DEPARTMENT OF AERONAUTICAL ENGINEERING

M.TECH AEROSPACE ENGINEERING
# M.TECH AEROSPACE ENGINEERING
## I YEAR I SEMESTER
### QUESTION BANK

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## M.TECH- AEROSPACE ENGINEERING
### I YEAR I SEMESTER
#### COURSE STRUCTURE

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**NOTE:** *Fundamentals of Aerospace Engineering*

*(Required to be taken by all students other than B.Tech Aeronautical/ Aerospace Engineering degree holders)*
### I Year II Semester

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### II Year I Semester

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Total: - - 22 - -
UNIT-I: INTRODUCTION TO MODELING AND SINGULAR PERTURBATION METHODS
Definition of a model, Procedure of modeling: problem identification, model formulation, reduction, analysis, Computation, model validation, Choosing the model, Singular Perturbations: Elementary boundary layer theory, Matched asymptotic expansions, Inner layers, nonlinear oscillations

UNIT-II: VARIATIONAL PRINCIPLES AND RANDOM SYSTEMS

UNIT-III: FINITE DIFFERENCES: ORDINARY AND PARTIAL DIFFERENTIAL EQUATIONS

CELLULAR AUTOMATA AND LATTICE GASES
Lattice gases and fluids, Cellular automata and computing

UNIT- IV: FUNCTION FITTING AND TRANSFORMS

FUNCTION FITTING ARCHITECTURES
Polynomials: Pade approximants, Splines, Orthogonal functions, Radial basis functions, Over-fitting, Neural networks: Back propagation, Regularization

UNIT-V: OPTIMIZATION AND SEARCH
Multidimensional search, Local minima, Simulated annealing, Genetic algorithms

FILTERING AND STATE ESTIMATION
Matched filters, Wiener filters, Kalman filters, Non-linearity and entrainment, Hidden Markov models

TEXT BOOK

REFERENCE BOOKS
3. *Applied Numerical Modeling for Engineers*, Donald De Cogan, Anne De Cogan, Oxford University Press, 1997
COURSE COVERAGE SUMMARY
FOR
MATHEMATICAL MODELING

<table>
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<tr>
<th>TEXT BOOK TITLE</th>
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<th>UNITS/TOPICS COVERED</th>
<th>AUTHOR</th>
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<th>EDITION &amp; YEAR</th>
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SECTION – I
1. a) Explain the Elementary boundary layer theory for singular Perturbations
   b) Explain the Steps Involved in the Procedure of mathematical modeling
   (Or)
2. a) Write a short note on
   b) Inner layers of Perturbations
   c) Singular perturbations
   d) Truncation Error
   b) Discuss briefly about Matched asymptotic expansions for singular Perturbations

SECTION – II
3. Derive the equations of Optics-Fermat’s principle and Hamilton’s principle for variational problems.
   (Or)
4. a) Discuss briefly about Rigid body motion and random variables
   b) Explain Monte Carlo method for a random system
   c) Explain Stochastic processes for a random system

SECTION – III
5. a) Describe the following one-dimensional diffusion equation using finite difference approximation and conduct the stability analysis.
    \[ \frac{\partial u}{\partial t} = D \left( \frac{\partial^2 u}{\partial x^2} \right) \]
   b) Describe the fourth-order Runge-Kutta method for a system of first order ordinary differential equations
6. a) Describe cellular automata model for a gas.
    b) Discuss through diagrams how FHP lattice gas operates in two dimensions with the help of triangular lattice.

SECTION – IV
7. a) How do you distinguish between parametric and non parametric function fitting?
    b) Describe the procedure of linear least squares fitting from observation data
c) Explain the principle of Singular Value Decomposition (SVD).

(Or)

8. a) Explain the concept of Radial basis functions of polynomials
b) Give the brief description about Neural Networks with the help of a diagram the procedure involved in building a mathematical model.

SECTION – V

9. Explain briefly about
   a) Matched Filters
   b) Kalman Filters
   c) Weiner Filters

(Or)

10. How are Genetic algorithms different from simulated annealing? Explain the steps involved in applying genetic algorithm in optimization and search problems.
SECTION – I

1. a) what are the different types of mathematical models?
   b) Explain the Steps Involved in the Procedure of mathematical modeling

(Or)

2. a) Write a short note on
   i) Approximation error
   ii) Round-off error
   iii) Truncation Error

b) Differentiate the differences between Singular Perturbations and regular Perturbations

SECTION – II


(Or)

4. a) Discuss Noether’s theorem for symmetries of system
   b) Formulate variational problems with constraints
   c) Explain Stochastic processes for a random system

SECTION – III

5. Explain the Beyond Runge-Kutta method for a system of first order ordinary differential equations by using predictor-corrector method.

(Or)

6. Explain the Lax method for the following first order hyperbolic Partial Differential Equation and conduct the stability analysis
   \[ \frac{du}{dt} = -v \frac{\partial u}{\partial x} \]
SECTION – IV
7. Discuss with the help of a diagram the procedure involved in building a mathematical model using Neural Networks

(Or)
8. a) Distinguish the differences between linear least square and nonlinear least square techniques
b) How is Levenberg-Marquardt Method useful in function fitting and explain.

SECTION – V
9. Explain briefly about Matched Filters
   i) Kalman Filters
   ii) Weiner Filters

(Or)
10. Explain simulated annealing technique used in optimization and search problems. Explain the concept of local minima for optimization and search.

* * * * * * * * * *
Code No: 5176A

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, February - 2014
MATHEMATICAL MODELING
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Instructions:

i) Part A is compulsory Question for 20 marks.
ii) Part B consists of five questions with "either" "or" pattern. The student has to answer any one. However students have to answer five questions from Part B (numbered from 2 to 6)

PART - A
(Answer all sub questions) 5 x 4 marks = 20

1.a) Explain approximation, round-off error and truncation error.
1.b) Explain the difference between Euler’s and Lagrangian models.
1.c) Prove that E = e^t
1.d) Explain the principle of Least squares.
1.e) Describe the steps involved in Kalman filtering for linear systems.

