tension of fixed beams, composite beam, stress resultants, modulus weighted section properties; Clapeyron's three moment equation;Moment distribution method. **Deformations due to Loading:** Differential equation of the elastic curve due to composite loading, double integration and moment area methods; Conjugate beam method; Macaulay's method; Principle of superposition. **Energy Methods:** Work and energy principles, strain energy and complementary strain energy; Principal of virtual work, Principal of virtual displacement; Maxwell's Reciprocal theorem; Potential and complementary potential theorems; Castigliano's theorem, unit load method, application of energy principles in analysis of determinate and indeterminate structures. **Columns:** Euler's column curve, elastic buckling; Use of energy methods; Beam-columns. **Failure Theories:** Maximum principle stress theory; Maximum principle strain theory; Distortion Theory; Maximum

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	strain energy theory;Octahedral shear stress theory. **Induced Stresses:** Thermal stresses; Impact loading;Fatigue; Creep; Stress Relaxation. TEXT BOOKS:- 1. "Aircraft Structures for Engineering Students", T.H.G. Megson, Butterworth-Heinemann 2. "Analysis of Aircraft Structures: An Introduction", B.K. Donaldson, Cambridge University Press REFERENCE BOOKS:- 1. "Theory and Analysis of Flight Structures", R.M. Rivello, McGraw-Hill 2. "Introduction to Aerospace Structural Analysis", D.H. Allen & W.E. Haisler, John Wiley & Sons 3. "Aircraft Structures", D.J. Peery, Dover Publications Inc. 4. "Understanding Aircraft Structures", J. Cutler & J. Liber, Wiley-Blackwell 5. "Fundamentals Of Aircraft Structural Analysis", H.D. Curtis, McGraw-Hill Higher Education
5ANU3	**Aircraft Performance**
	Atmosphere: Need to define standard atmosphere; International Standard Atmosphere; Stability of atmosphere; Equivalent, calibrated and indicated airspeed; Primary flight instruments. **Aerodynamic Characteristics:** Forces and moments acting on a flight vehicle, variation of aerodynamic coefficients with angle of attack, Reynolds number and Mach number; Effect of aspect ratio, planform, sweep, taper and twist on aerodynamic characteristics; Different types of drag, drag polar, design methods to reduce drag; Variation of thrust, power and SFC with velocity and altitudes for air-breathing engines. **Steady Level Flight:** Equations of motion; Thrust and power required for level unaccelerated flight; Maximum thrust and power available for jet engine and propeller engine, variation of thrust/power available and required with altitude;Maximum level flight speed, conditions for minimum drag and minimum power required; Stalling speed; Range

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	and endurance of jet and propeller engine airplanes; Condition for maximum range and endurance, effect of altitude, weight and wind. **Climbing Flight:** Unaccelearated climb; Excess power; Maximum rate of climb and steepest angle of climb, time to climb, climb hodograph; Absolute and service ceilings; Accelerated rate of climb, energy approach; Energy manoeuvrability. **Gliding Flight:** Steady descent, equilibrium glide angle, equilibrium glide velocity; Minimum rate of sink and shallowest angle of glide, maximum gliding range; Glide hodograph. **Take-off & Landing Performance:** Equations of motion during take-off and landing; Estimation of take-off and landing distances; Effect of head, tail and cross winds; Auxiliary systems: thrust augmentation, reverse thrust, jet assisted take-off system, spoilers. **Manoeuvring Flight:** Level coordinated turning flight in horizontal plane, bank angle, load factor, V-n diagram; Minimum turn radius; Maximum sustained and attained turn rate; Turn in vertical plane, pull-up and pull-down manoeuvres. **High Lift Devices:** Different types of trailing edge flaps, leading edge devices, boundary layer control, powered lift. TEXT BOOKS:- 1. "Aircraft Performance and Design", J.D. Anderson Jr., McGraw Hill 2. "Aircraft Performance", W.A. Mair & D.L. Birdsall, Cambridge University Press REFERENCE BOOKS:- 1. "Aircraft Performance", M. Saarlas, John Wiley & Sons 2. "Fundamentals of Flight", R.S. Shevell, Pearson Education Limited

	3. "Airplane Aerodynamics and Performance", Jan Roskam & Chuan-Tau Edward Lan, DAR Corporation 4. "Aircraft Performance: An Engineering Approach", M.H. Sadraey, CRC Press 5. "Flight Performance of Aircraft", S.K. Ojha, AIAA Education Series
5ANU4	**Aircraft Systems**
	Airplane Control Systems: Conventional Systems; Push pull rod system and its components; Types of flight control systems; Modern control systems, Digital fly by wire systems; Auto pilot system Technology; Introduction to Communication and Navigation systems; Instrument landing Systems, VHF Omnidirectional range. **Hydraulic Systems:** Components; Hydraulic system working, modes of operation; Pneumatic systems, components, working principles & advantages. **Landing Gear Systems:** Classification, indications, shock absorbers, landing gear extension and retraction mechanism; Anti-skid system, wheels and brake, steering systems. **Fuel Systems:** Types of fuels, their properties and testing, colour codes, Pumps, Types of fuel systems, indications and warnings; Inflight refuelling; Aircraft fuel jettison system. **Miscellaneous Systems:**Components and operation of air-conditioning system; Pressurization system; Oxygen systems; Fire protection systems; De-icing and anti-icing systems; Seat safety system: Ejection system. **General Maintenance Practices:** Jacking, levelling and mooring, refueling and defueling of aircraft, safety precautions; Hydraulic and fluid systems precautions against contamination; Identification colour coding, symbols and other markings to identify the fluid systems. TEXT BOOKS:- 1. "Aircraft Systems: Mechanical, Electrical and Avionics Subsystems Integration", I. Moir & A. Seabridge, Wiley-

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	Blackwell 2. "Aircraft Systems", D.A. Lombardo, McGraw Hill REFERENCE BOOKS:- 1. "Aircraft Instruments", E.H.J. Pallett, Pearson Education 2. "Aircraft Instrumentation and Systems", S. Nagabhushana, I.K. International Private Limited 3. "Aircraft Structures and Systems", Ray Wilkinson, Mechaero Publishing 4. "Aircraft Display Systems", M. Jukes, AIAA 5. "Aircraft Electrical Systems, Hydraulic Systems and Instruments", R.H. Drake, Sportsman's Vintage Press
5ANU5.1	**Machine Design**
	Materials: Mechanical Properties; Selection of material from properties and economic aspects. **Manufacturing Considerations**: Standardization, interchangeability, limits, fits, tolerances and surface roughness, BIS. **Design for Strength:** Allowable stresses, detailed discussion on factor of safety; Introduction of various design considerations like strength, stiffness, weight, cost, space etc.; Modes of failure, strength and stiffness considerations; Stress concentration, causes and mitigation. **Design of Members in Bending:** Beams, levers. **Design of Members in Torsion**: Shafts and shaft couplings, design of keys. **Design of Bearing:** Bearing classification, Methods of lubrication, hydrodynamic, hydrostatic, boundary etc.; Journal bearing, minimum film thickness, Sommerfield number, thermal equilibrium; Selection of anti-friction bearings for different load cycles, bearing life, static & dynamic load carrying capacity. **Fatigue Considerations in Design:** Variable load, loading pattern, endurance stresses; Influence of size, surface finish,

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	notch sensitivity and stress concentration; Goodman line, Soderberg line & Gerber line; Design of machine members subjected to combined, steady and alternating stresses; design of shafts under variable stresses, bolts subjected to variable stresses. TEXT BOOKS:- 1. "Design of Machine Elements", V.B. Bhandari, McGraw Hill Education 2. "Shigley's Mechanical Engineering Design", R.G. Budynas & J.K. Nisbett, McGraw Hill Education REFERENCE BOOKS:- 1. "Analysis and Design of Machine Elements", V.K. Jadon & S. Verma, I.K. International Publishing House Pvt. Ltd. 2. "A Text Book of Machine Design", A. Karwa, Laxmi Publication 3. "Machine Design", Hall, Holwenko & Laughlin, Schaum's Outlines Series, McGraw Hill 4. "Mechanical Machine Design", Bahl & Goel, Standard Publishers Distributors 5. "A Textbook of Machine Design", R.S. Khurmi & J.K. Gupta, S. Chand
5ANU5.2	**Experiments in Fluid Mechanics**
	Basic Concepts: Objective and importance of experimental studies; Properties of fluids, measuring instruments; Principle of similitude; Components of measuring systems. **Experimental Setup:** Low speed wind tunnel, high speed wind tunnel, special problems of testing in subsonic, transonic, supersonic and hypersonic speed regions; Water tunnel, towing tank; Effect of Reynolds number and freestream turbulence; Instrumentation and calibration. **Flow Visualization Techniques:** Smoke tunnel; Surface oil flow, tuft visualization; Dye injection techniques; Hele-Shaw

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	apparatus; Interferometer; Shadowgraph; Schlieren system. **Pressure Measurement:** Pitot static tube; Manometer; Pressure transducers; Pressure Sensitive Paints. **Velocity Measurement:** Hot-wire and hot-film anemometry; Laser Doppler Velocimetry; Particle Image Velocimetry. **Temperature Measurement:** Thermometer; Thermocouple; Thermistor. **Force measurement:** Different types of balances, internal and external balances; Balance calibration. **Data Acquisition andSignal Conditioning:** Data acquisition principle; Static and dynamic response of measuring systems; Analogue to digital conversion; Multiplexing; Types of signals; Fourier Analysis; Analysis of periodic signals. **Uncertainty Analysis:** Types of measurement error, error estimation; Error analysis and uncertainty propagation. TEXT BOOKS:- 1. "Instrumentation, Measurements, and Experiments in Fluids", E. Rathakrishnan, CRC Press 2. "Fluid Mechanics Measurements", R. Goldstein, CRC Press REFERENCE BOOKS:- 1. "Measurement in Fluid Mechanics", S. Tavoularis, Cambridge University Press 2. "Springer Handbook of Experimental Fluid Mechanics", C. Tropea, A. Yarin & J.F. Foss, Springer 3. "Introduction to Instrumentation and Measurements", R.B. Northrop, CRC Press
5ANU5.3	**Introduction to Robotics**
	Introduction: Brief history, types, classification and usage; Science and technology of robots. **Elements of Robots**: Joints, links, actuators and sensors; Position and orientation of a rigid body; Homogeneous

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	transformations; Representation of joints; Different kinds of actuators: stepper, DC servo and brushless motors; Types of transmissions; Purpose of sensors, internal and external sensors; Common sensors: encoders, tachometers, strain gauge based force-torque sensors, proximity and distance measuring sensors and vision. **Kinematics of Serial Robots:** Introduction, direct and inverse kinematics problems; Examples of kinematics of common serial manipulators, workspace of a serial robot; Inverse kinematics of constrained and redundant robots; Simulations and experiments. **Kinematics of Parallel Robots:** Degrees of freedom of parallel mechanisms and manipulators, active and passive joints; Constraint and loop-closure equations, direct kinematics problem, mobility of parallel manipulators, closed-form and numerical solution; Inverse kinematics of parallel manipulators and mechanisms. **Statics and Kinematics of Robot Manipulators:** Linear and angular velocity of links, velocity propagation; Manipulator Jacobians for serial and parallel manipulators; Velocity ellipse and ellipsoids; Singularity analysis for serial and parallel manipulators, loss and gain of degree of freedom; Statics of serial and parallel manipulators. **Dynamics of Serial and Parallel Robots:** Mass and inertia of links; Lagrangian formulation for equations of motion for serial and parallel manipulators; Generation of symbolic equations of motion using a computer; Simulation (direct and inverse) of dynamic equations of motion, examples of a planar 2R and four-bar mechanism; Recursive dynamics. **Motion Planning and Control:** Joint and Cartesian space trajectory planning and generation; Classical control concepts using the example of control of a single link; Independent joint PID control, control of a multi-link manipulator, Simulation and experimental case studies on serial and parallel manipulators; Control of constrained manipulators, Cartesian control, force control and hybrid position/force control. TEXT BOOKS:- 1. "Robotics: Fundamental Concepts and Analysis", A. Ghosal, Oxford University Press

