INSTITUTEOFAERONAUTICALENGINEERING

(Autonomous)
Dundigal,Hyderabad-500043

AERONAUTICAL ENGINEERING

COURSE DESCRIPTION FORM

Course Title	**SPACE MECHANICS**			
Course Code	**A72124**			
Regulation	**R15-JNTUH**			
Course Structure	**Lectures**	**Tutorials**	**Practical**	**Credits**
	4	**-**	**-**	**4**
Course Coordinator	**Dr. P K Mohanta, Associate Professor, Department of AE.**			
Team of Instructors	**Dr. P K Mohanta, Associate Professor, Department of AE.**			

I. COURSE OVERVIEW

The spacemechanics is the first course for graduate and undergraduate students in Aerospace Engineering.The advanced course on space flight mechanicendeavor on specialization of the sub streams of the Sun and planetary system, rockets and trajectory, orbits and space environments etc.The proposed course even though is introductory but effort will be made to expose to the complicacies of the sub streams in space flight mechanics,so that student get exposure to the various aspects of the subject related to space mission, and can appreciate the complicacies involved which will further imbue curiosity to understand the complexity of the subject and as well as to explore it.Even though the main thrust will be on the orbital mechanics but the subject will be enriched with the introduction to rockets which will make the subject matter well understood.Complete in the sense that from the starting phase of launching of a satellite to its orbit maintenance and determination will be covered to give the students a complete glimpse of the space flight without which it will remain a theoretical exercise which availed in many text books.A number of problems will be solved to enhance the understanding of the subject matter and besides, many unsolved problems will be provided with answers to further test the student's learning.

II. PREREQUISITE(S)

Level	Credits	Periods	Prerequisite
UG	5	4	Mathematics
UG	4	4	Flight Mechanics

III. MARKS DISTRIBUTION

Sessional Marks	University End Exam Marks	Total Marks
Mid Semester Test There shall be two midterm examinations. Each midterm examination consists of subjective type and objective type tests. The subjective test is for 10 marks of 60 minutes duration. Subjective test of shall contain 4 questions; the student has to answer 2 questions, each carrying 5 marks.The objective type test is for	75	100

10 marks of 20 minutes duration. It consists of 10 Multiple choice and 10 objective type questions, the student has to answer all the questions and each carries half mark.First midterm examination shall be conducted for the first two and half units of syllabus and second midterm examination shall be conducted for the remaining portion. **Assignment** Five marks are marked for assignments. There shall be two assignments in every theory course. Marks shall be awarded considering the average of two assignments in each course		

IV. EVALUATION SCHEME

S.No	Component	Duration	Marks
1	I Mid examination	80 minutes	20
2	I Assignment	--	05
3	II Mid examination	80 minutes	20
4	II Assignment	--	05
5	External examination	3 hours	75

V. COURSE OBJECTIVES

I. Understand and appreciate the importance of solar system and augmentation of knowledge on various aspects of space and the Earth bounded terms.
II. Know the mathematical physics involved on satellite and space vehicle flight dynamics.
III. Comprehend the life cycle and operational maneuvers of satellite.
IV. Calculate the ballistic missile performance and trajectory design.
V. Evaluate inter planetary motion of space probe and satellite.
VI. Awareness about the space environments.

VI. COURSE OUTCOMES

After completing this course the student must demonstrate the knowledge and ability to:

1. Develop the knowledge about space system and spaceenvironments.
2. Understood the parameters and variables of aorbitalmechanics.
3. Can represent the space flight mechanics phenomena as a mathematical model and Evaluate it to obtain the response
4. Understood the concept of ballistic trajectory and satellite operation, and how to find it for effectiveapplication.
5. Recognize the concept of life cycle of satellite and its orbitalmaneuver.
6. Analyze the interplanetarymission.
7. Cognize the process of satellite and space vehicle motion andcontrol.

