VISVESVARAYA TECHNOLOGICAL UNIVERSITY, BELGAUM

CHOICE BASED CREDIT SYSTEM (CBCS)

SCHEME OF TEACHING AND EXAMINATION 2015-2016

Aeronautical Engineering
VIII SEMESTER

Sl. No	Subject Code	Title	Teaching Hours /Week		Examination				Credit
			Theory	Practical/Drawing	Duration	I.A. Marks	Theory/ Practical Marks	Total Marks	
1	15AE81	AVIONICS	4	-	3	20	80	100	4
2	15AE82	FLIGHT VEHICLE DESIGN	4	-	3	20	80	100	4
3	15AE83X	Professional Elective	3	-	3	20	80	100	3
4	15AE84	Internship / Professional Practice	Industry Oriented		3	50	50	100	2
5	15AEP85	Project Work Phase -II	-	6	3	100	100	200	6
6	15AES86	Seminar	-	4	-	100	-	100	1
TOTAL			11	10	15	310	390	700	20

Professional Elective	
15AE831	FLIGHT TESTING
15AE832	BOUNDARY LAYER THEORY
15AE833	OPTIMIZATION TECHNIQUES
15AE834	CRYOGENICS

1. **Core subject:** This is the course, which is to be compulsorily studied by a student as a core requirement to complete the requirement of a programme in a said discipline of study.

2. **Professional Elective:** Elective relevant to chosen specialization/ branch

3. **Internship / Professional Practice:** To be carried between the 6th and 7th semester vacation or 7th and 8th semester vacation period.

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AVIONICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VIII

Subject Code	**15AE81**	IA Marks	20
Number of Lecture Hours/Week	04	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course Objectives: This course will enable students to

1. Understand the need for avionics in civil, military and space systems.
2. Appreciate the use of microprocessors, data buses and avionics system architectures.
3. Acquire the knowledge of display technologies, communication and navigation systems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Power Distribution System:** Bus Bar, split bus bar system, special purpose cables. Electrical diagram and identification scheme. Circuit controlling devices. Power utilization-typical application to avionics. Need for Avionics in civil and military aircraft.	**10 Hours**	**L1, L2**
Module -2 **Inertial Navigation System:** Gyroscopic versus Inertial platform. Structure of stable platform. Inertial Navigation units. Inertial alignment. Inertial interface system. Importance of Compass swing. **Electronic Flight Control System:** Fly-by-wire system: - basic concept	**10 Hours**	**L1, L2**

and features. Pitch and Roll rate: - command and response. Control Laws. Frequency response of a typical FBW actuator. Cooper Harper scale. Redundancy and failure survival. Common mode of failures and effects analysis.		
Module -3 **Electronic Flight Instrument Systems:** Display -units, presentation, failure, and annunciation. Display of air data. **Introduction to Avionics Sub Systems and Electronic Circuits:** Typical avionics subsystems. Amplifier, oscillator, aircraft communication system, transmitter, receiver, antenna.	**10 Hours**	**L1, L2, L3**
Module -4 **Principles of Digital Systems:** Digital Computers, Microprocessors, Memories **Flight Deck and Cockpits:** Control and display technologies CRT, LED, LCD, EL and plasma panel, Touch screen, Direct voice input (DVI) - Civil cockpit and military cockpit : MFDS, HUD, MFK, HOTAS.	**10 Hours**	**L1, L2**
Module -5 **Avionics Systems Integration:** Avionics equipment fit. Electrical data bus system. Communication Systems, Navigation systems, Flight control systems, Radar, Electronic Warfare, and fire control system. Avionics system architecture, Data buses, MIL–STD 1553 B.	**10 Hours**	**L1, L2**

Course Outcomes:

After studying this course, students will be able to:

1. Select the suitable data bus based on the application.
2. Identify the suitable navigation systems.
3. Distinguish the avionics system architecture.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

Text Books:

1. R.P.G. Collinson., "Introduction to Avionics Systems", Springer, 3rd edition, 2011,ISBN-13: 978-9400707078
2. Ian Moir, Allan Seabridge, Aircraft Systems: Mechanics, Electrical and Avionics Subsystems Integration, Wiley, 3rd Edition, 2012.