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	2. "Introduction to Robotics: Analysis, Control, Applications", S.B.Niku, Wiley REFERENCE BOOKS:- 1. "Introduction to Robotics: Mechanics and Control", J.J. Craig, Pearson 2. "Introduction to Robotics", S.K. Saha, McGraw-Hill 3. "Elements of Robotics", M. Ben-Ari & F. Mondada, Springer 4. "Robotics: Fundamental Concepts and Analysis", Ashitava Ghosal, Oxford 5. "Introduction to Robotics: Mechanics and Control", J.J. Craig, Pearson Education India
5ANU6.1	**Digital Electronics**
	Introduction: Flight instruments, cockpit layouts; Number systems: decimal, binary, octal, hexadecimal, standard code. **Data conversion and buses**: Analog to digital, digital to analog conversion; Bus system, ARINC 429, bus standards. **Logic Circuits**: Logic circuit, Boolean algebra, combinational, tri state, mono stable, bi-stable, logic families. **Computer system:** Computer system, data representation, data storage, program and software, backplane bus system, example of aircraft computer system. **Integrated circuits and MSI logic**: scale of integration, fabrication, packaging and pin numbering, fan –in and fan-out, coding system, decodes, encodes, multiplexers. **Large scale logic system and VHDL**: Hardware description language, entity declaration, behavioural declaration, VHDL design flow, program structure, signal mode and type, operators, simulations and test bench, timing. TEXT BOOK:- 1. "Aircraft Digital Electronic and Computer Systems", M. Tooley, Routledge publications.

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	REFERENCE BOOKS:- 1. "Modern Digital Electronics", R. P. Jain, McGraw Hill Education 2. "Digital logic and Computer design", M. M. Mano, Pearson Education India 3. "Fundamentals of Digital Circuits", A. Kumar, Prentice Hall India
5ANU6.2	**Experimental Stress Analysis**
	Measurements: Principles of measurements; Accuracy, sensitivity and range of measurements. **Extensometers and Displacement Sensors:** Mechanical, optical, acoustical and electrical extensometers and their uses, advantages and disadvantages; Capacitance gauges; Laser displacement sensors. **Electrical Resistance Strain Gauges:** Principle of operation; Types of strain gauges; Materials for strain gauges, strain gauge adhesives;Gauge sensitivity and gauge factor; Calibration and temperature compensation; Wheatstone bridge and potentiometer circuits for static and dynamic strain measurements; Load cells; Data acquisition. **Photoelasticity**: Two-dimensional photoelasticity, photoelastic materials; Photoelastic effects; Stress optic law; Transmission photoelasticity; Plane and circular polariscopes, interpretation of fringe pattern; Calibration of photoelastic materials; Introduction to three-dimensional photoelasticity. **Brittle Coating and Moire Techniques:** Relation between stresses in coating and specimen, use of failure theories in brittle coating; Moire method of strain analysis. **Non-Destructive Testing:** Fundamentals of NDT; Acoustic Emission Technique; Radiography; Thermography; Ultrasonic testing; Eddy Current testing; Fluorescent penetrant testing. TEXT BOOKS:- 1. "Experimental Stress Analysis", J.W. Dally & W.F. Riley, McGraw Hill Inc. 2. "Elements of Experimental Stress Analysis", A. W. Hendry, Elsevier

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	REFERENCE BOOKS:- 1. "Experimental Stress Analysis", U.C. Jindal, Pearson India 2. "Experimental Stress Analysis: Principles and Methods", G.S. Holister, Cambridge University Press 3. "Experimental Stress Analysis", Sadhu Singh, Khanna Publishers 4. "Handbook of Experimental Stress Analysis", Miklos Hetenyi, Forgotten Books 5. "Modern Experimental Stress Analysis", J.F. Doyle, Wiley India Private Limited
5ANU6.3	**Heat Transfer in Space Application**
	Spacecraft Thermal Environments: Need of spacecraft thermal control, launch and ascent environments, environment of earth orbit, environments ofinterplanetary missions;Modes of heat transfer, factors that influenceenergy balance in a spacecraft, principles of spacecraft thermal control. **Passive Thermal Control Techniques:**Thermal coating materials;Thermal insulation;Heatsinks;Phase change materials **Active Thermal Control Techniques:** Electrical heaters;Thermal louvers; HPR fluid systems;Heat pipes, Spaceborne cooling systems. **Ablative Heat Transfer:** Physical process and calculation of ablation rates, hypersonic ablation of graphite, heat transfer at high velocities, heat transfer in rarefied gases-transpiration and film cooling. **Analysis of Spacecraft Thermal Control:** Application of principles for developmentof spacecraft TCS; Thermal testing; Precision temperature control.
5ANU11	**CAD Lab**
	• Introduction and different features of the CAD Software (AutoDesk Inventor/ SolidWorks/ CATIA) • 2-D Drafting • 3-D modelling • Assembly modelling • Feature modification and manipulation

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	• Detailing • Surface modelling REFERENCE BOOKS:- 1. "AutoCAD 2019 for Beginners", Cadfolks, Createspace Independent Publishing Platform 2. "AutoCAD 2019 Beginners Guide", Amit Bhatt,Createspace Independent Publications 3. "Mastering AutoCAD 2019 and AutoCAD LT 2019", G. Omura & B.C. Benton,Wiley 4. "SolidWorks 2018 For Designers", Sham Tickoo, BPB Publications 5. "Catia V5-6r2017 For Designers", Sham Tickoo, Global Books & Subscription Services
5ANU12	**Aircraft System Lab**
	• Fuel quantity indicator principle mock-up • Aircraft Fuel Quantity & Fuel Flow Mock-Up • Auto Pilot Mock-up • AC Generator test benchwith Generator Control Unit (GCU) • RPM indicator Mock-up. • 'Flow test' to assess of filter element clogging • 'Pressure test' to assess hydraulic external/internal leakage • Maintenance and rectification of snags in pneumatic, hydraulic and fuel systems components and on aircraft • Functional test of aircraft landing gear retraction system and its relevant indications in the cockpit
5ANU13	**Vibration Lab**
	• To verify time period a simple pendulum • To determine radius of gyration of compound pendulum • To determine the radius of gyration of given bar by using bifilar suspension • To determine natural frequency of a spring mass system • To determine natural frequency of free torsional vibrations of single rotor system

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	• To verify Dunkerley's rule • Performing the experiment to find out damping coefficient in case of free damped torsional vibration • To conduct experiment of trifilar suspension • Harmonic excitation of cantilever beam using electro-dynamic shaker and determination of resonant frequencies • Study of vibration measuring instruments Perform study of the following using Virtual Lab: http://www.vlab.co.in/ • Forced vibration of a cantilever beam with a lumped mass at free end • Harmonically Excited Forced Vibration of a Single DOF System • Forced Vibration of a Cantilever Beam with a Lumped Mass at Free End • Harmonically Excited Forced Vibration of a Single DOF System
5ANU14	**Mechanics of Solids Lab**
	• Introduction to Universal Testing Machine • Use of Izod Impact Tester to measure impact loads • Calculation of Young's modulus of aluminum and steel • Determination of fracture strength and fracture pattern of ductile & brittle materials • Testing torsion load using Torsion Tester • Measurement of buckling load for columns • Performing tensile test and characterizing elastic limit, strain hardening, necking and yield point • Compression testing of a metal chip and calculation of compressive strength • Shear testing • Bending test and determination of Young's Modulus ofElasticity via deflection of beam • Performing fatigue test on a given material and to determine its fatigue strength • Creep testing and its significance

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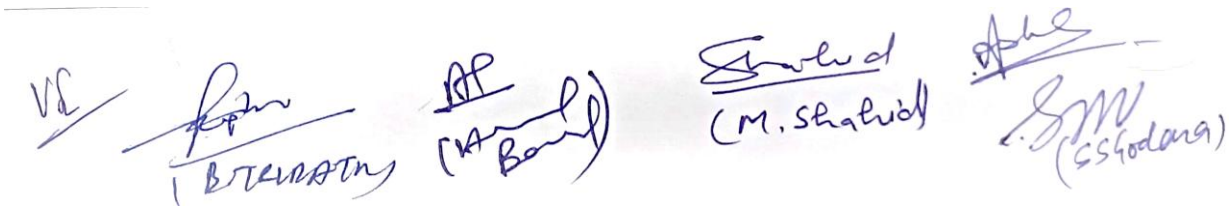
5ANU20	**Extra-Curricular and Discipline**
	As per UD, RTU norms



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Syllabus of B. Tech. Aeronautical Engineering, 6th Semester

Codes	Syllabus
6ANU1	**Aerospace Propulsion - I**
	Fundamentals of Air-Breathing Engines: Review of thermodynamic principles, basic principles of propulsion; History ofair-breathing engines; Different types of air-breathing engines, functions of different engine components; Engine-aircraft matching; Methods of thrust augmentation. **Performance of Air-Breathing Engines:** Ideal cycles for turbojet, turboprop, turbofan, turbo shaft and ramjet engines; ideal cycle analysis; Non-ideal cycle analysis, stage and component efficiencies; Thrust equation; Performance parameters of jet engines. **Inlets:** Internal flow and stall in subsonic inlets, boundary layer separation; Major features of external flow near a subsonic inlet; Diffuser performance; Supersonic inlets, starting problem in supersonic inlets, shock swallowing by variable area inlet or by overspeeding aircraft. **Centrifugal Compressor:** Operating principle, conservation of angular momentum, applications, advantages anddisadvantages; Stage dynamics, velocity diagrams, cascade efficiency, performance characteristics; Stall and surge.

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Axial Flow Compressor: Euler's turbo-machinery equations, velocity diagram analysis, cascade action; Multi-staging; Degree of reaction; Radial equilibrium; Flow problems, compressor efficiency.

Axial Flow Turbine: Types of turbines, performance parameters; Blade design principles; Axial turbine stage, stage efficiency; Turbine Performance; Blade stresses, blade cooling; Turbine and compressor matching.

Nozzles: Flow in isentropic nozzles, nozzle choking; Nozzle efficiency, losses in nozzles;Overexpanded and underexpandednozzles; Ejector and variable area nozzles; Thrust reversal.

