

## ROCKETS AND MISSILES

<b>II Semester: AE</b>																													
Course Code	Category	Hours /Week			Credits	Maximum Marks																							
<b>BAEC16</b>	<b>Elective</b>	L	T	P	C	CI A	SEE	Total																					
		3	-	-	3	30	70	100																					
<b>Contact Classes:45</b>		<b>Tutorial Classes: Nil</b>			<b>Practical Classes: Nil</b>		<b>TotalClasses:45</b>																						
<p><b>I. COURSE OVERVIEW:</b>            This course deals in detail about rockets propulsion systems. This course includes various equation of motion and various moments of a rocket. It compares and contrasts various thrust vector control mechanisms of nozzle and cooling systems of combustion chamber. It discusses on various materials and its properties that are used for manufacturing of rocket and missiles. This course also covers the basic concepts of guidance of missile and various types of tactical guidance systems and techniques.</p> <p><b>II. COURSE OBJECTIVES:</b>  <b>The students will try to learn:</b></p> <ol style="list-style-type: none"> <li>I. The fundamental concepts of various rocket propulsion systems, combustion process and forces/moments acting on the rocket under static and dynamic conditions.</li> <li>II. Various components and propellants of a chemical rocket propulsion system with its characteristics and applications.</li> <li>III. The various aerodynamic forces and moments acting on a rocket.</li> <li>IV. Properties of different materials that are used in manufacturing of various rocket and missile components.</li> </ol> <p><b>III. COURSE OUTCOMES:</b>  <b>After successful completion of the course, students will be able to:</b></p> <table border="1" style="width: 100%; border-collapse: collapse;"> <thead> <tr> <th style="width: 10%;">CO</th> <th style="width: 70%;">Outcome</th> <th style="width: 20%;">Level</th> </tr> </thead> <tbody> <tr> <td>CO1</td> <td>Apply the knowledge of combustion systems and feed systems of rockets for selecting the suitable component based on the mission requirement.</td> <td style="text-align: center;">Understand</td> </tr> <tr> <td>CO2</td> <td>Utilize the knowledge of aerodynamic forces and moments of Rockets and missiles for designing with optimum performance.</td> <td style="text-align: center;">Apply</td> </tr> <tr> <td>CO3</td> <td>Apply the concepts of 1-D, 2-D rocket motions in free space and gravitational fields for solving the problems in space.</td> <td style="text-align: center;">Analyze</td> </tr> <tr> <td>CO4</td> <td>Analyze the combinations of trajectories, range, altitude and velocity of rockets and missiles for specific application.</td> <td style="text-align: center;">Apply</td> </tr> <tr> <td>CO5</td> <td>Categorize the staging and controls of planned rocket and missiles for providing sufficient capability such as speed, range, and maneuverability.</td> <td style="text-align: center;">Apply</td> </tr> <tr> <td>CO6</td> <td>Make use of the selection criteria of materials properties for designing new components under adverse conditions.</td> <td style="text-align: center;">Understand</td> </tr> </tbody> </table> <p><b>IV. COURSE SYLLABUS:</b>  <b>MODULE-I: ROCKETSYSTEMS (08)</b>            Ignition system in rockets, types of igniters, igniter design considerations; Design consideration of liquid rocket combustion chamber, injector propellant feed lines, valves, propellant tanks and their outlets; Pressurized and turbine feed systems; Propellant slosh and propellant hammer; Elimination of geysering effect in missiles; Combustion system of solid rockets.</p> <p><b>MODULE-II: AERODYNAMICS OF ROCKET AND MISSILES (10)</b>            Airframe components of rockets and missiles; Forces acting on a missile while passing through atmosphere; Classification of missiles; Method of describing aerodynamic forces and moments; Lateral aero dynamic</p>									CO	Outcome	Level	CO1	Apply the knowledge of combustion systems and feed systems of rockets for selecting the suitable component based on the mission requirement.	Understand	CO2	Utilize the knowledge of aerodynamic forces and moments of Rockets and missiles for designing with optimum performance.	Apply	CO3	Apply the concepts of 1-D, 2-D rocket motions in free space and gravitational fields for solving the problems in space.	Analyze	CO4	Analyze the combinations of trajectories, range, altitude and velocity of rockets and missiles for specific application.	Apply	CO5	Categorize the staging and controls of planned rocket and missiles for providing sufficient capability such as speed, range, and maneuverability.	Apply	CO6	Make use of the selection criteria of materials properties for designing new components under adverse conditions.	Understand
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moment; Lateral damping moment and longitudinal moment of a rocket; Lift and drag forces; Drag estimation; Body up wash and down wash in missiles; Rocket dispersion; Numerical problems.