Reference Books:

1. Middleton, D.H., Ed., "Avionics Systems, Longman Scientific and Technical", Longman Group UK Ltd., England, 1989, ISBN-13: 978-0582018815.
2. Spitzer, C.R., "Digital Avionic Systems", McGraw-Hill Inc., US, 2nd edition, 1992, ISBN-13: 978-0070603332.
3. Mike Tooley and David Wyatt, Aircraft Communications and Navigation Systems, Butterworth Heinemann, 2007.
4. D.R. Cundy and R.S. Brown, Introduction to Avionics, Pearson, 2010.

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FLIGHT VEHICLE DESIGN
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII

Subject Code	**15AE82**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	50	Exam Marks	80

CREDITS – 04

Course Objectives: This course will enable students to

1. Comprehend the flight vehicle design process.
2. Acquire the knowledge of vehicle configuration and structural components.
3. Understand the stability & control and subsystems.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Overview of Design Process:** Introduction, Requirements, Phases of design, Conceptual Design Process, Initial Sizing, Take-off weight build up, Empty weight estimation, Fuel fraction estimation, Take- off weight calculation. **Thrust to Weight Ratio & Wing Loading:** Thrust to Weight Definitions, Statistical Estimate of T/W. Thrust matching, Spread sheet in design, Wing Loading and its effect on Stall speed, Take-off Distance, Catapult take-off, and Landing Distance. Wing Loading for Cruise, Loiter, Endurance, Instantaneous Turn rate, Sustained Turn rate, Climb, & Glide, Maximum ceiling.	**6 Hours**	**L1, L2**
Module -2 **Configuration Layout & loft**: Conic Lofting, Conic Fuselage Development, Conic Shape Parameter, Wing-Tail Layout & Loft. Aerofoil Linear Interpolation. Aerofoil Flat-wrap Interpolation. Wing	**6 Hours**	**L1, L2**

aerofoil layout-flap wrap. Wetted area determination. Special considerations in Configuration Layout: Aerodynamic, Structural, Detectability. Crew station, Passenger, and Payload arrangements. **Design of Structural Components:** Fuselage, Wing, Horizontal & Vertical Tail. Spreadsheet for fuselage design. Tail arrangements, Horizontal & Vertical Tail Sizing. Tail Placement. Loads on Structure. V-n Diagram, Gust Envelope. Loads distribution, Shear and Bending Moment analysis.		
Module -3 **Engine Selection & Flight Vehicle Performance** Turbojet Engine Sizing, Installed Thrust Correction, Spread Sheet for Turbojet Engine Sizing. Propeller Propulsive System. Propeller design for cruise. Take-off, Landing & Enhanced Lift Devices :- Ground Roll, Rotation, Transition, Climb, Balanced Field Length, Landing Approach, Braking, Spread Sheet for Take-off and Landing. Enhanced lift design -Passive & Active. Spread Sheet	**8 Hours**	**L1, L2, L3**
Module -4 **Static Stability & Control** Longitudinal Static Stability, Pitch Trim Equation. Effect of Airframe components on Static Stability. Lateral stability. Contribution of Airframe components. Directional Static stability. Contribution of Airframe components. Aileron Sizing, Rudder Sizing. Spread Sheets. Flying qualities. Cooper Harper Scale. Environmental constraints, Aerodynamic requirements.	**10 Hours**	**L1, L2, L3**
Module -5 **Design Aspects of Subsystems** Flight Control system, Landing Gear and subsystem, Propulsion and Fuel System Integration, Air Pressurization and Air Conditioning System, Electrical & Avionic Systems, Structural loads, Safety constraints, Material selection criteria.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Calculate the thrust to weight ratio and wing loading.
2. Compute the flight vehicle performance.
3. Select the subsystems as per vehicle design.

Graduate Attributes :

- Engineering Knowledge.

- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

Text Books:

1. Daniel P. Raymer, Aircraft Design - A Conceptual Approach- AIAA Education Series, IV Edition, 2006.
2. Thomas C Corke, Design of Aircraft- Pearson Edition. Inc. © 2003.

Reference Books:

1. J Roskam, Aeroplane Design –Vol: 1 to 9
2. John Fielding, Introduction to Aircraft Design - Cambridge University Press, 2009
3. Standard Handbook for Aeronautical & Astronautical Engineers, Editor Mark Davies , Tata McGraw Hill, 2010.