TEXT BOOKS:-

1. "Gas Turbine Theory", H.I.H. Saravanamuttoo, G.F.C. Rogers, H. Cohen & P.V. Straznicky, Prentice Hall
2. "Mechanics and Thermodynamics of Propulsion", P. Hill & C. Peterson, Pearson Education

REFERENCE BOOKS:-

"Aircraft Propulsion", Saeed Farokhi, Wiley-Blackwell
"Elements of Gas Turbine Propulsion", J.D. Mattingly, McGraw Hill Education
"Aircraft Propulsion and Gas Turbine Engines", A.F. El-Sayed, CRC Press
"Fundamentals of Jet Propulsion with Applications", R.D. Flack, Cambridge University Press
"Gas Turbines", V. Ganesan, McGraw Hill Education

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	"Gas Turbine Propulsion", D.P. Mishra, Viva Books.
6ANU2	**Aircraft Structure - II**
	Unsymmetrical Bending: Bending stresses in beams of unsymmetrical sections, general, principal axis and neutral axis methods;Bending stresses in beams of symmetric section with skew loads **Shear Flow in Open Sections:** Thin-walled beams, concept of shear flow, shear centre;Shear flow distribution in symmetrical and unsymmetrical thin-walledsections **Shear Flow in Closed Sections:**Bredt-Bathomethod, single and multi-cell structures; Shear flow in single and multicell under torsion, shear and bending; Shear centre of closed sections **Buckling of Thin Plates:** Rectangular sheets under compression, local buckling stress of thin walled section; Thin walled column strength, crippling strength estimation; Buckling of sheet-stiffener combination, effective width **Stress Analysis in Wing and Fuselage:**Loads on an aircraft, shear force and bending moment distribution for semi-cantilever and othertypes ofwing and fuselage; Shear and bending moment distribution for cantilever and semi-cantilever types of beams; Thin-webbed beam with parallel and non-parallel flanges; Shear-resistant web beams

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	TEXT BOOKS:- 1. "Aircraft Structures for Engineering Students", T.M.G.Megson, Butterworth-Heinemann 2. "Analysis and Design of Flight Vehicles Structures", E.H. Bruhn,Jacobs Publishing Inc. REFERENCE BOOKS:- "Theory and Analysis of Flight Structures", R.M. Rivello, McGraw Hill "Aircraft Structures", D.J. Peery & J.J Azar, McGraw Hill
6ANU3	**Aircraft Stability and Control**
	Introduction: Static stability, dynamic stability, longitudinal, lateral and directional stability; Equations of motion **Longitudinal Static Stability and Control:** Contribution of wing, horizontal tail and fuselage to total moment, canard configuration, flying wing configuration; Stick-fixed neutral point and static margin,stick-free neutral point, determination of neutral point by flight test, manoeuvre point;Power contribution to stability, elevator power, elevator angle to trim, elevator hinge movement,stick force and stick gearing, stick force gradients, aerodynamic balancing **Directional Static Stability and Control:** Vertical tail contribution, fuselage contribution, wing contribution, propeller

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	effect; Rudder power, yaw damping;Rudder-fixed and rudder-free directional stability, asymmetric power,pedal forces, rudder lock **Lateral Static Stability and Control:** Effect of wing location, sweep and dihedral, fuselage and vertical tail; Coupling between rolling and yawing moments; Adverse yaw effects; Aileron reversal; Lateral control power; Roll damping, directional divergence **Dynamic Stability and Control:** Euler angles, Equations of motion, stability & control derivatives;Decoupling oflongitudinal and lateral-directional dynamics;Longitudinal modes; Lateral-directional modes; Autorotation and spin;Control response, impulse and step response. TEXT BOOKS:- 1. "Flight Stability and Automatic Control" , R.C. Nelson, McGraw Hill Education 2. "Flight Dynamics Principles", M.V. Cook, John Wiley & Sons Inc. REFERENCE BOOKS:- "Performance, Stability, Dynamics and Control of Airplanes" , B.N. Pamadi, AIAA "Airplane Performance, Stability and Control", C.D. Perkins & R.E. Hage, John Wiley & Sons "Mechanics of Flight", R.H. Barnard, D.R. Philpott & A.C. Kermode, Prentice Hall

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	"Mechanics of Flight", W.F. Phillips, John Wiley & Sons "Dynamics of Flight: Stability and Control", B. Etkin& L.D. Reid, John Wiley & Sons
6ANU4	**Computational Fluid Dynamics**
	Introduction: Importance and applications of CFD in diverse fields; Different types of partial differential equations — hyperbolic, parabolic, elliptic and mixed types; Fundamental concept of CFD. **Governing equations:** Continuity, momentum and energy equations in conservative and non-conservative forms; Governing equations in boundary layers and inviscid flows; Initial and boundary conditions. **Discretization:** Concept and need of discretization of differential equations; Different discretization techniques — finite difference, finite element and finite volume methods and their comparison; Fundamentals of FDM, forward, backward and central difference, ADI scheme, applications to simple problems such as transient one-dimensional and two-dimensional conduction; Stability criterion, errors, consistency, optimum step size. **Grid generation:** Types of grid; Structured, unstructured and hybrid mesh in 2d & 3d, their relative merits and regions of application; Coordinate transformation; Elliptic grid generation; Grid independence test; Adaptive grids, modern developments in grid generation.

Calculation of flow field: Methods of solution, simple 1d computations using different methods; Convergence criterion; Implicit and explicit algorithms; Pressure and velocity corrections; Vorticity-stream function method; Solution of turbulent flows and turbulence modelling.

TEXT BOOKS:-

1. "Computational Fluid Dynamics – The Basics with Applications", J. D. Anderson Jr., McGraw-Hill
2. "Computational Fluid Flow and Heat Transfer", K. Muralidhar& T. Sundarajan, Narosa Publishing House

REFERENCE BOOKS:-

1. "Numerical Computation of Internal and External Flows", C. Hirsch, Butterworth-Heinemann
2. "Fundamentals of Engineering Numerical Analysis", P. Moin, Cambridge University Press
3. "Numerical Methods for Engineering Application", J. H. Ferziger, Wiley
4. "Computational Methods for Fluid Dynamics", J. H. Ferziger& M. Peric, Springer
5. "Computational Fluid Dynamics", T.J. Chung, Cambridge University Press.

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6ANU5.1	**Mechanics of Composites**
	Fundamentals of Composite materials: Definition, matrix & fibres, various types of matrix materials and their properties, properties of various type of fibres like glass, Kevlar, carbon and graphite; Polymers, properties of polymers like epoxy, polyester and phenolic; Applications of composites with emphasis on aerospace industry. **Manufacturing of Composites:** Hand lay-up technique; Autoclave moulding; Pressure bag and vacuum bag moulding; Pultrusion; Resin-transfer moulding; Injection moulding; Bulk and sheet moulding compound methods; Prepregs. **Elastic Behaviour of Composite Lamina-Micromechanics:** Volume fraction, weight fraction, density of composites; Micromechanics and Macromechanics approach; Longitudinal elastic properties, transverse elastic properties, in-plane shear modulus, Poisson's ratio, Halpin-Tsai equations. **Elastic behaviour of Composite Lamina-Macromechanics:** Stress-Strain relations, general anisotropic materials, orthotropic material, transversely isotropic material, isotropic material; Stress-strain relations for a thin lamina. **Analysis of multidirectional Laminates:** Laminate orientation code, symmetric and balanced laminate; Introduction to cross-ply, angle-ply and quasi isotropic laminates; Classical laminate theory, strain-displacement relationship, stress-strain relations, force and moment resultants, in-plane and flexural laminate stiffness; Asymmetric laminate and coupling effect; Stress analysis of cross-ply symmetric laminate under in-plane and flexural loading. **Special Types of Composites:** Short fibre composites; Sandwich structure composites; Honeycomb structure. **Mechanical Testing of Composites:** Tensile testing; Compressive testing; Intra-laminar shear testing; Fracture testing; Impact testing; Fatigue testing. **Failure and Maintenance of Composites:** Failure types in laminates; Damage to laminate structures; Inspection methodology, quality control.

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	TEXT BOOKS:- 1. "Analysis and Performance of Fiber Composites", B.D. Agarwal & L.J. Broutman, John Wiley & Sons 2. "Engineering Mechanics of Composite Materials", I.M. Daniel &O.Ishaai, Oxford University Press REFERENCE BOOKS:- 1. "Mechanics and Analysis of Composite Materials", V.V. Vasiliev& E.V. Morozov, Elsevier Science Ltd. 2. "Mechanics of Composite Materials", R.M. Jones,Technomic Publication 3. "Composite Material: Science and Engineering", Krishnan K. Chawle. Springer 4. "Mechanics of Composite Materials", Autar K. Kaw, Taylor and Francis "Composite Material: Science and Engineering", K.K. Chawla, Springer-Verlag New York Inc
6ANU5.2	**Internal Combustion Engines**
	History of IC engines: Nomenclature, Classification & Comparison, SI & CI, 4stroke- 2 stroke, First Law analysis, Energy Balance. Fuel-air cycles, Actual cycles.

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	Testing & Performance: Performance parameters, Measurement of operating parameters e.g. speed, fuel & air consumption, Powers, IHP, BHP, FHP, Efficiencies Thermal, Mechanical, Volumetric, Emission Measurement, Indian & International standards of Testing, Emission. **Fuels& Combustion:** Combustion in CI & SI engines, Ignition Limits, Stages of combustion, Combustion parameters. Delay period and Ignition Lag, Effects of engine variables on combustion parameters, Detonation & knocking, Types of combustion chamber, Alternative Fuels **Engine Systems & Components:** Fuel System (SI Engine), Carburetion & Injection, process & parameters, properties of A/F mixture, Requirements of A/F ratios as per different operating conditions, Carburettors, types, Aircraft carburettor, comparison of carburetion & injection, F/A ratio calculations.Engine Cooling **Ignition system:** Conventional & Modern ignition systems Magneto v/s Battery, CB point v/s Electronic ignition, Fuel Ignition Energy requirements. Spark advance, centrifugal, vacuum Firing order, spark plugs.Supercharging **Special Engines:** Working principles of Rotary, Stratified charge, Free piston, Variable compression ratio engines. TEXT BOOK:-

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	1. “Internal Combustion Engines”, Mathur & Sharma, Dhanpat Rai & Sons REFERENCE BOOKS:- 1. “Fundamentals of Internal Combustion Engines”, Gupta H.N., Prentice Hall of India 2. “Internal Combustion Engines”, F. Edward Obert, Harper and Raw Publisher. 3. “Internal Combustion Engines Fundamentals”, John B. Heyword, McGraw Hill 4. “Internal Combustion Engines”,Lichty, McGraw Hill. 5.“Fundamentals of Internal Combustion Engine’,Gill, Smith, Ziurs, Oxford & IBH Publishing 6. “IC Engines”,Rogowsky, International Book Co. 7. “Internal Combustion Engine”,Ganeshan, V., Tata Mc Graw Hill. 8. “I.C Engine”, R. Yadav, Central Publishing House, Allahabad
6ANU5.3	**Introduction to Aeroelasticity**
	Aeroelasticity: Elements of aero elasticity. General nature of aero elastic problems. Divergence of a Lifting Surface. Control Surface Reversal. **Nature of static aeroelastic phenomenon:** Wing divergence and control system reversal for an idealized two-dimensional

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	wing and approximate solution for a finite wing. **Dynamic Aeroelasticity:** Energy Method. Sinusoidal Excitation. Periodic Force. Arbitrary Force.Equations of Motion of a Two DOF Model of an Aircraft Wing. Quasi-Steady Aerodynamic Theory. Dynamics of Airfoil. Random Motion. **Flutter phenomena and flutter analysis:**Flutter of a Cantilever Wing. Difference between flutter instability and resonance. Simplified expressions for aerodynamic forces and moments for an oscillating airfoil. Determination of flutter speed and frequency for an idealized two dimensional wing as well as for a finite wing. Methods of flutter control and prevention. Elementary theory of buffeting. TEXT BOOKS:- 1. S Timoshenko, Vibration Problems in Engineering, Van Nostrand. 1982. 2. W T Thomson, Vibration Theory and Application, Allen and Unwin. REFERENCE BOOKS: 1. Y C Fung, Introduction to the Theory of Aeroelasticity 2. R L Bisplinghoft, H Ashley and R. L. Halfman, Aero elasticity, Addison Wesley.
6ANU6.1	**Unmanned Aerial Systems**