PART - B
Answer either "a" or "b" from each question, but not both 5 x 8 marks = 40

2.a) i) What are different types of mathematical models?
   ii) Explain the steps involved in the procedure of mathematical modelling.
   OR

b) i) What are the features to be observed for identifying a singular perturbation problem?
   ii) Discuss Prandtl’s technique for the solution of the boundary value problem.
       \[ y'' + a y' + b = 0 \]
       \[ y(0) = \alpha \text{ and } y(1) = \beta \]

       using the method of asymptotic expansions.

3.a) i) What are the differences between Newtonian Mechanics and Analytical Mechanics?
   ii) Derive Euler-Lagrange equations for a conservative system using Hamilton’s principle and illustrate it with an example.
   iii) Discuss Noether’s theorem for symmetries of systems.
   OR

b) i) Explain the difference between a function and a functional.
   ii) Formulate a variational problem with constraints.
   iii) Explain how Lagrange Multipliers can be used in solving it.
4.a) i) Describe the fourth-order Runge-Kutta method for a system of first order ordinary differential equations.
ii) Explain how the step size is chosen based on the approximation error.

b) Discretize the following one-dimensional diffusion equation using finite difference approximation and conduct the stability analysis.

\[
\frac{\partial u}{\partial t} = D \frac{\partial^2 u}{\partial x^2}
\]

5.a) i) Define Discrete Fourier Transformation (DFT) and its corresponding inverse transform for n-dimensional data vector.
ii) Discuss the logic involved in enhancing the computing speed of DFT by Fast Fourier Transform (FFT).

OR

b) i) How do you distinguish between parametric and non-parametric function fitting?
ii) Describe the procedure of linear least squares fitting from observation data.
iii) Explain the principle of Singular Value Decomposition (SVD) and discuss when one has to go for SVD technique.

6.a) i) Discuss Simulated Annealing technique used in optimization and search problems.
ii) How is it different from Genetic algorithms?

OR

b) i) Explain the extended Kalman filter for state estimation of non-linear systems.
ii) Discuss the process of entrainment for non-linear systems.
1. What are the features to be observed for identifying a singular perturbation problem? Discuss Prandtl’s technique for the solution of the boundary value Problem

\[ \varepsilon y'' + y' + y = 0, \]

\[ y(0) = \alpha \text{ and } y(1) = \beta \]

using the method of asymptotic expansions.

2. What is a variational principle? Derive Euler’s equation for a variational extremum and illustrate it with an example to find minimum distance between two points in a plane.

3. Explain the Lax method for the following first order hyperbolic Partial Differential Equation and conduct the stability analysis:

\[ \frac{\partial u}{\partial t} = -\nu \left( \frac{\partial u}{\partial x} \right) \]

4. Describe the fourth-order Runge-Kutta method for a system of first order ordinary differential equations, and explain how the step size is chosen based on the approximation error.

5. Distinguish between parametric and non-parametric function fitting. Explain the technique of linear least squares fitting of observation data. Explain when one has to go for Singular Value Decomposition (SVD) technique and briefly describe the principle of SVD.

6. Define Discrete Fourier Transformation (DFT) and its corresponding inverse transform for N-dimensional data vector. Explain the logic involved in enhancing the computing speed of DFT by Fast Fourier Transform (FFT).

7. How are Genetic algorithms different from simulated annealing? Explain the steps involved in applying genetic algorithm in optimization and search problems.

8. Explain the differences between Kalman filtering and Weiner filters. Discuss the steps involved in Extended Kalman filter for non-linear systems.

********
UNIT-I: THE MORPHOLOGY OF FLIGHT VEHICLES
Introduction, Key factors affecting vehicles configuration, some representative flight vehicles.

UNIT-II: EQUATIONS OF MOTION FOR RIGID FLIGHT VEHICLES
Definitions, Vector and Scalar realizations of Newton’s second law, The tensor of inertia, Choice of vehicle axes, Principal axes, Stability axes, Aerodynamic axes, Orientation of the vehicle relative to the ground; flight path determination, Gravitational terms in the equations of motion, The state vector, Equations of motion; Aerodynamic Approximations; stability derivatives; Estimation of stability derivatives: Longitudinal.

INTRODUCTION TO VEHICLE AERODYNAMICS
Aerodynamics contributions to X, Y and M, dimensionless coefficients defined, equations of perturbed longitudinal motion.

UNIT-III: AIRCRAFT DYNAMICS
Equations of Motion of Aircraft including forces and moments of control surfaces, Dynamics of control surfaces

STATIC STABILITY, TRIM STATIC PERFORMANCE AND RELATED SUBJECTS
Impact of stability requirements on design and longitudinal control, Static performance

UNIT-IV: DYNAMIC PERFORMANCE OF SPACECRAFT WITH RESPECT TO NON-ROTATING PLANETS

UNIT-V: DYNAMIC PERFORMANCE OF SPACECRAFT
Equations of Motion of Launch Vehicles with respect to a rotating planet, Motion of Spacecraft with respect to a rotating planet.

DYNAMIC PERFORMANCE-ATMOSPHERIC ENTRY
Equation of motion, Approximate analysis of gliding entry into a planetary atmosphere.

TEXT BOOK

## COURSE COVERAGE SUMMARY FOR

### ENGINEERING ANALYSIS OF FLIGHT VEHICLES

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<td>Engineering analysis of flight vehicles</td>
<td>1,2,3,6,7,8,9,11</td>
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<td>Holt Ashley</td>
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Note: Question paper Consists of 5 SECTIONS (One SECTION for each UNIT) and answer FIVE Questions, Choosing ONE Question from each SECTION. Each Question carries 15 marks.

**SECTION – I**
1. Explain in brief about the supersonic Delta-Winged Interceptor (Convair F-102)
   (Or)
2. Compare and contrast the external configurations of a subsonic and a supersonic aircraft with the help of neat sketches.