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Professional Electives:

<table>
<tr><td colspan="4" align="center">FLIGHT TESTING
[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII
Professional Elective</td></tr>
<tr><td>Subject Code</td><td>15AE831</td><td>IA Marks</td><td>20</td></tr>
<tr><td>Number of Lecture Hours/Week</td><td>03</td><td>Exam Hours</td><td>03</td></tr>
<tr><td>Total Number of Lecture Hours</td><td>40</td><td>Exam Marks</td><td>80</td></tr>
<tr><td colspan="4" align="center">CREDITS – 03</td></tr>
<tr><td colspan="4">Course Objectives: This course will enable students to
1. Comprehend the basic concepts of flight test instrumentation.
2. Acquire the knowledge of performance flight testing and stability control.
3. Understand the flying qualities.</td></tr>
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Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Introduction:** Sequence, Planning and governing regulations of flight testing. Aircraft weight and center of gravity, flight testing tolerances. Method of reducing data uncertainty in flight test data - sources and magnitudes of error, avoiding and minimizing errors. **Flight test instrumentation:** Planning flight test instrumentation, Measurement of flight parameters. Onboard and ground based data acquisition system. Radio telemetry.	**6 Hours**	**L1, L2**
Module -2 **Performance flight testing - range, endurance and climb:** Airspeed – in flight calibration. Level flight performance for propeller driven aircraft and for Jet aircraft - Techniques and data reduction. Estimation of range, endurance and climb performance. **Performance flight testing -take-off, landing, turning flight:**	**6 Hours**	**L1, L2**

Maneuvering performance estimation. Take-off and landing - methods, procedures and data reduction.		
Module -3 **Stability and control - longitudinal and maneuvering** Static & dynamic longitudinal stability: - methods of flight testing and data reduction techniques. Stick free stability methods. Maneuvering stability methods & data reduction.	**8 Hours**	**L1, L2, L3**
Module -4 **Stability and control - lateral and directional** Lateral and directional static & dynamic stability: - Coupling between rolling and yawing moments. Steady heading slide slip. Definition of Roll stability. Adverse yaw effects. Aileron reversal. Regulations, test techniques and method of data reduction.	**10 Hours**	**L1, L2, L3**
Module -5 **Flying qualities:** MIL and FAR regulations. Cooper-Harper scale. Pilot Rating. Flight test procedures. **Hazardous flight testing:** Stall and spin- regulations, test and recovery techniques. Test techniques for flutter, vibration and buffeting.	**10 Hours**	**L1, L2, L3**

Course Outcomes:

After studying this course, students will be able to:

1. Measure the flight parameters.
2. Estimate the performance of flight.
3. Apply the FAR regulations.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

module.

Text Books:

1. Ralph D Kimberlin, Flight Testing of Fixed Wing Aircraft, AIAA educational Series,2003.
2. Benson Hamlin, Flight Testing- Conventional and Jet Propelled Airplanes, Mac Millan, 1946

Reference Books:

1. AGARD, Flight Test Manual Vol. I to IV
2. A.J. Keane, A. Sobester, Small Unmanned fixed-wing Aircraft Design, Wiley, 2017.
3. A. Filippone, Flight Performance of Fixed and Rotary Wing Aircraft, AIAA Series, 2006.

BOUNDARY LAYER THEORY

[As per Choice Based Credit System (CBCS) scheme]
SEMESTER – VIII
Professional Elective

Subject Code	**15AE832**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

CREDITS – 03

Course Objectives: This course will enable students to

1. Comprehend the basic concepts and equations of viscous flow.
2. Acquire the knowledge of laminar boundary layer and its equations.
3. Understand the turbulence, instrumentation and measurements.

Modules	**Teaching Hours**	**Revised Bloom's Taxonomy (RBT) Level**
Module -1 **Preliminary Concepts** Some examples of viscous flow phenomena: - aerofoil, cylinder, circular pipe. Boundary conditions for viscous flow problems. The kinematics properties of viscous flow.	**6 Hours**	**L1, L2**