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	Introduction: History, Classification and applications of UAVs, Unmanned Aircraft System (UAS), UAS composition, societal impact, future prospects, Regulations and safety considerations **Characteristics of UAV types:** Long-range, long-endurance, MUAV types, MAV and NAV types, UCAV, Novel hybrid aircraft configurations **UAV Propulsion:** Internal combustion engines, turbine engines, electrical systems **Aerodynamics:** Low Reynolds number effects, Lift-induced drag, parasite drag, rotary wing aerodynamics, response to air turbulence, dynamic stall **Control and stability:** Flight control, HTOL aircraft, helicopters, convertible rotor aircraft, Autopilot Systems & Ground control Station, Sensors used in UAVs, on-board flight control **Introduction to design and selection of UAV:** Conceptual design, preliminary design, detailed design, selection of UAV for particular requirement **Aspects of airframe design:** Airframe configuration, Scale effects, packaging density, Aerodynamic design, Strength,

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	stiffness and reliability requirements, flight and gust envelopes including manoeuvre loads, selection of power plants; Design for stealth **Payload types:** Non-dispensable and dispensable payloads, sensing / surveillance, weaponized, delivery **Communications:** Communication media, radio communication, mid-air collision avoidance system, communication data range and bandwidth usage, antenna types, telemetry **Navigation:** NAVSTAR-GPS, TACAN, LORAN-C, inertial navigation, radio tracking **Control stations:** Control station composition, open system architecture, mini-UAV 'Laptop' ground control station, close-range UAV systems, medium and long range UAV systems, sea control stations, air control station TEXTBOOKS:- 1. "Unmanned Aircraft Systems: UAVS Design, Development and Deployment", Reg Austin, Wiley 2. "Introduction to Unmanned Aircraft Systems", D.M. Marshall, R.K. Barnhart, E. Shappee& M.T. Most, CRC Press

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	REFERENCE BOOKS:- 1. "Small Unmanned Aircraft: Theory and Practice", R.W. Beard &T.W. McLain, Princeton University Press 2. "Unmanned Aircraft Systems", E. Atkins, A. Ollero& A. Tsourdos, John Wiley & Sons 3. "Introduction to UAV Systems", P. Fahlstrom& T. Gleason, Wiley 4. "Theory, Design, and Applications of Unmanned Aerial Vehicles", A.R. Jha, CRC Press 5. "Unmanned Aviation Systems: The Definitive Guide", M. Leasure& M.S. Nolan, eAcademicBooks LLC
6ANU6.2	**Fuels & Propellant Technology**
	Properties and tests for petroleum products: Motor gasoline, Aviation gasoline, Aviation turbine fuels, Requirements of aviation turbine fuels of Kerosene type and high flash point type, Requirements for fuel oils Single base propellants, Double base propellants, composite propellants, CMDB propellants, Metalized composite Propellants, Brief introduction to combustion theory of composite and double base propellants. **Various liquid propellants and their properties:**Monopropellant and bipropellant systems, Concept of ullage, Ignition studies of liquid propellants, Propellant loading tolerances, Inventory-Volume versus mass loading, Loading measurement and control, Outage control.

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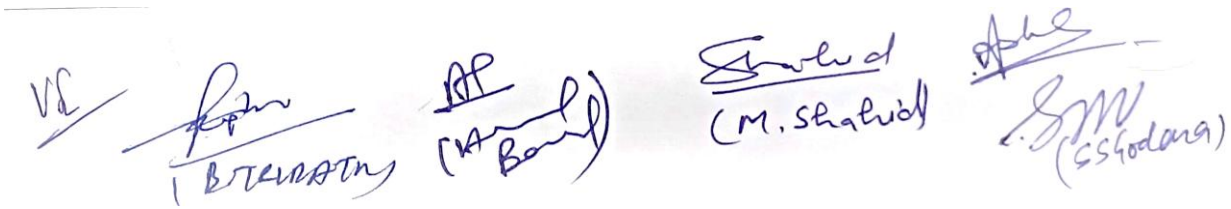
	Introduction to cryogenic propellants: Liquid Hydrogen, liquid Oxygen, Liquid nitrogen and liquid helium, Theory behind the production of low temperature, Expansion Engine, Cascade process, Joule Thompson Effect, Magnetic effect, Ortho and Para H2, Hilium4 and Helium3, Ideal cycles and Efficiency of cryo systems, Storing of cryogenic propellants, Cryogenic loading problems. **Laboratory testing:** Arc Image Furnace, Ignitability studies, Differential Thermal Analysis, Thermo gravimetric analysis, Particle size measurement Micro-merograph, Strand burner tests Impulse Bomb, Performance estimation. TEXT BOOKS:- 1. "Rocket Propulsion Elements", Sutton, G.P., John Wiley. REFERENCE BOOKS:- "Fuels and Combustion", Sharma,S.P. and Mohan.C., McGraw Hill Publishing. "Gas Turbines and Jet and Rocket Propulsion", Mathur,M. ,and Sharma.R.P., Standard Publishers. "Electrical Vehicle Technology", James Laraminie, Wiley.
6ANU6.3	**Theory of Machines**
	Kinematics: Links, pairs, mechanisms, four bar chain and its inversions; Velocity and acceleration, Klein's construction, Coriolis component; Instantaneous center method, pantograph; Scott-Russel, Tchbeicheff straight line, indicator diagram mechanisms.



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Friction: Laws of static, dynamic and rolling friction, dry and viscous friction; Inclined plane and screw jack; Pivots, clutches; Brakes: Band, block and band & block brakes, braking action.

Dynamometers: Absorption and transmission type dynamometers, prony, rope and hydraulic dynamometers.

Gears: Laws of gearing, gears terminology; Interference, undercutting and minimum number of teeth on pinion in contact with gear; Spur, helical, bevel gear, rack and pinion mechanism.

Gear Trains: Simple, compound, reverted and epicyclic gear trains, analytical and tabular methods for velocity ratio; Gear boxes.

Gyroscope: Principle of gyroscopic couple, effect of gyroscopic couple and centrifugal force on airplanes taking a turn.

Balancing: Balancing of rotating masses; Balancing of reciprocating masses; Balancing of inline engines and V-engines.

TEXT BOOK:-

Rattan, S. S., "Theory of Machines", 2nd Ed., Tata McGraw Hill.

"Theory of Machines and Mechanisms", Uicker, Pennocle&Shigley, Oxford University Press

REFERENCE BOOKS:-

"Theory of Machines", Thomas Bevan, Pearson Education

"Mechanism and Machine Theory", A. G. Ambekar, Prentice-Hall Of India

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	"Theory of Mechanisms and Machines", A. Ghosh, Affiliated East West Press "Theory of Mechanisms and Machines", Sharma & Purohit, Prentice-Hall Of India 5. Singh, S., "Theory of Machines", Pearson Education.
6ANU11	**Computational Fluid Dynamics Lab**
	Introduction to ANSYS Fluent, its features and different options Generation of structured and unstructured mesh over simple objects Boundary layer resolution and grid independence test Flow over flat plate and use of transition models Inviscid and viscous flow over circular cylinder at different Reynolds number Laminar and turbulent flow in a pipe Flow over airfoil at high Reynolds number and use of different turbulence models Supersonic flow past wedge and cone Transonic flow over subsonic and supercritical airfoils Flow over finite wing Flow in nozzles and diffusers Writing codes in C/ C++/ MATLAB/ Python for simple flow fields REFERENCE BOOKS:- 1. "ANSYS Fluent Tutorial Guide", Sylvain Serra 2. "ANSYS FLUENT 14.0 Simulation Analysis and Design Optimization", S.B. Cheng & L.M.G. Bian, Machinery

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	Industry Press 3. "FLUENT Learning Modules", S. Weidner, Cornell University Confluence (https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules) 4. "ANSYS Workbench 14.0 for Engineers and Designers", Sham Tickoo, Dreamtech Press
6ANU12	**Aeromodelling Lab**
	Design and fabrication of fixed-wing gliders Comparison of properties of thermocole, balsa wood, Styrofoam, composites for aeromodel fabrication Detailed design of fixed-wing powered aeromodels Design, fabrication and testing of different components Aerodynamic and structural design Use of flight simulator Concepts used in unconventional UAVs such as rotary wing models and ornithopters
6ANU13	**Aircraft Structures Lab**
	Calculation of Young's modulus of aluminium and steel Determination of fracture strength and fracture pattern of ductile & brittle materials Deflection of beams with various end conditions for different load Verification of Maxwell's Reciprocal theorem & principle of superposition Measurement of strain using strain gauges Shear centre location for open and closed sections Estimation of principle axes Compression tests on long and short columns and determination of buckling load Wagner's Theorem

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6ANU14	**Composite Materials Lab**
	Preparation of Continuous fibre reinforced Polymer Composites Preparation of Dis-Continuous Fibre reinforced Polymer Composites Study of Tensile strength and Youngs modulus of FRP composites Study of Flexural strength of FRP composites Study of Hardness of FRP composites Study of drop weight impact testing Preparation of composites Study of microstructure, hardness and density of these composite Study of Tensile strength of Al-SiC composites Environmental Testing (Humidity and temperature) Study of Tribological behaviour of composites
6ANU20	**Extra-Curricular & Discipline**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 7th Semester

Codes	Syllabus
7ANU1	**Aerospace Propulsion-II**
	Propeller Theory: Momentum theory, blade element theory, combined blade element and momentum theory, propeller power losses, propeller performance parameters. **Fundamentals of Combustion:** Thermochemistry, stoichiometric ratio and mixture ratio, energy release during combustion, heat of formation, heat of combustion, stoichiometric reaction; Adiabatic flame temperature, flammability and stability limits; Premixed and diffusion flames; Chemical equilibrium, chemical kinetics, reacting flow, frozen flow. **Gas Turbine Combustors:** Types of aviation fuels; Classification of combustion chambers, important factors affecting combustion chamber design; Combustion process; Combustion chamber performance; Ignition and engine starting; Flame tube cooling; Flame stabilization; Afterburners, supercharging. **Ramjet Propulsion:** Operating principle of ramjet propulsion, types of ram propulsion; Efficiencies of different components; Critical, subcritical and supercritical modes of combustion; Need for supersonic combustion for hypersonic propulsion, salient features of scramjet engine and its applications for hypersonic vehicles, problems associated with supersonic combustion. **Rocket Propulsion:** Brief history and principle of rocket; Rocket equation; Classification of rockets, mass ratio of rocket; Solid propellant rockets, estimation of solid propellant adiabatic flame temperature; Salient features of liquid propellant rockets, selection of liquid propellants, thrust control in liquid rockets, cooling in liquid rockets; Hybrid rocket propulsion; Rocket nozzles, conical nozzle and contour nozzle, under and over expanded nozzles, flow separation in nozzles, unconventional nozzles; Nozzle performance, nozzle area ratio, mass flow rate, characteristic velocity; Thrust coefficient, performance parameters; Staging and clustering. **Advanced Propulsion Techniques:** Arc jet, Resisto jet; Hall effect thrusters; Electric rocket propulsion; Ion propulsion techniques; Nuclear rocket; Solar sail; Preliminary Concepts in nozzleless propulsion; Thrust reverser; Stealth technology.