**SECTION – II**
3. Derive the equations of perturbed longitudinal motion and explain them.
   (Or)
4. a) Discuss in detail the choice of vehicle axes.
    b) Consider an aircraft in uniform motion, with speed $v_c$ at angle of attack $\alpha$ in a medium of constant density $\rho$, A typical length dimension is $l$. Find the drag $D$ on the vehicle

**SECTION – III**
5. Explain in detail about the forces and moments of control surfaces of an aircraft.
   (Or)
6. Briefly discuss about the dynamics of control surfaces.

**SECTION – IV**
7. Study analytically the performance of a jet-powered aircraft flying in the stratosphere under the following approximations:
   Thrust $T = T_s (\rho / \rho_s)$, Density $\rho = \rho_s e^{h/H}$, $L = W$, $C_D = C_{D0} + (C_L^2 / \pi e AR)$
   Here $h$ is altitude measured from base of the stratosphere, at which altitude quantities are identified by subscript $s$. Also $H, W, C_{D0}$ and $\pi e AR$ all are constants, and $T$ at full throttle is independent of speed for a given $h$.
   Find the following as functions of $h$.
   1) Maximum rate of climb for constant velocity in direction of flight path
   2) Maximum rate of climb
   3) Minimum time to climb between two altitudes.
   (Or)
8. Explain about Equations of boost from a rotating planet.
SECTION – V

9. Briefly discuss about the maximum declaration of a re-entry body and the altitude.

(Or)

10. Derive the equation of motion of launch vehicle under the influence of Earth’s rotation.
SECTION – I
1. Briefly discuss about any five factors affecting the vehicle configuration.
   (Or)
2. Discuss about the strut wire braced biplane of World War I era.

SECTION – II
3. Derive an equation for vector and scalar relations of Newton’s second law.
   (Or)
4. Derive the equations of perturbed longitudinal motion and explain them.

SECTION – III
5. Explain in detail about the forces and moments of control surfaces of an aircraft.
   (Or)
6. A). Briefly discuss about impact of stability requirements on design and longitudinal control.
   B) Briefly discuss about the dynamics of control surfaces.

SECTION – IV
7. Briefly discuss and write necessary ordinary differential equations to represent
dynamic Performance of spacecraft with respect to non rotating planets.
   (Or)
8. Derive the Runge-kutta formula for $X_{n+1}$ to third order or fourth order in $h$ for general $(nx1)$ column vectors $X$
   and $f(X,t)=\dot{X}$.

SECTION – V
9. Explain the behavior of vehicle motion with appropriate constrained from the equation of motion of launch
   vehicle under the influence of Earth’s rotation.
   (Or)
10. Briefly discuss about the maximum declaration of a re-entry body and the altitude.
Code No: 5176B
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, February - 2014
ENGINEERING ANALYSIS OF FLIGHT VEHICLES
(Aerospace Engineering)
Time: 3 Hours Max. Marks: 60

Instructions:
(i) Part A is compulsory. Question for 20 marks.
(ii) Part B consists of five questions with “either” “or” pattern. The student has to answer any
one. However students have to answer five questions from Part B (numbered from 2 to 6)

PART - A
(Answer all sub questions)
5 x 4 marks = 20

1.a) Briefly discuss any 4 factors affecting the vehicle configuration.

b) Draw the $C_l$ versus $\alpha$ for various flap angles on a airfoil and use this to explain
graphically, why the slope of the lift curve of a horizontal tail is reduced when the
elevator is free to rotate.

c) A small wing is fastened on one end of a rod 5 feet long. The rod is rotating about
the other end at 10 rpm, causing the wing to move downward. The aspect ratio of
the wing is 7, $a = 0.08$, and $b = 2.0$ in. Speed 100 feet per second at standard sea
level. Find the wing lift coefficient at the AOA 10°.

d) In a wind tunnel a wing having a mass of $m$ is suspended from a spring having a
constant of $k$. The wing can move vertically but is restrained from rotating. At
rest the wing is at a zero angle of attack. Derive an expression for the vertical
position of the wing as a function of time if the wing is displaced from its static
position and released.

e) Compare the vehicle performance of military and civil aircraft in respect of
stability and control.

PART - B
5 x 8 marks = 40

Answer either “a” or “b” from each question, but not both

2.a) Assume that you wish to analyze a tailless aircraft with a delta wing.
i) Discuss the requirements for longitudinal balance.
ii) What airfoil section would you select? Justify.

b) Airlines have found that passengers prefer travelling in small jets to flying in
equal capacity turboprops
i) Why do you think this is the case?
ii) The airlines were able to rationalize the substitution of jets for the turboprops
on economic grounds only after the development of small fanjet engines. Why?
3. a) An aircraft is initially in a dive and at the bottom of the dive; the pilot affects a steady pullout with a constant pitch rate \( q, \text{rad/s} \). Obtain the equations of motion for small disturbances during the pullout.

OR

b) i) An aircraft model is tested in a low speed wind tunnel at an angle of attack of 20 deg, sideslip 12 deg and a bank angle of 30 deg. An internal strain gage balance was used to measure the aerodynamic forces acting on the model, which gives components of force in the body axes system. The measurements \( F_x = -100N \), \( F_y = -150N \), and \( F_z = -410N \). Determine transformation mat \( T_r \), lift, drag and side forces acting on model.

ii) At a certain time during a continuous motion of an airplane the following direction cosine matrix is recorded. It is suspected that the elements marked \( xx \) are in error and hence are discarded. Determine the missing elements

\[
C = \begin{bmatrix}
0.7899 & -0.3943 & 0.0617 \\
0.9165 & -0.3196 & \\
x & xx & 0.8966
\end{bmatrix}
\]

4. a) Examine the longitudinal stability of airplane using Routh’s criterion for the longitudinal characteristic equation given by

\[
s^4 + 1.6s^3 + 3.35s^2 + 0.305s + 0.08 = 0
\]

OR

b) A light airplane has the following longitudinal transfer functions:

\[
G_x(s) = \frac{-0.19s^3 + 12s^2 + s + 1.75}{s^4 + 3s^3 + 2.6s^2 + 0.13s - 0.6}
\]

\[
G_y(s) = \frac{-(11s^2 + 22s + 1.3)}{s^4 + 3s^3 + 2.3s^2 + 0.16s - 0.3}
\]

Determine longitudinal eigenvalues. Is airplane longitudinally stable?