Fundamental Equations of Viscous Flow Conservation of mass, momentum and energy equations. Mathematical characterisation of basic equations. Dimensionless parameters in viscous flow.		
Module -2 **Solutions of Viscous Flow Equations** Classification of solutions. Couette flow, stability of Couette flow. Poiseuille steady flow through duct. Unsteady duct flow between plates with bottom injection and top suction. Plane stagnation flow-differential equation free of parameters.	**6 Hours**	**L1, L2**
Module -3 **Introduction to Laminar Boundary Layer** Laminar boundary layer equations. Flat plate Integral analysis. Displacement thickness, Momentum and Energy thicknesses for two dimensional flows; Shape factor. Some insight into boundary layer approximations. Discussion of Navier Stokes equations. Concept of thermal boundary layer.	**8 Hours**	**L1, L2, L3**
Module -4 **Laminar Boundary Layer Equations** Dimensionless variables. Laminar boundary layer equations. Similarity solutions for steady two-dimensional flow. Blasius solution for flat- plate flow, wall shear stress. Flat plate heat transfer for constant wall temperature. Some examples of Falkner-Skan potential flows. Reynolds analogy as a function of pressure gradient.	**10 Hours**	**L1, L2, L3**
Module -5 **Transition to Turbulence** Stability of laminar flows - concept of small disturbance stability. Temporal instability and Spatial instability. Stability of Blasius and Falkner-Skan profiles. Effect of wall temperature. Transition to turbulence. Affecting parameters **Incompressible Turbulent Mean Flow** Physical and mathematical description of turbulence. Fluctuations and time averaging. Turbulent flow in pipes and channels. Free turbulence: - jets, wakes and mixing layers.	**10 Hours**	**L1, L2, L3**

Instrumentation and Measurements: Hot wire and Hot film anemometer for turbulence measurements. Schlieren methods for flow visualization. Pressure probes, Interferometer and Smoke method.		

Course Outcomes:

After studying this course, students will be able to:

1. Apply the basic concepts and equations of viscous flow.
2. Discuss the importance of Navier Stokes equation.
3. Measure the turbulence.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

Text Books:

1. H. Schlichting, `Boundary Layer Theory`, McGraw- Hill, New York, 1979.
2. Frank White,` Viscous Fluid flow` - McGraw Hill, 1991.

Reference Books:

1. J.P. Hollman and W.J. Gajda, Jr. ‘Experimental methods for Engineers’, 5th Edition McGraw- Hill , 1989
2. Ronald L., Panton, `Incompressible fluid flow`, John Wiley & Sons, 1984.

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OPTIMIZATION TECHNIQUES

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VIII

Professional Elective

Subject Code	**15AE833**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

CREDITS – 03

Course Objectives:

This course will enable students to

1. Understand the unconstrained and constrained minimization.
2. Comprehend the direct search methods, discrete and dynamics programming.
3. Acquire the knowledge on finite element based optimization.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction:** Non-linear programming. Mathematical fundamentals. Numerical evaluation of gradient. **Unconstrained Optimisation:** One dimensional, single variable optimization. Maximum of a function. Unimodal-Fibonacci method. Polynomial based methods.	**8 Hours**	**L1, L2**
Module -2 **Unconstrained Minimization:** Multivariable functions. Necessary and sufficient conditions for optimality. Convexity. Steepest Descent Method - Convergence Characteristics. Conjugate Gradient Method. Linear	**7 Hours**	**L1, L2**

programming -Simplex Method.		
Module -3 **Constrained Minimization:** Non-linear programming. Gradient based methods. Rosens`s gradient, Zoutendijk`s method, Generalised reduced gradient, Sequential quadratic programming. Sufficient condition for optimality.	**7 Hours**	**L1, L2, L3**
Module -4 **Direct Search Methods: D**irect search methods for nonlinear optimization. Cyclic coordinate search. Hooke and Jeeves Pattern search method. Generic algorithm. **Discrete And Dynamic Programming:** Integer and discrete programming. Branch and bound algorithm for mixed integers. General definition of dynamic programming problem. Problem modeling and computer implementation. Shortest path problem	**9 Hours**	**L1, L2**
Module -5 **Optimisation Application:** Transportation problem. Transportation simplex method. Network problems. Maximum flow in net works. General definition of dynamic programming. Problem modeling and computer implementation. **Finite Element Based Optimisation :** Parameter optimization using gradient methods -Derivative calculation. Shape optimisation. Topology optimisation of continuum structures.	**9 Hours**	**L1, L2**

Course Outcomes:

After studying this course, students will be able to:

1. Identify the unconstrained and constrained minimization effect of fluid properties.
2. Apply the direct search methods, discrete and dynamics programming.
3. Classify the optimisation application.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

Text Books:

1. Ashok D Belegundu and Tirupathi R . Chandrupatla, `Optimisation Concepts and Applications in Engineering`, Pearson Education, In C.,1991.
2. Fletcher, R, `Practical Methods of Optimisation`, Wiley, New York ,2nd Edition, 2009,ISBN-13: 978-8126524259.