VII. HOW PROGRAM OUTCOMES ARE ASSESSED

Program outcomes		Level	Proficiency assessed by
PO1	**General knowledge:** Knowledge in fundamentals of mathematics, science and engineering	H	Assignments
PO2	**Problem Analysis:**An ability to identify, formulate and solve problems in key areas of Aerodynamics, Structures, Propulsion, Flight Dynamics and Control, Design, Testing, Space and Missile Technologies and Aviation of Aeronautical Engineering discipline	S	Exercise
PO3	**Design/Development of solutions:**An ability to design and conduct experiments, analyze and interpret data related to various areas of Aeronautical Engineering.	H	Assignments, Discussion
PO4	**Conduct investigations of complex problems**: An ability in conducting investigations to solve problems using research based knowledge and methods to provide logical conclusions.	S	Exercise
PO5	**Modern tool usage:**Skills to use modern engineering and IT tools, software and equipment to analyze the problems in Aeronautical Engineering.	H	Exercise
PO6	**The engineer and society**: Understanding of impact of engineering solutions on the society to assess health, safety, legal, and social issues in Aeronautical Engineering.	H	Exercise
PO7	**Environment and sustainability:**The impact of professional engineering solutions in environmental context and to be able to respond effectively to the needs of sustainable development.	--	----
PO8	**Ethics:**The knowledge of Professional and ethical responsibilities.	H	Discussion, Seminars
PO9	**Individual and team work:**An ability to work effectively as an individual and as a team member/leader in multidisciplinary areas.	H	Discussions
PO10	**Communication:**An ability to critique writing samples (abstract, executive summary, project report), and oral presentations.	H	Discussion, Seminars
PO11	**Life-long learning**:Knowledge of management principles and apply these to manage projects in multidisciplinary environments.	--	-----
PO12	**Project management and finance**: The need of self education and ability to engage in life - long learning.	H	Discussions

S - Supportive **H – Highly Related**

VIII. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED

Program Specific Outcomes		Level	Proficiency Assessed by
PSO 1	**Professional Skills:**Able to utilize the knowledge of aeronautical/aerospace engineering in innovative, dynamic and challenging environment for design and development of new products.	H	Lectures and Assignments
PSO 2	**Problem-solving skills:**Imparted through simulation language skills and general purpose CAE packages to solve practical, design and analysis problems of components to complete the challenge of airworthiness for flight vehicles	--	----
PSO 3	**Practical implementation and testing skills:** Providing different types of in	--	---

	house and training and industry practice to fabricate and test and develop the products with more innovative technologies		
PSO 4	**Successful career and Entrepreneurship:**To prepare the students with broad aerospace knowledge to design and develop systems and subsystems of aerospace and allied systems and become technocrats	H	Seminars and Projects

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IX. SYLLABUS

UNIT – I

BASICCONCEPTS

Thesolar system,cometsandmeteors,Kepler'slawsandNewton'slawofgravitation,concept of celestial sphere, vernal equinox,ecliptic.Coordinatesystems-ECIsystem,geographiccoordinatesystem,azimuth-elevationcoordinatesystem,eclipticsystem,Timesystems-siderealtime,meansolartime,Juliandate,universaltime,ephemeristime.

UNIT – II

TWO-BODYAND RESTRICTED THREE BODY PROBLEM:

N-Body problem, two-body problem-simplifying assumptions.Equations of relative motion. Constants of the motion- conservationofangularmomentum,Trajectoryequation,ellipticalorbit- geometry of the ellipse, period of an elliptical orbit, circular orbit, parabolic orbit, hyperbolic orbit. Geometry of the hyperbola, hyperbolic excess speed.Orbital elements.Introduction, equations of motion, Lagrangian points, stability of the Lagrangian points, Jacobi's integral, accessible regions.