5. a) Derive equation of motion of launch vehicle under the influence of earth’s rotation. Explain the behavior of the vehicle motion with appropriate constraints from the equation.

OR

b) A person standing on a very tall tower fired a bullet with heavy gun. If the drag on the bullet is neglected assuming that there is no atmospheric effect. Explain how rotational affect of earth influences the path of bullet.

6. a) Derive an equation of motion of a particle around a small mass of body in the space. Discuss the significance of terms of the equation.

OR

b) An entry vehicle entering the earth’s atmosphere has a mass 50kg and has a diameter of 3.53 m and a half cone angle of 45 degrees, \( V_e = 8000 \text{ m/s} \). Find the value of ballistic coefficient. If elevation angle is +22 deg, find the velocity at an altitude of 50km.
1. Compare and contrast the external configurations of a subsonic and a supersonic aircraft with the help of neat sketches.

2. Derive the equations of motion of an aircraft symmetrical about the plane passing through the longitudinal and yaw axes. The sketches should be neat and the symbols used should be explained very clearly.

3. (a) Describe the aerodynamic forces acting on an aircraft and the vehicle parameters that influence the magnitudes of these forces.
   (b) Explain the variations of the aerodynamic forces and moments occurring on an airfoil as the relevant parameters vary.

4. State the equations of motion of an aircraft, and from them, derive the small perturbation equations of motion in longitudinal plane.

5 (a) Explain the forces and moments acting on an aircraft in the pitch plane.
   (b) Derive an expression for the elevator deflection angle required to ensure a trimmed flight in longitudinal plane.

6. Explain, in the case of a vehicle boosting from a non-rotating planet,
   (a) Thrust and characteristic velocity,
   (b) Change in speed,
   (c) Effect of gravity,
   (d) Loss due to drag.

7. Derive the equations of motion of a rocket lifting from the earth, considering the effect of angular velocity of the earth.

8. Define non-dimensional altitude used to define the density of earth’s atmosphere. With the help of this, derive the equations of motion of a reentry body.

* * * * * * *
1. Explain the major factors affecting the configuration of a reusable space transport vehicle. [12]

2. Starting from the six degrees of freedom equations of motion of a rigid body under the effect of moments about X, Y and Z axes, in terms of, derive the equations in terms of the Inertia tensor. [12]

3. Derive the equation for flow turning angle in Prandtl-Meyer expansion of a supersonic flow. [12]

4. Starting from the equations of motion of a rigid body acted upon by forces along the three body axes, derive the perturbation equations of motion. [12]

5. Explain Elevator Hinge Moment and Stick Force to trim. [12]

6. Derive the equation for acceleration of a rocket in ‘field-free space’ including the effect of drag. [12]

7. A two stage rocket is launched vertically from a place on the equator under the following conditions. Specific impulse, propellant fractions are 200 seconds and 0.9 respectively for both the stages. Mass of each motor at launch is 1000 kg and the payload mass is 100 kg. Compute the velocity of the rocket, considering the earth rotational velocity. [12]

8. Derive the equation for the flight path angle of a lifting re-entry vehicle. [12]
UNIT-I: INTRODUCTION
Rockets and military missiles – function, types, role, mission, mission profile, thrust profile, propulsion system, payload, staging, control and guidance requirements Performance measures, design, construction, operation – similarities and differences. Some famous space launch vehicles and strategic missiles.

UNIT-II: SOLID AND LIQUID PROPULSION SYSTEMS

Liquid propellants – types, composition, properties. Performance. Propellant tanks, feed systems – pressurisation, turbo-pumps-valves and feed lines, injectors, starting and ignition. Engine cooling support structure. Control of engine starting and thrust build up. System calibration, integration and optimization – safety and environmental concerns combustion instabilities. Description of the space shuttle main engine. Propellant slosh, propellant hammer, geysering effect in cryogenic rocket engines. Tsiolkovsky’s rocket equation in the absence of gravity, vertical motion in the earth’s gravitational field, inclined motion, flight path at constant pitch angle, motion in the atmosphere, the gravity turn – the culmination altitude, Multi staging. Earth launch trajectories – vertical segment, the gravity turn, constant pitch trajectory, orbital injection. Actual launch vehicle trajectories – types. Examples, the Mu-3-S-II. Ariane, Pegasus launchers, Reusable launch vehicles – future launchers – launch assist technologies

UNIT-III: AERODYNAMICS OF ROCKETS AND MISSILES AND ATTITUDE CONTROL
Classification of missiles, Airframe components of rockets and missiles. Forces acting on a missile while passing through atmosphere, method of describing aerodynamic forces and moments. Lateral aerodynamic moment, lateral damping moment, longitudinal moment of a rocket, lift and drag forces, drag estimation, body upwash and downwash in missiles. Rocket dispersion. Re-entry body design considerations. Rocket thrust vector control – methods of thrust vector control for solid and liquid propulsion systems, thrust magnitude control, thrust termination; stage separation dynamics, separation techniques.
UNIT-IV: MATERIALS AND ROCKET TESTING
Criteria for selection of materials for rockets and missiles- requirements for choice of materials for propellant tanks, liners, insulators, inhibitors, at cryogenic temperatures, requirements of materials at extremely high temperatures, requirements of materials for thermal protection and for pressure vessels. Ground testing and flight testing- types of tests, test facilities and safeguards monitoring and control of toxic materials, instrumentation and data management. Ground testing, flight testing, trajectory monitoring, post accident procedures. Description of a typical space launch vehicle launches procedure.