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	TEXT BOOKS:- 1. "Rocket Propulsion Elements", G.P. Sutton & O. Biblarz, John Wiley & Sons 2. "Theory of Aerospace Propulsion", P.M. Sforza, Butterworth-Heinemann REFERENCE BOOKS:- 1. "Aerospace Propulsion System", T.A. Ward, Wiley 2. "Aerospace Propulsion", T.W. Lee, Wiley-Blackwell 3. "Aircraft Engines and Gas Turbines", J.L. Kerrebrock, The MIT Press 4. "Aircraft Propulsion and Gas Turbine Engines", A.F. El-Sayed, CRC Press 5. "Understanding Aerospace Chemical Propulsion", H.S. Mukunda, I.K. International Publishing House Pvt. Ltd.
7ANU2	**Aircraft Design**
	Aircraft Design Fundamentals: Introduction to design, engineering design, feasibility analysis, review, evaluation, and feedback; Conceptual system design, preliminary system design, detail system design; Aircraft design requirements and specifications, airworthiness, aerodynamic and structural design considerations; UAV design. **Aircraft Conceptual Design:** Aircraft configuration alternatives, aircraft classification and design constraints; Configuration selection process and trade-off analysis; Material selection; Conceptual design optimization. **Preliminary Design:** Maximum Take-Off Weight Estimation; Estimation of cruise and manoeuvring loads; Load factor, v-n diagram; Wing loading, wing area; Engine sizing. **Wing Design:** Factors influencing selection of airfoil and planform; Spanwise load distribution, Stalling, take-off and landing considerations; Bending moment and shear force; Selection of wing vertical location, airfoil section, wing incidence, aspect ratio, taper ratio, sweep angle, twist angle, dihedral angle, high-lift device; Estimation of wing drag. **Tail Design:** Aircraft trim requirements; Tail configuration, canard or aft tail; Optimum tail arm; horizontal tail

	parameters; Vertical tail design. **Fuselage Design:** Fuselage configuration design and internal arrangement; Cockpit design; Passenger cabin design; Cargo section design; Other fuselage internal segments; Optimum length-to-diameter ratio; Lofting. **Propulsion System Design:** Functional analysis and design requirements; Selection of type of engine, number of engines, engine location; Engine installation; Propeller sizing; Engine performance. **Landing Gear Design:** Functional analysis and design requirements; Selection of landing gear configuration, possible retraction mechanism into fuselage or wing; Landing Gear position according to aircraft centre of gravity; Absorption of landing loads. **Design of Control Surfaces:** Aileron Design, Elevator Design, Rudder Design. **Weight Calculation:** Estimation of weight of major components, Aircraft weight distribution; Aircraft centre of gravity calculation, centre of gravity range; Aircraft mass moment of inertia. **Advanced Design Concepts:** Supersonic aircraft design; Very large aircraft; Morphing aircraft; Supercritical wing; Flying wing, tailless, lifting fuselage, and blended wing-body designs; Special considerations such as stealth, maintainability etc. **Complete Design Problem:** Design of airframe for given specifications with constraints; Prediction of performance, stability and control, noise and emission levels; Reviewing selection of engines from all considerations; Freezing the design; Preparation of preliminary drawings including 3 views and layout. TEXT BOOKS:- 1. "Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Education Series 2. "Aircraft Design: A Systems Engineering Approach", M. H. Sadraey, Wiley-Blackwell REFERENCE BOOKS:-

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	1. "Aircraft Design", A.K. Kundu, Cambridge University Press 2. "Introduction to Aircraft Design", J.P. Fielding, Cambridge India 3. "General Aviation Aircraft Design: Applied Methods and Procedures", S. Gudmundsson, Butterworth-Heinemann 4. "Design of Aircraft", T.C. Corke, Pearson
7ANU3	**Finite Element Methods**
	Introduction: FEM and its applicability, Review of Matrix algebra, Gauss elimination method, Uniqueness of solution, Banded symmetric matrix and bandwidth. **Structure analysis:** Two-force member element, Local stiffness matrix, coordinate transformation, Assembly, Global stiffness matrix, imposition of Boundary conditions, Properties of stiffness matrix **One-dimensional Finite Element Analysis:** Basics of structural mechanics, stress and strain tensor, constitutive relation, Principle of minimum Potential, General steps of FEM, Finite element model concept / Discretization, Derivation of finite elements, equations using potential energy approach for linear and quadratic 1-D bar element, Shape functions and their properties, Assembly, Boundary conditions, Computation of stress and strain; solution of problems from fluid mechanics and heat transfer. **Two Dimensional Finite Element Analysis:** Finite element formulation using three-node triangular (CST) element , Plane stress and Plain strain problems, Shape functions, Isoparametric formulation with examples, Numerical integration using gauss quadrature formula; Application to thermal problems. **Finite Element Formulation from Governing Differential Equations:** Method of Weighted Residuals and Galerkin's method. Application to one-dimensional problems, introduction to variational formulation (Ritz Method.) **Higher Order Elements:** Lagrange's interpolation formula for one and two independent variable, Convergence of solution, compatibility, element continuity, static condensation, p and h methods of mesh refinement, Aspect ratio and element shape, Introduction to concept of element mass matrix in dynamic analysis.

	TEXT BOOKS:- 1. "Text Book of Finite Element Analysis", P. Seshu, Prentice Hall India REFERENCE BOOKS:- 1. "An Introduction to the Finite Element Method", J.N. Reddy, McGraw-Hill 2. "Finite Element Procedure in Engineering Analysis", K.J. Bathe, Prentice Hall India 3. "Introduction to Finite Elements in Engineering", T.R. Chandrupatla & A.D. Belegundu, Prentice Hall of India 4. "Applied Finite Element Analysis", L.J. Segerlind, John Wiley & Sons 5. "Concepts and Applications of Finite Element Analysis", R.D. Cook, D.S. Malcus, M.E. Plesha & R.J. Witt, John Wiley & Sons
7ANU4	**Space Dynamics**
	Introduction: Definition of space, space environment, effect of space environment on materials of spacecraft structure; Solarsystem, celestial sphere, ecliptic, equatorial plane and equinoxes; History of space exploration, different types of earth orbits, types of spacecraft, spacecraft subsystems; Newton's law of gravitation, Kepler's laws; Vector differentiation, kinematics relative to rotating frames. **Two-body Problem:** Equation of relative motion, conservation of angular momentum and energy; Different types oftrajectories, orbital elements; Lambert's theorem. **N-body Problem:** Equation of motion; Restricted three-body problem, Lagrangian points, concept of sphere of influence. **Orbital Manoeuvres:** Hohmann transfer, bielliptic transfer, plane change manoeuvres, combined manoeuvres, low thrusttransfer manoeuvres, Non-coplanar transfer; Rendezvous missions, interplanetary trajectories, gravity assist trajectories; Orbitperturbations. **Rocket Vehicle Dynamics:** Basic functions and features of rockets and missiles; Tsiolkovsky rocket equation; Launch

	vehicle ascent trajectories and its different phases, effect of aerodynamic drag and gravity on ascent mission performance, vertical, inclined and gravity turn trajectories; Static and dynamic stability of rockets, rocket thrust vector control methods; Concept of multi-staging, series and parallel staging configurations, optimal staging solutions; Re-entry vehicles and missions, aerobraking. **Attitude Dynamics and Control:** Euler's equations for rotational dynamics; Torque-free motion of asymmetric andaxisymmetric rigid bodies; Spinning and non-spinning spacecraft, dual spin spacecraft, effect of energy dissipation on stability of rotational motion; Overview of actuation mechanisms for attitude control, gyroscopic motion, stabilization through gravity gradient, attitude sensors, design of control of three-axis stabilized spacecraft in orbit using reaction wheels, thrusters, magnets, single and double gimbaled control moment gyros, Yo-Yo mechanism. TEXT BOOKS:- 1. "Orbital Mechanics for Engineering Students", H.D. Curtis, Butterworth-Heinemann 2. "Elements of Space Technology", R.D. Meyer, Academic Press REFERENCE BOOKS:- 1. "Orbital Mechanics", V.A. Chobotov, AIAA Education Series 2. "Fundamentals of Astrodynamics", R.R. Bate, D.D. Mueller & J.E. White, Dover Books 3. "Spaceflight Dynamics", W.E. Wiesel, Aphelion Press 4. "Fundamentals of Astrodynamics and Applications", D.A. Vallado, J. Wertz, Microcosm Press 5. "Rocket and Spacecraft Propulsion", M.J.L. Turner, Springer
7ANU5.1	**Automatic Control Systems**
	Introduction: Open loop and closed loop control systems, series and parallel system; Feedback characteristics of controlsystems; Mathematical models of physical systems; Control systems and components. **Feedback Control System**: Transfer function of linear systems; Impulse response of linear Systems; Block diagrams offeedback control systems, reduction of block diagrams, signal flow graphs, output to input ratios; Time response analysis, effects of derivative and integral control; Steady state response of feedback control system Frequency response;

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	Correlation betweenfrequency domain and time domain specifications; Bode plot analysis. **System Stability:** Concept of stability and algebraic criteria; Routh-Hurwitz criterion; Root locus technique; Nyquist stabilitycriterion. **State Variable Analysis and Design:** Introduction to state variables; Compensator design; Controller design. **Longitudinal Autopilot:** Brief description through block diagrams and root locus of displacement; Pitch orientation control system, acceleration control system; Fly-by-wire control system; Instrument Landing System. TEXT BOOKS:- 1. "Modern Control Engineering", K. Ogata, PHI learning 2. "Automatic Control Systems", B,C. Kuo & F. Golnaraghi, Wiley REFERENCE BOOKS:- 1. "Aircraft Flight Dynamics and Control", W. Durham, Wiley-Blackwell 2. "Control System Design: An Introduction to State-Space Methods", B. Friedland, Dover Publications Inc. 3. "Automatic Control of Aircraft and Missiles", J.H. Blackelock, John Wiley & Sons 4 "Aircraft Control and Simulation: Dynamics, Controls Design, and Autonomous Systems", B.L. Stevens, F.L. Lewis &E.N. Johnson, John Wiley & Sons 5 "Advanced Control of Aircraft, Spacecraft and Rockets", Ashish Tewari, Wiley-Blackwell
7ANU5.2	**Structural Health Monitoring**
	Introduction to Structural Health Monitoring: Motivation and applications of SHM, SHM as a way of making materials and structures smart, Basic components& working mechanism of SHM, SHM as a part of system management, Passive and active SHM, NDE, Integrated Vehicle Health Monitoring (IVHM) **Maintenance and Repair Strategies:** Facts and importance of Maintenance, Various aspects of Inspection, Assessment

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	procedure for evaluating a damaged structure, Rapid visual screening. Implementation of SHM in aerospace applications. **Vibration-Based Techniques:** Basic concepts, Local and global methods, Damage diagnosis as an inverse problem, Model-based damage assessment, Damage Diagnostic methods based on vibrational response. **Neural network approach:**Basic idea of neural networks, Neural networks in damage detection, localization and quantification, Multi-layer Perceptron (MLP). **Smart Materials in Aerospace Structures:** Piezoelectric sensors, Electromechanical impedance for defect detection, piezoelectric implant method. Energy Harvesting using Piezoelectric Materials in Aerospace Structures Electrostrictive materials, Magnetostrictive materials, Shape Memory Alloys, Optical Fiber. **Case Studies:** Case studies for SHM technologies for damage detection, diagnosis and prognosis in Aerospace StructuresVarious case studies with innovative technologies of SHM in aerospace applications including sandwich composite structures, civil infrastructures, pipelines, rotating machinery. TEXT BOOK:- 1. Fuh-Gwo Yuan, Structural Health Monitoring (SHM) in Aerospace Structures, Woodhead Publishing, 1st Edition 2016. REFERENCE BOOKS:- 1. Jayantha Ananda Epaarachchi and Gayan Chanaka Kahandawa, Structural Health Monitoring Technologies and Next-Generation Smart Composite Structures (Composite Materials), CRC Press; 1st Edition (December 2019) 2. Wiley and Staszewski, Health Monitoring Of Aerospace Structures: Smart Sensor Technologies And Signal Processing, WILEY INDIA; 1st Edition (January 2017). 3. Daniel Balageas, Claus-Peter Fritzen, Alfredo Güemes, Structural Health Monitoring, WileyISTE, 2006. 4. Douglas E Adams, Health Monitoring of Structural Materials and Components-Methods with Applications, John Wiley and Sons, 2007.