UNIT – III

BASICORBITALMANEUVRES AND ORBITPERTURBATIONS

Lowaltitudeearthorbits- effectoforbitalaltitudeonsatellitelifetimes,direct ascent orbit,perturbationsoflowearthorbitsduetotheoblateshapeof theEarth.Highaltitudeearthorbits-thesynchronoussatellite, launching highaltitudesatellite.In-planeorbitchanges-adjustmentofperigeeandapogeeheight,Hohmanntransfer,generalcoplanartransferbetweencircularorbits,Out-ofplaneorbitchanges-simpleplanechange.Generaloverviewoforbitperturbations,Earthgravityharmonics,lunisolargravitationalattractions,solarradiation pressureeffects,atmosphericdrageffects,tidalfrictioneffectsandmutualgravitationalattraction.earth'soblateness(J2) effects,criticalinclination.Sun-synchronous orbits,J3effectsandfrozenorbits,Earth'striaxialityeffectsandeast-weststationkeeping.

UNIT – IV

BALLISTICMISSILETRAJECTORIES

Thegeneralballisticmissileproblem-geometryofthetrajectory,freeflightrangeequations,flightpathangleequation,maximumrangetrajectory,timeoffree flight.Effectoflaunchingerrorsonrange-effectoflateraldisplacementoftheburnoutpoint,crossrangeerrorduetoincorrectlaunchazimuth, effect ofdownrange displacementoftheburnoutpoint,errorsinburn-outflight-pathangle,downrangeerrorscausedbyincorrectburnoutheightandincorrectspeedatburnout.Theeffectofearthrotation-compensatingfortheinitialvelocityofmissileduetoearthrotation,compensatingformovementofthetargetduetoearth rotation.

UNIT – V

INTERPLANETARYTRAJECTORIES

Patched-conicapproximation-heliocentrictransferorbit,phaseangleatdeparture,escapefromtheearth'sphereofinfluence,arrivalatthetargetplanet, effectivecollisioncross-section.Locatingtheplanets-launchopportunity,synodicperiod,trajectorytypeandclass,ephemeriscalculations,Non-coplanarinterplanetarytrajectories,Gravity-assistmanoeuver.Fastinterplanetarytrajectories.

Text books:

1. Bate,R.R., D.D. Mueller,White,J.E.,FundamentalsofAstrodynamics,DoverPublicationsInc.,NewYork,1971.

Reference books:

1. C. H. Friend, "Aircraft Maintenance Management", Longman, 1992.
2. M. Kroes, W. Watkins, F. Delp, "Aircraft Maintenance and Repair", Tata McGraw-Hill, 2010.
3. M. S. Patankar, J. C. Taylor, "Risk Management and Error Reduction in Aviation Maintenance", Ashgate, 2004, ISBN 0-7546-1941-9.

X. COURSE PLAN:

The course plan is meant as a guideline. There may probably be changes.

Lecture No.	Topics to be covered	Course Learning Outcomes	Reference
1	Explain Basic concepts	The solar system, comets and meteor	R1, R2, R3, R4
2-5	Explain Kepler's law and Newton's Law of gravitation	Kepler's laws and Newton's law of gravitation, concept of celestial sphere, vernal equinox,ecliptic	R1
6-8	Discuss coordinate systems.	Coordinate systems-ECI system, geographic coordinate system,	R1
9	Discuss coordinate systems	azimuth-elevation coordinate system, ecliptic system,	R1
10-11	Discuss Time systems	Time systems-side real time, mean solar time, Julian date, universal time, ephemeris time.	R1
12-15	Explain N-body problem	N-body problem, two-body problem-simplify in gas assumptions. Equations of relative motion. Constants of the motion-conservation of angular momentum	R1
16-17	Explain Trajectories	Trajectory equation, elliptical orbit- geometry of the ellipse, period of an elliptical orbit, circular orbit,	R1
18-19	Explain orbits	Parabolic orbit, hyperbolic orbit.	R2
20	Explain orbital elements	Geometry of the hyperbola, hyperbolic excess speed. Orbital elements.	R2
21-22	Describe three body and restricted three body.	Restricted three body problem	R1
23-24	Explain equations of motion	Introduction, equations of motion	R1