UNIT-V: ALTERNATIVE PROPULSION SYSTEMS AND FLIGHT VEHICLES
Hybrid propulsion system. Ramjet propulsion and its performance and limitations, the scramjet engine – construction, flow process, drag components, fuel injection systems, applications, components performance analysis – Hypersonic transport vehicles, missions, trajectories, sounding rockets, cruise missiles, unmanned Aerial Vehicles and drones, Micro Aerial Vehicles – applications of these vehicles

TEXT BOOKS

REFERENCE BOOKS
2. James all the world flight vehicles Jones aviation publications London
MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY  
(Autonomous Institution – UGC, Govt. of India)  
M.Tech. I Year - I Semester, February 2016  
Sub: Rocket and Missile Technology  
(Aero Space Engineering)  

Time: 3 hours  
Max. Marks: 75  

**Note:** Question paper Consists of 5 SECTIONS (One SECTION for each UNIT) and answer FIVE Questions, Choosing ONE Question from each SECTION. Each Question carries 15 marks.

* * * * * *

**SECTION – I**

1. a) What is rocket staging? Derive the rocket payload estimation using rocket equation.
   b) With the suitable examples explain different types of rockets and missiles.

(Or)

2. The booster rocket of a satellite launch vehicle operates an altitude of 30 Km. The rocket has a constant chamber pressure of 7 MPa.
   a) If the nozzle is designed for optimum expansion at an altitude of 16 km determine the area ratio of the nozzle. The specific heat ratio of the gases can be assumed constant and equal to 1.20. The throat area of the nozzle is 0.1 m². The variation of ambient pressure with altitude is given in the following:

<table>
<thead>
<tr>
<th>Altitude (Km)</th>
<th>0</th>
<th>4</th>
<th>8</th>
<th>12</th>
<th>16</th>
<th>20</th>
<th>30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pressure (N/m²)</td>
<td>101325</td>
<td>61660</td>
<td>35651</td>
<td>19399</td>
<td>10353</td>
<td>5529</td>
<td>1186</td>
</tr>
</tbody>
</table>

   b) What would be the thrust coefficient of the nozzle at the altitude of 30 Km? What is the percentage reduction from the value corresponding to optimum expansion at 30 Km?
   c) Till what altitude would flow separation in the nozzle take place?

**SECTION – II**

3. Derive the Rocket “Tsiolkowski” equation. (ii) An end burning rocket uses a cylindrical double base propellant grain with a diameter of 200 mm and generates a thrust of 350 N over a period of 300 sec. the thrust coefficient is 1.15. The characteristics of the propellants are:
   - Density of propellant grain = 1500 Kg/m³.
   - Speed of Sound(aₗₖₖ=4mm/sec).
   - Choice of index (n) = 0.5
   - Characteristic velocity (C*) = 1500 m/sec.

   Calculate
   (a) Length of propellant grain
   (b) Throat diameter of rocket Nozzle.

(Or)
4. With the help neat diagrams explain different types of liquid propellant rocket feed systems.

SECTION – III
5. a) Explain the forces acting on a missile while passing through atmosphere.
   b) Describe the airframe components of rockets and missiles.
   (Or)
6. a) Explain the re-entry body design considerations.
   b) Explain the methods of thrust vector control for solid propulsion system.

SECTION – IV
7. a) Explain the requirements for choice of materials for propellant tanks.
   b) Explain the typical materials used for vessels.
   (Or)
8. Explain the trajectory monitoring and flight testing of rockets and missiles, with the instrumentations used.

SECTION – V
9. Write the principle of ramjet and scramjet engine with sketches. What are the applications of scramjet and ramjet engine?
   (Or)
10. Write notes on:
    a) Micro Aero vehicles
    b) Applications of UAV’s (Unmanned Aerial Vehicles).
    c) Drones.

* * * * * * * * *
UNIT-I: INTRODUCTION TO AEROSPACE ENGINEERING

UNIT-II: INCOMPRESSIBLE ONE DIMENSIONAL FLOWS AND COMPRESSIBLE FLUIDS
Continuity equation, Bernoulli’s equation, Application of Bernoulli’s equation: Airspeed indicators and wind tunnels, One-dimensional compressible flow concepts, Speed of sound, Compressible flow equations in a variable-area stream tube, Application to airspeed measurement, Applications to channels and wind tunnels

TWO-DIMENSIONAL FLOW AND FINITE WING: Limitations of one-dimensional flow equations, Theory of lift: circulation, Airfoil pressure distribution, Helmholtz vortex theorems, Simulating the wing with a vortex line, Downwash, Elliptic lift distribution, Lift and drag: momentum and energy, Slope of finite wing lift curve, Verification of Prandtl wing theory, Additional effects of wing vortices, Search for reduced induced drag

UNIT-III: EFFECTS OF VISCOSITY, TOTAL DRAG
Boundary layer, Boundary layer on bluff bodies, Creation of circulation, Laminar and turbulent boundary layers: skin friction, Nature of Reynolds number, Effect of turbulent boundary layer on separation; Parasite drag, Drag due to lift, Importance of aspect ratio; Prediction of drag divergence Mach number, Sweptback wings, Total drag, Supersonic flow: shock waves and Mach waves, Supersonic wing lift and drag, Area rule, Supersonic aircraft,

AIRFOILS, WINGS AND HIGHLIFT SYSTEMS: Early airfoil development, Modern airfoils, Supersonic airfoils, Airfoil pitching moments, Effects of sweepback on lift, airfoil characteristics, Airfoil selection and wing design; Airfoil maximum lift coefficient, Leading and trailing edge devices, Effect of sweepback, Deep stall, Effect of Reynolds number, Propulsive lift

UNIT-IV: AERODYNAMIC PERFORMANCE, STABILITY AND CONTROL

UNIT-V: AEROSPACE PROPULSION AND AIRCRAFT STRUCTURES
Aerospace Propulsion: Piston engines, Gas turbines, Speed limitations of gas turbines: ramjets, Propellers, Overall propulsion efficiency, Rocket engines, Rocket motor performance, Propulsion-airframe integration;

Aircraft structures: Importance of structural weight and integrity, Development of aircraft structures, Importance of fatigue, Materials, Loads, Weight estimation