	5. Structural Health Monitoring: Current Status and Perspectives, Fu Ko Chang
7ANU5.3	**Operation Research**
	Introduction: Origin of operation research; Methodology; Scope and application of operationsresearch. **Linear Programming Problem:** Introduction, requirement of LP; Basic assumptions, formulation of LP, general statementof LP; Solution techniques of LP: Graphical methods, Analytical methods; Sensitivityanalysis. **Transportation and Assignment:** Transportation problems definition; Linear form; Solution methods: Northwest cornermethod, least cost method, Vogel's approximation method; Trans-shipment problems; Travelling salesman problem. **Queuing Theory:** Basis of queuing theory, elements of queuing theory, Kendall's notation; Operating characteristics of aqueuing system; Classification of queuing models. **Inventory Control:** Inventory classification; Different cost associated to inventory, economic order quantity; Inventorymodels with deterministic demands. **Replacement Theory:** Introduction; Replacement of capital equipment which depreciated with time, replacement byalternative equipment; Group and individual replacement policy. **Game Theory:** Introduction, characteristics of game theory; Two person zero sum games; Pure strategy; Dominance theory;Mixed strategies (2x2, mx2). **Decision Theory:** Introduction; Decision under certainty; Decision under risk; Decision under uncertainty: Laplacecriterion, MaxiMin criterion, MiniMax criterion; Decision tree. **Project Management:** Introduction to PERT and CPM; Critical path calculation.

	TEXT BOOKS:- 1. "Operations Research: An Introduction", Hamdy A. Taha, Pearson Education India **2.** "Operations Research: Principles and Applications", G. Srinivasan, PHI Learning Private Limited REFERENCE BOOKS:- 1. "Operations Research: Applications and Algorithms", Wayne L. Winston, Duxbury Resource Center 2. "Introduction to Operations Research", F.S. Hillier, G.J. Lieberman, B. Nag & P. Basu, McGraw Hill Education 3. "Operations Research: Principles and Practice", Ravindran, Phillips & Solberg, Wiley 4. "Operations Research", P. Ramamurthy, New Age International 5. "Optimization in Operations Research", Ronald Rardin, Pearson Education
7ANU11	**Aircraft Design Lab**
	• Conceptual design based on preliminary mission requirements • Survey of existing vehicular configurations (in similar category) • Preliminary weight estimation • Calculation of wing loading and thrust loading • Selection of wing parameters • Selection of fuselage parameters and internal layout • Selection of engine • Location of engines and landing gear • Design of tail areas and control surfaces • Estimation of weights of various components • Calculation of centre of gravity and its shift • Estimation of aerodynamic characteristics and performance evaluation • Estimation of spanwise load distributions on wing and tail • V-n diagram for the design study • Estimation of cost and airworthiness of airplane, trade-off studies

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	TEXT BOOK:- 1. "Aircraft Design: A Conceptual Approach", D.P. Raymer, AIAA Educational Series REFERENCE BOOKS:- 1. "Fundamentals of Aircraft Design", L.M. Nicolai, METS Inc. 2. "Synthesis of Subsonic Airplane Design", E. Torenbeek, Springer 3. "Aircraft Conceptual Design Synthesis", D. Howe, Wiley 4. "Aircraft Design Projects: For Engineering Students", L.R. Jenkinson & J.F. Marchman, AIAA Education Series 5 "Civil Jet Aircraft Design", L.R. Jenkinson, P. Simpkin & D. Rhodes, AIAA Education Series
7ANU12	**FEA Lab**
	• Introduction of GUI of the software ANSYS • Analysis of trusses • Analysis of beams and frames (bending and torsion problems) • Plane stress and plane strain analysis problems • Problems leading to analysis of axisymmetric solids • Problems leading to analysis of three dimensional solids • Heat transfer problems • Model analysis problems for natural frequency determination TEXT BOOKS:- 1. "Finite Element Analysis: Theory and Application with ANSYS", S. Moaveni, Pearson Education Limited 2. "Engineering Analysis with ANSYS Workbench 18", G. Zhang, College House Enterprises

	REFERENCE BOOKS:- 1. "Finite Element Modeling and Simulation with ANSYS Workbench", X. Chen & Y. Liu, CRC Press 2. "Practical Aspects of Finite Element Simulation – A Student Guide", free ebook by Altair University 3. "Working with ANSYS: A Tutorial Approach", D. Zindani, A.K. Roy & K. Kumar, I.K. International Publishing House Pvt. Ltd. 4. "ANSYS Workbench 14.0 for Engineers and Designers", S. Tickoo, Dreamtech Press 5. "Introduction to ANSYS 16.0", R.B. Choudary, I.K. International Publishing House Pvt. Ltd.
7ANU13	**Minor Project**
	• The students are required to work in groups of not more than three students on a project related to Aerospace Engineering under the guidance of a faculty member in one of the labs in the college. • The project topic should be such that it enables them to bring into practice the theoretical concepts learnt as wellas learn new concepts and has to be approved by Project Coordinator. • The students are required to meet their project guides at least once in a fortnight and maintain a record of the same in a project diary. • A feasible working strategy should be developed and presented within a month. • At least two mid-semester presentations should be organized by Project Coordinator to review the progress during the semester. • A technical report and presentation has to be submitted at the end of the semester for evaluation of the work. The Project Coordinator should preferably be one of the members of the external grading committee.
7ANU14	**Practical Training**
	• As per the curriculum, all the students should undertake a summer training or internship in an industry or academic institute, that allows them to learn new skills increasing their employability. • After returning to the college, each student has to prepare a report and presentation to showcase the work done

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	during the training period, as per the guidelines provided by the training coordinator. • Regular presentations will be organised in the class where students will present their learning during the training. • Before the end of the semester, every student has to complete and submit the report and presentation, based on which the grading will be done.
7ANU15	**Extra-Curricular & Discipline**
	As per UD, RTU norms

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Syllabus of B. Tech. Aeronautical Engineering, 8th Semester

8ANU1.1	**Airport Management and Aircraft Maintenance**
	Introduction: The evolution of aviation, growth drivers, issues and challenges; Global and Indian aviation industry; major players in aviation industry in India, SWOT analysis of the different airline companies in India; market potential and current challenges of airline industry in India. **Aircraft Rules:**ICAO, international environmental protection policies;Airport Authority of India, DGCA, Airport Economic Regulatory Authority of India; Aircraft Act 1934, The Aircraft Rules 1937, Civil Aviation Requirements (CAR); Aircraft manuals, Airworthiness Advisory Circular, Aeronautical Information Circulars; Issue of type approval. **Airport Planning and Management:** Types of airports; Airport layouts and configurations; Ground handling, air cargo management, various airport services; Airline's impact on airport; Effect of privatization; An overview of any international airport. **Air Traffic Control:** Principles of Air Navigation and Air Traffic Control; Classification of ATS air spaces; Assignment of cruising levels; Air traffic zones and approach areas, radio/radar communications and landing aids, methodology for slot allocation, aerodrome data; Airport & aircraft security, crisis management at airports. **Airworthiness:** Knowledge of various mandatory documents issued to establish airworthiness of aircraft parts; Airworthiness requirement for gliders, micro-light aircraft, ferry flight and hot air balloons; Flight manuals; Import/Export of aircraft; Load and trim sheet; Cockpit check list, preparation and use of concept and emergency check list, defect recording, reporting, investigation, rectification; Aircraft inspection; Various logbooks required to be maintained for aircraft, method of maintaining the logbook. **Maintenance of Aircraft Structural Components:** Types of maintenance schedules, damage investigation, non-destructive testing; Ensuring quality welds; Soldering and brazing;Sheet metal repair and maintenance;Maintenance and repair of plastic components;Inspection and repair of composite components; Installation and maintenance of instruments; Inspection and maintenance of various aircraft systems such as power plant, landing gear system, air-conditioning and pressurization system,

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	fuel & hydraulic system, position and warning system,auxiliary systems. **Licensing of Aircraft Maintenance Engineers:** Knowledge of privileges and responsibilities of the various categories of AME Licence and approved persons; Two types of maintenance; Human performance and limitations relevant to the duties of an aircraft maintenance engineer licence holder; Student flight engineer; Validation of foreign AME licence. TEXT BOOKS:- 1. "Airport Planning and Management", S.B. Young & A.T. Wells,McGraw-Hill Education 2. "Aviation Maintenance Management", H.A. Kinnison& T. Siddiqui, McGraw Hill Education REFERENCE BOOKS:- 1. "Fundamentals of Aircraft Maintenance Management", H. Timothee, Notion Press 2. "Airport Management", C.D. Prather,Aviation Supplies & Academics Inc. 3. "Aircraft Maintenance and Repair", M. Kroes& R. Sterkenburg, McGraw Hill Education 4. "Aviation Management: Global and National Perspectives", Ratandeep Singh, Kanishka Publishing House 5. "Air Transportation: A Management Perspective", J. G. Wensveen, Routledge
8ANU1.2	**Turbomachinery**
	Introduction: Definition and classification of turbomachines; Specific Work, Losses and efficiency; Effect of reheat and preheat factor. Degree of reaction. Energy transfer - Euler's equation, velocity triangles. Relevant Dimensionless parameters and their physical significance, specific speed, **Pumps:**Hydraulic Pumps: Centrifugal Pumps, Pump output and Efficiencies - Effect of Vane angle – Cavitation - Pump Characteristics - Multistage pumps. **Hydraulic Turbines:** Velocity triangles. Efficiencies of draft tubes - Hydraulic turbine characteristics. Francis and Kaplan turbines.Elementary cascade theory, cascade nomenclature, compressor cascade, turbine cascade, cascade efficiency, stalling and surging.