25-26	Explain Lagrangian points	Lagrangian points, stability of the Lagrangian points	R1
27	Explain Jacobi's integral	Jacobi's integral, accessible regions.	R1
28-29	Explain Basic orbital maneuvers	Introduction	T2,R6
30-31	Explain Earth orbits	Low altitude earth orbits-effect of orbital altitude on satellite life times, direct ascenttoorbit	T2,R6
32	Discuss Earth orbit perturbations	Perturbations of low earth orbits due to the oblate shape of the Earth	T2,R6
33-34	Analyze Earth orbit perturbations	High altitude earth orbits-the synchronous satellite, launching a high	T2,R6
35-36	Analyze In- plane orbit changes	In-plane orbit changes-adjustment of perigee and apogee eight, Hohmann transfer	T2,R6
37-38	Discuss General coplanar transfer	General coplanar transfer between circular orbits, Out-of plane orbit changes-simple plane change.	T2,R6
39	Discuss orbit perturbations	General overview of orbit perturbations	T1
40-41	Explain solar radiation	Earth gravity harmonics, luni solar gravitational attractions, solar radiation pressure effects, atmospheric drag	T1
42-43	Discuss tidal friction effects	tidalfrictioneffectsandmutualgravitationalattraction.earth'soblateness (J2)	T1
44-46	Describe critical inclination	Critical inclination. Sun-synchronous orbits, J3 effects and frozen orbits	T1
47-48	Discuss tri axility effects	Earth's triaxiality effects and east-west station keeping.	T1
49-50	Analyze general ballistic missile trajectory	The general ballistic missile problem-geometry of the trajectory, free flight range equations, flight path angleequation	T1,R6
51	Discuss maximum range trajectory	Maximum range trajectory, time of free flight. Effect of launching errors on range-effect of lateral displacement of the burnoutpoint,	T1,R6
52-53	Analyze errors in burn-out	Cross range error due to incorrect launch azimuth, effect ofdown range displacement of the burnout point	T1,R6
54-55	Explain effect of earth rotation	Errors in burn-out flight-path angle, down range errors caused by incorrect burnout height and incorrect speed at burnout	T1,R6
56-58	Discuss earth rotation	The effect of earth rotation-compensating for the initial velocity of missile due to earth rotation	T1,R6
59	Analyze Restricted three body problem	Compensating for movement of the target due to earth rotation	T1
60-62	Explain interplanetary trajectories	Patched-conic approximation-heliocentric transfer orbit, phase angle at departure, escape from the earth's sphere of influence,	T1,T2
63-64	Explain launch opportunity	Arrival at the target planet, effective collision cross-section. Locating the planets-launchopportunity,	T1,T2
65-67	Discuss synodic period	Synodic period, trajectory type and class, ephemeris calculations	T1,T2

68	Describe Non-coplanar interplanetarytrajectories	Non-coplanar interplanetary trajectories	T1,T2
69	Explain Gravity-assist maneuver	Gravity-assist maneuver	T1,T2
70-71	Explain Fast inter planetary trajectories	Fast interplanetary trajectories	T1,T2
72	Discuss interplanetary trajectories	Interplanetary trajectories	T1,T2

XI. MAPPING COURSE OBJECTIVES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1		S	H			S	S	H		S	H			H	H
2	S			S		H		S	S	S	H	H	H	S	
3		S			H		S				H	H	S	H	H
4	S			H		S		S	S	S	S	H			H
5		S	H			H	S	H	S				S	H	H
6	S	S	H		H	H			H		S		S	H	H

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XII. MAPPING COURSE OUTCOMES LEADING TO THE ACHIEVEMENT OF THE PROGRAM OUTCOMES

Course Objectives	Program Outcomes												Program Specific Outcomes		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
1			H			S	S		S	S	H	S	S	S	S
2	H	S	S		S	S					S	S			
3				H	S		S		S	S		S	S	H	S
4	S	S			H	S		S		S			H		
5			H				S				H	S			H
6		S		S		S		H	S	H			S	S	
7			H		S	H	S		S		H	S	S	S	S

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