ROCKET TRAJECTORIES, ORBITS AND REENTRY
Rocket trajectories, Multistage rockets, Escape velocity, Circular orbital or satellite velocity, Elliptical orbits, Orbital maneuvers.
TEXT BOOK

REFERENCE BOOK
# COURSE COVERAGE SUMMARY FOR

**FUNDAMENTALS OF AEROSPACE ENGINEERING**

*(ELECTIVE – I)*

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>Chapters in Text Book</th>
<th>Units / Topics Covered</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
</tr>
</thead>
</table>
SECTION - I
1. A wind tunnel located at a pressure altitude of 500 meters \((\rho = 1.1674 \text{ kg/m}^3, p = 95472 \text{ N/m}^2)\), has a circular test section with 3 meter diameter. The air speed is 80 m/sec in the test section, which is vented to the ambient atmosphere. The air speed in the larger diameter section just upstream of the contraction is 16 m/sec. Calculate upstream diameter, dynamic pressure in the test section, upstream pressure and height of mercury column.

\[
[15]
\]

(Or)

2. A supersonic wind tunnel has Mach 2 flow at the test section along with standard sea-level states there. What are the bottle pressure, bottle temperature and area ratio of test section required to maintain the above conditions.

\[
[15]
\]

SECTION – II
3. Derive the compressible flow equations in a variable area stream tube. A DC-10 is cruising at its assigned mach number of 0.85. The outside air temperature is 232K. At a given point on the upper surface of the wing the pressure measured is 20,100 N/m\(^2\). The temperature at this point is 221K. What are the lift force, pressure, density and true speed of airplane?

\[
[15]
\]

(Or)

4. What is air speed indicator, how it measures air speed and explain different air speed used in aircraft.

\[
[15]
\]

SECTION – III
5. a) What is boundary layer and explain the turbulence and laminar boundary layer with diagram.

\[
[8]
\]

b) What is drag and discuss various types of drag.

\[
[7]
\]

(Or)

6. Discuss how drag coefficient varies with Mach number and how prediction of drag divergence Mach number is carried out.

\[
[15]
\]

SECTION – IV
7. Describe about stability and control of an airplane and give the conditions for static longitudinal stability. Also explain about static margin and neutral point.

\[
[15]
\]

(Or)

8. Derive the equation for stick free and stick fix longitudinal stability.

\[
[15]
\]
9. Write short notes on;
   a) Circular orbital velocity,
   b) Space vehicle re-entry heating
   c) Escape velocity.

   (Or)

10. Note down the need for developing multistage rocket with suitable numerical example.
SECTION – I
1. What are various parts of an aeroplane and give the functioning of control surfaces? How are aerodynamic forces developed on an aeroplane? Describe the parameters affecting these aerodynamic forces through dimensional analysis.
   [15]
   (Or)

2. List out the types of wind tunnel and explain any one of them with neat sketch.
   [15]

SECTION – II
3. a) Derive the expression for speed of sound.
   [8]
   b) Derive the 3D Momentum Equation in partial differential form.
   [7]
   (Or)

4. Write short notes about:
   a) Downwash and induced drag
   b) Horse shoe vortices
   c) Biot – Savart law
   d) Helmholtz’s theorem
   e) Bound vortex

SECTION – III
5. Discuss in detail about:
   a) Leading & trailing edge devices.
   b) Deep stall.
   c) Effect of sweep back on maximum lift.
   d) Airfoil selection & wing design.

6. Consider the supersonic flow over a 5° of angled wedge at zero angle of attack as sketched in figure 6a. The free stream mach number ahead of wedge is 2.0, and the free stream pressure and density are 1.01 \times 10^5 \text{ N/m}^2 and 1.23 \text{ kg/m}^3, respectively (this corresponds to standard sea level conditions). The pressure on the upper and lower surfaces of the wedge are constant with distance s and equal to each other, namely, \( p_u = p_l = 1.31 \times 10^5 \text{ N/m}^2 \), as shown in figure 6b. The pressure exerted on the base of the wedge is equal to \( p_\infty \). As seen in figure 6c, the shear stress varies over both the upper and lower surfaces as \( \tau_w = 431s^{-0.2} \). The chord length ‘c’, of the wedge is 2 m. Calculate the drag coefficient for the wedge.

[15]
7. a) Derive the equation for static longitudinal stability. [8]
b) Explain spiral divergence and Dutch roll. [7]

(Or)

8. a) Derive an expression for rate of climb. [8]
b) What is level turn and derive an expression for it. [7]

SECTION – V

9. a) Derive the thrust equation for rocket engine. [8]
b) Explain about the importance of fatigue in aircraft structures. [7]

(Or)

10. Explain in detail about:
   a) Elliptical orbit
   b) Escape velocity
   c) Ballistic entry

   * * * * * * *
MTECH AEROSPACE QUESTION BANK

Code No: S1761
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, February - 2014
FUNDAMENTALS OF AEROSPACE ENGINEERING
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Instructions:
1. Part A is compulsory. Question for 20 marks.
2. Part B consists of five questions with "either/or" pattern. The student has to answer any one. However, students have to answer five questions from Part B (numbered from 2 to 6).

PART - A
(Answer all sub questions) 5 × 4 marks = 20

1.a) What is the standard atmosphere? Derive the expression for standard atmosphere in relation with density, pressure and temperature.
b) Derive an expression for speed of sound in air.
c) Explain the effect of sweepback on lift.
d) Derive Breguet's Range Equation for Propeller Engine.
e) Write about the working principle of SCRAM Jet Engine.

PART - B
5 × 8 marks = 40

Answer either "a" or "b" from each question, but not both

2.a) Using the theory of dimensional analysis, derive an expression for aerodynamic force as a function of Reynolds number and Mach number. State the assumptions.

b) With neat graphs explain:
   i) Cl vs Re
   ii) Cd vs Re
   iv) Cl and Cd for cambered and symmetrical airfoil.