Reference Books:

1. Dennis J.E. and Schnabel, R. B., `Numerical Methods for Unconstrained Optimisation and Nonlinear Equations`, Prentice Hall, Engle Wood Cliffs, New Jersey, 1983.
2. S.S. Rao, ` Optimisation -Theory and Application`, Wiley Eastern Ltd., 5th Edition.1990.

CRYOGENICS

[As per Choice Based Credit System (CBCS) scheme]

SEMESTER – VIII

Subject Code	**15AS834**	IA Marks	20
Number of Lecture Hours/Week	03	Exam Hours	03
Total Number of Lecture Hours	40	Exam Marks	80

CREDITS – 03

Course objective:

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This course will enable students to

1. Understand the basic of cryogenic engineering.
2. Understand the cryogenic properties and insulation.
3. Acquire the knowledge on storage of cryogenic liquids and equipments.

Modules	Teaching Hours	Revised Bloom's Taxonomy (RBT) Level
Module -1 **Introduction to Cryogenic Engineering:** Thermo physical and fluid dynamic properties of liquid and gas hydrogen, Thermo physical and fluid dynamic properties of liquid and gas helium, Liquefaction systems of hydrogen and helium gases, Liquefaction systems of hydrogen and helium gases, Refrigeration and liquefaction principals; Joule Thomson effect and inversion curve; Adiabatic and isenthalpic expansion with their comparison.	**9 Hours**	**L1, L2**
Module -2 **Properties:** Cryogenic fluids, Solids at cryogenic temperatures; Superconductivity, Recuperative - Linde - Hampson, Claude, Cascade, Heylandt, Kapitza, Collins, Simon; Regenerative - Stirling cycle and refrigerator, Slovay refrigerator, Gifford-McMahon refrigerator, Vuilleumier refrigerator, Pulse Tube refrigerator; Liquefaction of natural gas. .	**8 Hours**	**L1, L2**
Module -3 **Cryogenic Insulation:** Vacuum insulation, Evacuated porous insulation, Gas filled Powders and fibrous materials, Solid foams, Multilayer insulation, Liquid and vapour Shields, Composite insulations	**7 Hours**	**L1, L2, L3**
Module -4 **Storage and Instrumentation of Cryogenic liquids:** Design considerations of storage vessel; Dewar vessels; Industrial storage vessels; Storage of cryogenic fluids in space; Transfer systems and Lines for cryogenic liquids; Cryogenic valves in transfer lines; Two phase flow in Transfer system; Cool-down of storage and transfer systems, Measurement of strain, pressure, flow, liquid level and Temperature in cryogenic environment; Cryostats.	**8 Hours**	**L1, L2**

Module -5	**8 Hours**	**L1, L2**
Cryogenic Equipment: Cryogenic heat exchangers - recuperative and regenerative; Variables affecting heat exchanger and system performance; Cryogenic compressors, Pumps, expanders; Turbo alternators; Effect of component inefficiencies; System Optimization, Magneto-caloric refrigerator; 3He-4He Dilution refrigerator; Cryopumping; Cryogenic Engineering applications in energy, aeronautics, space, industry, biology, preservation Application of Cryogenic Engineering in Transport.		

Course Outcomes:

After studying this course, students will be able to:

1. Recognize the basic of cryogenic engineering.
2. Identify the storage and instrumentation required for cryogenic liquids.
3. Classify the types of cryogenic equipments.

Graduate Attributes :

- Engineering Knowledge.
- Problem Analysis.
- Design / development of solutions
- Interpretation of data

Question paper pattern:

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

Text Books:

1. T.M. Flynn, Marcel Dekker., Cryogenic Engineering, CRC Press,2nd edition, 2004,ISBN-13: 978-8126504985
2. A. Bose and P. Sengupta, "Cryogenics: Applications and Progress", Tata McGraw Hill.

Reference Books:

1. J.G. Weisend II, Taylor and Francis , "Handbook of Cryogenic Engineering", CRC Press,1st edition,1998,ISBN-13: 978-1560323327
2. R.Barron,"Cryogenic Systems", Oxford University Press.
3. K.D.Timmerhaus and T.M. Flynn, "Cryogenic Process Engineering", Plenum Press,1st edition,2013,ISBN-13: 978-1468487589
4. G.G.Haselden,"Cryogenic Fundamentals", Academic Press.
5. C.A.Bailey,"Advanced Cryogenics", Springer,1971,ISBN-13: 978-0306304583
6. R.W. Vance and W.M. Duke , "Applied Cryogenic Engineering", John Wiley & sons,1962,ISBN-13: 978-0471902706