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	Centrifugal Compressors: Constructional details, Stage Pressure rise - Stage Pressure Coefficient - Stage Efficiency - Degree of Reaction - Various Slip factors - Introduction to Fans and Blowers. **Axial flow Compressors:** general expression for degree of reaction; velocity triangles for different values of degree of reaction, Blade loading and flow coefficient, Static pressure rise, Workdone factor. **Steam and Gas Turbines:** Axial turbine stages - Stage velocity triangles Single stage impulse turbine - Speed ratio - Maximum utilization Factor - Compounding of Turbines and its types, Degree of Reaction - Reaction Stages. Inward Flow radial turbine stages (IFR) - Working principle and Performance Characteristics. TEXT BOOKS:- 1. S.M. Yahya, Turbines, Compreessors and Fans, Tata Mcgraw Hill. 2.Gopalakrishnan G, Prithvi Raj D, "A treatise on Turbomachines", Scitec Publications, Chennai, 2002. 3. Sheppard, Principles of Turbomachinery. REFERENCE BOOKS:- 1 R.K.Turton, Principles of Turbomachinery, E & F N Spon Publishers, London & New York. 2 Balajee, Designing of Turbomachines.
8ANU1.3	**Helicopter Engineering**
	Introduction: Chronological development, Types of main rotor configurations, Types of helicopters **Fundamentals of Rotor Aerodynamics:** Introduction, Disc loading, Power loading, Induced inflow ratio, Thrust and Power coefficients, Figure of Merit, Rotor solidity, blade loading coefficients, Blade lock number **Momentum Analysis:** Introduction to hover, axial climb and descent, forward flight

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	Blade element Analysis: Introduction to hover, axial climb and descent, forward flight **Basic helicopter Performance:**Hovering and axial climb performance, forward flight performance: Induced power, blade profile power, parasitic power, climb power, Tail rotor power, Total power **Conceptual design of helicopters:**Introduction, Design requirements, Design of main rotor: rotor diameter, tip speed, rotor solidity, number of blades, blade twist, blade planform and tip shape, airfoil sections TEXT BOOKS:- 1 " Principles of Helicopter Aerodynamics" ,J. Gordon Leishman, 2 "Basic Helicopter Aerodynamics", John M. Seddon, Simon Newman REFERENCE BOOKS:- 1 "Helicopter Theory" ,Wayne Johnson**,** 2 "Helicopter Performance, Stability, and Control",Raymond W. Prouty
8ANU2.1	**Non-destructive testing**
	Introduction to NDT: Fundamentals of non-destructive testing and evaluation, physical characteristics of materials and their applications in NDT, advantages and limitations of NDT; Visual inspection techniques. **Liquid Penetrant Testing:** Basic principle; types and properties of liquid penetrants, methods of application; Developer application and inspection, interpretation of results. **Magnetic Particle Testing:** Basic theory of magnetism; Magnetization methods; Field indicators, particle application, inspection. **Eddy Current Testing:** Basic principle, Faraday's law, inductance, Lenz's law, self and mutual inductance, impedance plane; Generation of eddy currents, properties of eddy currents, eddy current sensing elements, inspection system and probes,

	eddy current instrumentation; System calibration; Applications and limitations. **Ultrasonic Testing:** Basics of ultrasonic waves; Ultrasonic equipment; Test method, variables affecting an ultrasound test; Distance and Area calibration; Weld inspection by UT. **Radiography:** X-rays and their properties; X-ray generation, absorption and atomic scattering; Image formation, image quality; Digital Radiography, neutron radiography; Image interpretation; Radiation Shielding; Radiography applications, limitations and safety. **Special Techniques:** Acoustic Emission testing; Holography; Thermography; Magnetic Resonance Imaging; In-situ metallography. **Industrial Applications of NDT:** Span of NDT activities in railways, nuclear and chemical industries, aircraft and aerospace industries, automotive industries, offshore gas and petroleum projects, coal mining industry; NDT of pressure vessels, castings, welded constructions. TEXT BOOKS:- 1. "Non-Destructive Testing", Louis Cartz, ASM International 2 "Non-Destructive Test and Evaluation of Materials", J. Prasad & C.G.K. Nair, McGraw Hill Education REFERENCE BOOKS:- 1. "Non-Destructive Testing Techniques", Ravi Prakash, New Age International Publishers 2. "Introduction to Non-Destructive Testing: A Training Guide", P.E. Mix, Wiley 3. "Aeronautical Applications of Non-Destructive Testing", Abbas Fahr, DEStech Publications 4. "Practical Non-Destructive Testing", B. Raj, T. Jayakumar & M. Thavasimuthu, Narosa Publishing House **5.** "Non-Destructive Testing", B. Hull & V. John, Springer-Verlag New York Inc.
8ANU2.2	**Rockets and Missiles**

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	Introduction: History of rockets and missiles;Classification of missiles; Concept of guidance, peaceful application of guidance;Selection of materials for missiles. **Major Components of Missiles:** Airframe, flight control system, guidance subsystem, proximity fuse, warhead, propulsion system. **Rocket Performance:** Aerodynamics characteristics of airframe components, forces and moments whilepassing through atmosphere, slender body aerodynamics, drag estimation; Equations of motion for three-dimensional motionthrough atmosphere and vacuum; One-dimensional and two-dimensional rocket motions in free space and homogeneousgravitational fields, description of vertical, inclined and gravity turn trajectories; Effect of earth's rotation, inertial and non-inertial frames, coordinate transformation; Powered and unpowered flight, boost-glide trajectory, boost-sustain trajectory, long range cruise trajectory, long range ballistic trajectory, re-entry conditions; Brief description of fin-stabilized and spin-stabilized missiles and their force systems; Manoeuvring flight: flat turns, pull-ups, relation between manoeuvrability& static stability margin; Multi-staging of ballistic missiles, separation techniques. **Fundamentals of Guidance:** Different phases of missile; Homing guidance categories; Introduction to aerodynamic and jet control methods; Various types of aerodynamic control methods for tactical and short-range missiles; Various types of thrust vector control methods; Interception and avoidance. **Rocket Propulsion:** Solid, liquid, hybrid rocket motor, single base propellants, double base propellants, composite propellants, CMBD propellants and their ingredients; Propellant grains and types of burns, erosive burning, pyrotechnicdevices and systems, igniter & ignition system; Propellant mass fraction, thrust coefficient, characteristic velocity, burn rate,total impulse; Types of nozzles and thrust vector control. TEXT BOOKS:- 1. "Missile Design and Systems Engineering", E.L. Fleeman, American Institute of Aeronautics & Astronautics 2. "Missile Guidance and Control Systems", George M. Siouris, Springer

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	REFERENCE BOOKS:- 1. "Tactical and Strategic Missile Guidance", P. Zarchan, AIAA 2. "Modern Missile Guidance", R. Yanushevsky, CRC Press 3. "Automatic Control of Aircraft And Missiles", John H. Blacelock, Wiley 4. "Missile Guidance and Pursuit: Kinematics, Dynamics and Control", N.A. Shneydor, Woodhead Publishing 5. "Rocket Propulsion and Spaceflight Dynamics", J.W. Cornelisse, H.F.R. Schöyer& K.F. Wakker, Pitman Publishing Limited
8ANU2.3	**Artificial intelligence**
	Introduction: Artificial intelligence and related fields, brief history of AI; Applications of artificial intelligence; Definition and importance of Knowledge and Learning. **Problem Solving:** Problem definition, problem as a state space search, problem formulation; Problem types, well-defined problems, constraint satisfaction problem, game playing, production systems. **Search Techniques:** Uninformed search techniques: depth first search, breadth first search, depth limit search, search strategy comparison; Informed search techniques: hill climbing, best first search, greedy search, A* search; Adversarial search techniques: minimax procedure, alpha beta procedure. **Machine Learning:** Concepts of learning; Learning from examples; Explanation based learning; Learning by analogy; Learning by simulating evolution; Learning by training neural nets; Learning by training perception. **Knowledge Representation and Reasoning:** Ontologies, foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time, and space; Predicate logic, situation calculus, description logics, reasoning with defaults, reasoning about knowledge, sample applications. **Decision-Making**: Basics of Utility Theory; Decision Theory, sequential decision problems; Elementary Game Theory.

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	Fuzzy Set Theory: Introduction to fuzzy set with properties; Fuzzy relations; Fuzzy arithmetic; Fuzzy logic; Fuzzy control. TEXT BOOKS:- 1. "Artificial Intelligence: A Modern Approach", S.J. Russell & P. Norvig, Pearson Education India 2. "A First Course in Artificial Intelligence", Deepak Khemani, McGraw Hill Education REFERENCE BOOKS:- 1. "Artificial Intelligence", R. Knight, McGraw-Hill 2. "Neural Networks: A Comprehensive Foundation", S. Haykin, Pearson Education 3. "Artificial Intelligence", P.H. Winston, Pearson Education 4. "Artificial Neural Networks", B. Yegnanarayana, Prentice Hall of India 5. "Artificial Intelligence", E. Rich, K. Knight & S.B. Nair, McGraw Hill Education
8ANU3.1	**Refrigeration and Air conditioning**
	Introduction: Brief history and need of refrigeration and air conditioning, methods of producing cooling, ton of refrigeration, coefficient of performance, types and application of refrigeration and air condensing systems. **Refrigerants:** Classification, nomenclature, desirable properties; Eco-friendly refrigerants and environmental issues of refrigeration & air conditioning industry. **Vapour Compression Refrigeration (VCR) Systems:** Simple vapour compression refrigeration systems; Analysis of VCR cycle considering degrees of subcooling and superheating, VCR cycle on P-V, T-s and P-h diagrams; Actual VCR cycle; Comparison of VC cycle with air refrigeration cycle. **Aircraft Refrigeration System:** Necessity of cooling the aeroplane; Reversed Carnot cycle and its limitation; Reversed Brayton cycle; Bell-Coleman cycle; Aircraft refrigeration systems; Working and analysis of simple, bootstrap, reduced ambient and regenerative air refrigeration systems.

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	Psychrometry and Air-conditioning Processes: Properties of moist air: specific humidity, dew point temperature, degree of saturation, relative humidity, wet bulb temperature; Psychrometric chart; Psychrometry of air conditioning processes; Mixing process and other basic processes in conditioning of air. **Air-Conditioning Load Calculations:** Outside and inside design conditions, sources of heating load, sources of cooling load, heat transfer through structure, solar radiation, electrical applications, infiltration and ventilation, heat generation inside conditioned space. **Duct Design:** Classifications, equipment selection; Air distribution system,single and central air conditioning systems; Duct systems design; Filters; Refrigerant piping; Temperature, pressure and humidity sensors; Actuators and safety controls. TEXT BOOKS:- 1. "Refrigeration & Air Conditioning", R.C. Jordan & G.B. Priester, Prentice Hall of India 2. "Refrigeration & Air Conditioning", C.P. Arora, McGraw Hill Education REFERENCE BOOKS:- 1. "Refrigeration and Air Conditioning", W.F. Stoecker& J.W. Jones, McGraw Hill Education 2. "Basic Refrigeration and Air Conditioning", P.N. Ananthanarayanan, McGraw Hill Education 3. "Refrigeration and Air Conditioning", Manohar Prasad, New Age International Private Limited 4. "Refrigeration and Air Conditioning", R.C. Arora, Prentice Hall India Learning Private Limited 5. "Refrigeration and Airconditioning: High Side Design", Arvind Agrawal, New Academic Science Limited
8ANU3.2	**Introduction to Avionics**
	Introduction to Avionics: Basics of avionics, need of avionics in civil and military aircraft and space systems; Cockpit basics; Integrated avionics architecture, typical avionics system and subsystems. **Digital Avionics Bus Architecture:** Data buses MIL-STD-1553B, RS-232, RS-422, RS-485, AFDX, ARINC 664, ARINC