3.a) Write short notes on the following:
   i) Critical Mach number
   ii) Critical pressure coefficient
   iii) Drag divergence Mach number
   iv) Swept back wings

b) Discuss in detail about:
   i) Boundary layer formation on bluff bodies
   ii) Effect of turbulence boundary layer

4.a) Explain SLUF Condition and obtain the equations of motions for aircraft force system.

b) i) How do you calculate endurance of an airplane?
   ii) Explain about various types of propulsion systems used in aircraft and compare the working of piston engine and turbojet engine.
5.a) Explain static longitudinal stability, dynamic longitudinal and lateral stability?  
OR

b) Discuss in detail about orbital maneuvers and atmospheric entry. A satellite is to be launched to an orbital altitude of 500 Km, what is orbital velocity and orbital period?

6.a) Explain atmospheric entry, ballistic entry and lifting entry.  
OR

b) Describe importance of structural weight and integrity in the development of aircraft structures.
1. Explain the variation of temperature with altitude. Define various altitudes and give the relationships between them. Calculate the pressure, pressure ratio, temperature, density and density ratio at an altitude of 14 km. [12]

2. Starting from continuity equation derive Bernoulli’s equation and explain its application in air speed indicators and wind tunnels. A wind tunnel located at a pressure altitude of 500 meters ($\rho = 1.1674 \text{ kg/m}^3$, $p = 95472 \text{ N/m}^2$), has a circular test section with 3 meter diameter. The air speed is 80 m/sec in the test section, which is vented to the ambient atmosphere. The air speed in the larger diameter section just upstream of the contraction is 16 m/sec. Calculate upstream diameter, dynamic pressure in the test section, upstream pressure and height of mercury column. [12]

3. Explain in detail about vortex flow and generation of lift through circulation. [12]


5. Discuss in detail about:
   a) Leading & trailing edge devices.
   b) Deep stall.
   c) Effect of sweep back on maximum lift.
   d) Airfoil selection & wing design. [12]

6. Describe about stability and control of an airplane and give the conditions for static longitudinal stability. Also explain about static margin and neutral point. [12]

7. What are the structural elements and materials used in the construction of an aircraft? [12]

8. Explain in detail about elliptical orbits & Kepler’s laws of planetary motion. [12]
1. What are various parts of an aeroplane and give the functioning of control surfaces? How are aero
dynamic forces developed on an aeroplane? Describe the parameters affecting these aero dynamic
forces through dimensional analysis.

2. Derive the compressible flow equations in a variable area stream tube. A DC-10 is cruising at its
assigned mach number of 0.85. The outside air temperature is 232K.
At a given point on the upper surface of the wing the pressure measured is 20,100N/m^2. The
temperature at this point is 221K. What is the lift force, pressure, density and true speed of
airplane?

3. State Helmholtz vortex theorems. Applying these theorems on to flow over a wing calculate induced
drag coefficient for an elliptical lift distribution?

4. Discuss in detail about
   a. Boundary layer formation on bluff bodies
   b. Importance of aspect ratio & its effect on aerodynamic forces.

5. Write a short note on
   a) Development of airfoils
   b) Airfoil selection & wing design
   c) Leading & trailing edge devices
   d) Propulsive lift.

6. How do you calculate range and endurance of an airplane?

7. Explain about various types of propulsion systems used in aircraft and compare the working of
piston engine and turbojet engine?

8. Discuss in detail about orbital maneuvers and atmospheric entry. A satellite is to be boosted to an
orbital altitude of 500Km. What is orbital velocity & orbital period?

* * * * * * *
UNIT-I: REVISION OF BASICS LEARNT AT UNDER GRADUATE LEVEL IN BRIEF

**AERODYNAMIC CHARACTERISTICS OF AIRFOILS:** Vortex sheet, Vortex sheet in thin-airfoil theory, Planar wing, Properties of symmetrical airfoil, Properties of cambered airfoil, Flapped airfoil, Numerical Solution of thin airfoil problem, Airfoil of arbitrary thickness and camber

**UNIT II: THE FINITE WING**
Flow fields around finite wings, Downwash and induced drag, Fundamental equations of finite-wing theory, Elliptical lift distribution, Arbitrary circulation distribution, Twisted wing: Basic and Additional lift, Approximate calculation of additional lift, Winglets, Stability and trim of wings, Higher approximations, The complete airplane, Interference effects,

**AIRFOILS IN COMPRESSIBLE FLOWS**
Boundary conditions, subsonic airfoils Prandtl-Glauert transformation, Critical Mach number, Drag divergence Mach number, Airfoils in transonic flow, Airfoils in supersonic flow

**UNIT-III: WINGS AND WING-BODY COMBINATIONS IN COMPRESSIBLE FLOW**
Wings and bodies in compressible flows: Prandtl-Glauert-Goethert transformation, Influence of sweepback, Design rules for wing-fuselage combinations

**LAMINAR BOUNDARY LAYER IN COMPRESSIBLE FLOW**
Conservation of energy in the boundary layer, Rotation and entropy gradient in the boundary layer, Similarity considerations for compressible boundary layers, Solution of energy equation for Prandtl number unity, Temperature recovery factor, Heat transfer versus skin friction, Velocity and temperature profiles and skin friction, Effects of pressure gradient

**UNIT-IV: FLOW INSTABILITIES AND TRANSITION FROM LAMINAR TO TURBULENT FLOW**
Gross effects, Reynolds experiment, Tollmien-Schlichting instability and transition, Natural laminar flow and laminar flow control, Stability of vortex sheets, Transition phenomenon, Methods for experimentally detecting transition, Flow around spheres and circular cylinders

**TURBULENT FLOWS**
Description of turbulent field, Statistical properties, Conservation equations, Laminar sub-layer, Fully developed flows in tubes and channels, Constant-pressure turbulent boundary layer, Turbulent drag reduction, Effects of pressure gradient, Stratford criterion for turbulent separation, Effects of compressibility on skin friction, Reynolds analogy: Heat transfer and temperature recovery factor, Free turbulent shear flows