### **MODULE-III: ROCKET MOTION IN FREE SPACE AND GRAVITATIONAL FIELD (10)**

One dimensional and two dimensional rocket motions in free space and homogeneous gravitational fields; Description of vertical, inclined and gravity turn trajectories.

Determination of range and altitude; Simple approximations to burn out velocity.

### **MODULE-IV: STAGING AND CONTROL OF ROCKET AND MISSILES (09)**

Rocket vector control, methods, thrust termination; Secondary injection thrust vector control system; Multistage of rockets; Vehicle optimization; Stage separation dynamics; Separation techniques.

### **MODULE-V: MATERIALS FOR ROCKET AND MISSILES (08)**

Selection of materials; Special requirements of materials to perform under adverse conditions.

## **V. TEXT BOOKS:**

1. P. Sutton, O. Biblarz, "Rocket Propulsion Elements", John Wiley & Sons Inc., New York, 8<sup>th</sup> Edition, 2010.
2. M.J.L.Turner, "Rocket and Spacecraft Propulsion", Praxis publishing, 2<sup>nd</sup> Edition, 2006.
3. M.Mathur, R.P.Sharma, "Gas Turbines and Jet and Rocket Propulsion", Standard Publishers, New Delhi, 4<sup>th</sup> Edition, 2005.

## **VI. REFERENCE BOOKS:**

1. J.W.Cornelisse, H.F.R.Schoyer & K.F.Wakker, "Rocket Propulsion and Space Dynamics", Pitman Publications, London, 1<sup>st</sup> Edition, 1979.
2. E.R.Parket, "Materials for Missiles and Spacecraft", McGraw Hill Book Co., 2<sup>nd</sup> Edition, 1982.
3. Gordon C. Oates, "Aerothermodynamics of Gas Turbine Rocket Propulsion" American Institute of Aeronautics and Astronautics, Inc. 3<sup>rd</sup> Edition, 1997.

## **VII. WEB REFERENCES:**

1. <http://as.wiley.com/WileyCDA/WileyTitle/productCd-0470080248.html>
2. <https://archive.org/details/RocketPropulsionAndSpaceflightDynamics>
3. [http://rapidshare.com/files/163497637/The\\_Jet\\_Engine.rar](http://rapidshare.com/files/163497637/The_Jet_Engine.rar)
4. <http://www.personal.utulsa.edu/~kenneth-weston/chapter5.pdf>

## **VIII. E-TEXT BOOKS:**

1. [http://www.ewp.rpi.edu/hartford/~ernesto/S2013/EP/MaterialsforStudents/Lee/Sutton-Biblarz-Rocket\\_Propulsion\\_Elements.pdf](http://www.ewp.rpi.edu/hartford/~ernesto/S2013/EP/MaterialsforStudents/Lee/Sutton-Biblarz-Rocket_Propulsion_Elements.pdf)
2. <https://archive.org/details/RocketPropulsionAndSpaceflightDynamics>
3. [http://www.pyrobin.com/files/rocket%20and%20spacecraft%20propulsion%203540221905\\_1.pdf](http://www.pyrobin.com/files/rocket%20and%20spacecraft%20propulsion%203540221905_1.pdf)