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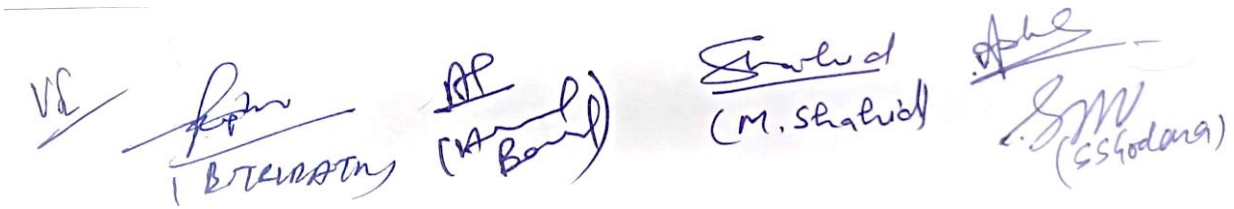
	429, ARINC 629; Aircraft system interface. **Flight Deck and Display Systems**: Flight deck display technologies, CRT, LED, LCD, Touch screen, Head up display, Electronic instrumentation systems. **Audio and Communication Systems:** Aircraft audio systems, basic audio transmitter and receiver principles, VHF communication system, UHF communication systems. **Ranging and Landing Systems**: VHF omnidirectional range, VOR receiver principles, distance maturity equipment, principles of operation; Instrument landing system, localizer and glide slope. **Position Inertial and Navigation System**: Satellite navigation systems, GPS principles, triangulation, position accuracy, applications in aviation; Principle of operation of INS, navigation over earth, components of inertial navigation systems, accelerometers, gyros and stabilized platform. **Surveillance System**: ATC surveillance systems, principles and operations; Standards; Collision avoidance system; Ground proximity warning system. **Auto Flight System:**Basic principles of auto pilot, longitudinal and lateral auto pilot;Automatic flight control system; Fly-by-wire and fly-by-light technologies; Flight director systems; Flight management systems. TEXT BOOKS:- 1. "Introduction to Avionics Systems", R.P.G. Collinson, Springer 2. "Introduction to Avionics", D.R. Cundy & R.S. Brown, Pearson REFERENCE BOOKS:- 1. "Digital Avionics Handbook", C.R .Spitzer, U. Ferrel& T. Ferrel, CRC Press



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	2. "Principles of Avionics", A. Helfrick, Avionics Communications Inc. 3. "Principles of Modern Avionics", S. Nagabhushana& N. Prabhu, I.K. International Publishing House 4. "Civil avionics system" & "Military Avionics Systems", I. Moir, A. Seabridge & M. Jukes, Wiley-Blackwell 5. "Avionics Fundamentals", Jeppensen, Aviall Services
8ANU3.3	**Viscous Flow**
	Introduction: Ideal and real fluid, viscosity in real flows and its effect, d'Alembert's paradox; Laminar and turbulent flow; Vector and tensor notation; Material derivative; Acceleration, translation, rotation and distortion of fluid element; Shear stress and shear strain, Newtonian and non-Newtonian fluids, coefficient of dynamic viscosity and its variation with temperature, coefficient of kinematic viscosity; Physical significance of Reynolds number; Vorticity. **Conservation Laws:** Continuity equation for compressible and incompressible flows, conservative and non-conservative form; Derivation of Navier-Stokes equations and its simplification for incompressible flow, Stokes hypothesis; Energy conservation equation. **Exact Solution of Simplified Flows**: Internal viscous flow in pipes and ducts, Couette flow, lubrication theory, Hagen-Poiseuille flow, Unsteady parallel flow; External viscous flow over flat plates; Creeping flow, Stokes equations, Stokes law. **Laminar Boundary Layer:** Laminar boundary layer equations; Displacement, momentum and energy thickness, shape factor; Kármán momentum integral equation; Similarity solutions, Blasius solution, Kármán-Pohlhausen method for non zero pressure gradient, Holsten and Bohlen method, Waltz's-Quadrature formula; Boundary layer separation, effect of pressure gradient, boundarylayer control. **Turbulent Flows:** Introduction to turbulent flows, features of turbulence, energy cascade, turbulence length scales; Different modes of transition to turbulence; Intermittency factor, mean and fluctuating components, derivation of Reynolds Averaged Navier-Stokes equations, Reynolds stress tensor; Skin friction coefficients for hydrodynamic smooth and rough pipes, Darcy-Weisbach equation, Moody's chart; Turbulent boundary layer equations, eddy viscosity and mixing length hypothesis;

	Structure of turbulent boundary layer, universal law of wall, laminar sublayer, power law for turbulent boundary layer. TEXT BOOKS:- 1. "Viscous Fluid Flow", F.M. White, McGraw Hill Education **2.** "Fluid Mechanics", P.K. Kundu, I.M. Cohen & D.R. Dowling, Academic Press REFERENCE BOOKS:- 1. "Boundary Layer Theory", H. Schlichting, McGraw Hill Education 2. "Viscous Flow", H. Ockendon & J.R. Ockendon, Cambridge University Press 3. "Fluid Mechanics", R.W. Fox, A.T. McDonald, P.J. Pritchard, J.W. Mitchell, Wiley India Edition 4. "Viscous Flows: The Practical Use of Theory", S.W. Churchill, Butterworth-Heinemann Ltd. **5.** "Viscous Flow", Frederick S. Sherman, McGraw-Hill Inc.
8ANU13	**Seminar**
	The purpose of this course is to introduce students to the field of technical research and formal documentation of research work in the form of research papers and technical reports. • Every student is required to select a seminar topic in emerging areas of science and technology broadly related to Aerospace Engineering different from those already covered in previous years, with the consent of Seminar Coordinator. • Each student will be allotted a faculty member to serve as Seminar Guide, under whose guidance the student is supposed to study and present the latest research work related to the topic. • The student should learn to study and summarize research works related to the topic, and identify the state-of-the-art on the chosen topic. • During the class timings, students will give interim presentations on their chosen topics in front of their section tutors. At least two presentations per student should be completed during the semester. • By the end of the semester, every student has to prepare a Seminar Report and a Seminar Presentation. The report should formally summarize the relevant research in the area and be divided into no less than 5 chapters encompassing at least 40 pages, and its formatting should be in accordance with the guidelines provided by Seminar Coordinator.

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	The presentation should be for about 15 minutes and include important and interesting points related to the topic and be technically perfect with proper formatting and grammar. • For internal evaluation, 60% marks will be assigned by section tutor allotted to the respective section based on the presentations given by the student during the semester, and 40% marks will be given by the Seminar Guide according tohis evaluation of efforts put by student. • The external grading would be done by a committee of external examiners appointed by Head of Department, on the basis of final report and presentation.
8AN14	**Major Project**
	• The primary objective of this course is to develop in students the professional quality of synthesis employing technicalknowledge obtained in the field of engineering & technology through a project work involving design and analysisaugmented with creativity, innovation and ingenuity. • The students should form groups of two to four students for the project work. • Each group should work under the guidance of a faculty member who will serve as the project mentor. A feasible and interesting project objective related to aerospace engineering should be chosen taking approval from Project Coordinator. • Each group should meet with its project mentor regularly and maintain the record of discussion in a project diary. • The Project Coordinator should call regular meetings of all groups to monitor their regular progress in their projects, and give constructive suggestions as required. • For internal grading, the Project Coordinator would assign 40%marks based on regular assessment throughout the semester during project review meetings, and the project mentor would give 60 % marks to each student based on his perception of sincerity of the student. • Each group has to prepare a technical report according to the guidelines provided by Project Coordinator. The report should contain introduction to the topic, technical background, objective, working methodology, detailed calculations, data analysis, results, discussion and the final conclusion of project. • The external evaluation would be done by external examiners appointed by HoD based on the final presentation, project demonstration and the technical report. 40% marks may be allocated to the report, 30% marks to the

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	presentation and30% marks to the successful demonstration and realization of desired objectives.
8ANU20	**Discipline & Extra Curricular Activities**
	As per UD, RTU norms

Option-B

8ANUI3	**Seminar**
	• Before proceeding for internship, the student should choose a Seminar topic and get it approved by Seminar Coordinator. • A faculty member as Seminar Guide will be allotted to every student, and the student is required to keep working on the Seminar topic being in touch with his/her Seminar Guide by email/ phone throughout the semester. • The Seminar Guide may ask the student to send interim report/ presentation on the topic, as deemed suitable to assess the efforts put by the student. The entire internal marks shall be allocated based on the discretion of Seminar Guide. • The student is supposed to complete the Seminar Report and presentation within the semester, and be present before the external examination committee at the scheduled date of external exam. The external marks would be assigned by the external examiners based on the report and presentation, giving almost equal weightage to both of them.
8ANU14	**Project cum Internship**
	Guidelines for Semester-long Internship Project **(A) Duration** • The duration of internship should be between 16 to 24 weeks. • The external mentor should ensure that the attendance record of the student is maintained daily and the record

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along with total number of permitted/ unpermitted leaves be handed to the department at the end of approved internship duration.

(B) Nature of internship

- Guiding principle behind internship would be improvement in knowledge/skills and employability of the students and emphasis would be on core companies and practical work on any project.
- Students would be allowed internships in research institutes if they indicate profound interest in academics/ research.
- For non-core companies, the head of department should frame a policy by constituting a department level committee. For each student choosing to go to such an organization, the department level committee would review each case on its merit after receiving the justification from the student.
- The special opportunity for whole semester internship is optional, subject to the student getting a suitable and justifiable project work to replace the course work and project in the college. The permission shall be granted only on merit of the problem statement and the proposed organisation, not for general training similar to mandatory summer training after third year where information on some aspects may be provided without a well-defined project objective.

(C) Approval of Internship Request

- A student who wishes to undertake semester long internship outside the college should submit a cover letter containing the details of proposed work along with the approval letter from his proposed mentor as per the format provided by Project Coordinator by the end of November to the project coordinator.
- The project coordinator would forward the application with his specific comments to HoD, or in case of non-core companies to the departmental committee, which will then give its recommendation to HoD.
- Head of Department would be the final authority to sanction the request for outstation internship of any student.

(D) Monitoring

- Students whose outstation internship request is approved have to ensure that their joining reports in standard form provided by the department are received by the department within 15 days of joining, failing which the approval for internship may deemed to be cancelled.

- The concerned department may try to identify and request adjunct faculty/ experts/ RTU alumni to guide and monitor the work of the students working nearby their location.
- The students need to mail the monthly progress report signed by the official mentor to the project coordinator.
- The project coordinator should try to remain in touch with the students' project mentors via email/ phone to keep a watch on the progress of project work.

(E) Preparation of Report

- Each student needs to prepare a comprehensive report of the work as per guidelines given by the project coordinator.
- A copy of the final report should be submitted to the internship organization at the end of project work and another copy signed by the project mentor to the project coordinator before the final external practical exam at the department.

(F) Feedback

- The project external mentor should fill an online feedback form regarding the performance of student during the stay at the end of the duration of internship using a link provided by project coordinator.
- The student should also fill a feedback form regarding his/her experience during the internship for future reference.

(G) Grading

- External evaluation would be done by a panel of faculty members appointed by HoD based on the presentation given by student and final report submitted at the end of project duration.
- 250 marks in the internal evaluation should be given by external mentor to the project coordinator confidentially in the online feedback form.
- The remaining internal marks would be assigned by project coordinator based on regular submission of progress report, feedback from mentor and viva.

(H) Certification

- After successful completion of internship, a certificate should be provided by the host institute to the student with specific comment about his/ her performance.

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	• The department will also provide a certificate to the student mentioning the project topic and place of internship.
8ANU20	**Extra-Curricular & Discipline**
	As per UD, RTU norms

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