**AIRFOIL DESIGN, MULTIPLE SURFACES, VORTEX LIFT, SECONDARY FLOWS, VISCIOUS EFFECTS**
Airfoil design for high $C_{l_{max}}$, multiple lifting surfaces, Circulation control, Stream wise vorticity, Secondary flows, Vortex lift strakes, Flow about three-dimensional bodies, unsteady lift

**UNIT-V: UNSTEADY AERODYNAMICS**
Unsteady lifting force coefficient, Unsteady aerodynamics of slender wings, Compressible Unsteady
aerodynamics, Equations of motion, Boundary condition, Moving coordinate system, Navier Stokes equations, Aerodynamic forces and moments, Turbulence modelling, Numerical Problems

**INCOMPRESSIBLE FLOW OVER AN AIRFOIL**

**INCOMPRESSIBLE FLOW OVER WINGS**
Steady flow: Lifting line theory (results), Weissinger’s L – method, Low aspect ratio wings, unsteady flow: Reissner’s Approach, Numerical solutions, Numerical Problems

**TEXT BOOKS**

## COURSE COVERAGE SUMMARY FOR AERODYNAMICS OF FLIGHT VEHICLES

### (ELECTIVE-I)

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>Chapters in Text Book</th>
<th>Units / Topics Covered</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
</tr>
</thead>
</table>
MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - I Semester, February 2016
Sub: Aerodynamics Of Flight Vehicles
(Aero Space Engineering)

Time: 3 hours Max. Marks: 75

Note: Question paper Consists of 5 SECTIONS (One SECTION for each UNIT) and answer FIVE Questions, Choosing ONE Question from each SECTION. Each Question carries 15 marks.

SECTION - I
1. A thin airfoil has a cubic camber line defined by \( z = kc (x^3 - 3x^2 + 2x) \) in cartesian set of axis system with its origin at the leading edge. Its maximum camber is 2% of the chord. Determine \( C_l \) and \( C_{m,c/4} \) at \( 3^\circ \) incidence.

(or)
2. Discuss the properties of symmetric and cambered airfoils. Compare the circulation distribution and aerodynamic characteristics of symmetric and cambered airfoils.

SECTION – II
3. Derive the fundamental equation of Prandtl’s lifting line theory and obtain an expression for the induced drag coefficient for elliptic lift distribution.

(Or)
4. (a) Using linearized subsonic potential equation, derive an expression for the coefficient of pressure over a thin body at a small angle of attack.

(b) A thin flat plate is kept at angle of attack of \( 4^\circ \) in a uniform subsonic stream of Mach number 0.6. The coefficient of pressure at mid chord in incompressible flow is given as \( C_p = -0.07 \). Determine the pressure coefficient at the same point for Mach number 0.6.

SECTION – III
5. Derive the governing momentum and energy equations for the compressible laminar flow of a perfect gas in similarity form using Illingworth transformation.

(Or)
6. Write Notes on:
   i) Prandtl - Goethert transformation.
   ii) Effect of sweep back angle.
   iii) Lift enhancement techniques.

SECTION – IV
7. (a) What are the factors influencing boundary layer separation? How is boundary layer separation controlled?

(b) Explain the role of free stream turbulence on laminar-turbulent transition of boundary layers.
8. (a) Write short notes on “engineering prediction of turbulence”.

(b) With a neat sketch explain the sequence of events of “shock wave - boundary layer interactions”.

SECTION – V

9. The equation of a paraboloid of length l and whose axis is in line with x axis is given as \( c(x/1) = y^2 + z^2/a^2 \), \( 0 \leq x \leq l \) and \( 0 \leq y, z \leq a \). Obtain the downwash expression at the surface. If a slender paraboloid undergoes SHM about its nose in a vertical y–z plane, find the unsteady downwash expression at the surface.

(Or)


* * * * * * * * *
Code No: R15D7605-151-S

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - I Semester supplementary Examinations, Aug 2016
Aerodynamics of Flight Vehicles
(ASP)

Time: 3 hours Max. Marks: 75

Note: This question paper Consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

SECTION – I
1. Derive the fundamental equation of thin aerofoil theory for the symmetric aerofoil?
   (Or)
2. (a) State and Explain the Kelvin Circulation Theorem? Briefly discuss the starting vortex?
   (b) State and explain the Kutta condition for finite angle and cusp trailing edges?

SECTION – II
3. (a) Derive the fundamental equation of Prandtl's lifting-line theory for finite wing?
   (b) Write a short notes on (i) Downwash and induced drag (ii )Trailing vortices  (iii) Horse-shoe vortex.
   (Or)
4. (a) Derive the compressibility correction for compressible flow over thin aerofoil at small angle of attack using Prandtl-Glauert transformation?
   (b) At a given point on the surface of an airfoil, the pressure coefficient is -0.3 at very low-speeds. If the freestream Mach number is 0.6, calculate the $C_p$ at this point?

SECTION – III
5. Derive the linearized velocity potential equation for compressible flow over a thin airfoil using small perturbation theory?
   (Or)
6. (a) Consider the NACA 0012 airfoil at zero angle of attack. The minimum value of pressure co-efficient on the surface is – 0.43. Estimate the critical Mach number of this aerofoil?
   (b) Drive the energy equation governing compressible laminar boundary layer?

SECTION – IV
   (Or)
8. Derive the equations governing the two-dimensional, incompressible and isothermal turbulent shear flows?
   Note: Consider the boundary layer equation of motion as given below.
9. Discuss briefly about unsteady lifting force coefficient and unsteady aerodynamics of slender wings?
(Or)

\[
p\left(\frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} + v \frac{\partial u}{\partial y}\right) = -\frac{\partial p}{\partial x} + \frac{\partial}{\partial y}\left(\mu \frac{\partial u}{\partial y}\right)
\]
PART - A
(Answer all sub questions)

1.a) What is Kutta condition and why it is important in airfoil theory?

1.b) What are trailing edge vortices and how they are generated around wings?

1.c) Why it is necessary to have wing sweep for high speed flight vehicles?

1.d) Why transition from laminar to turbulence flow occurs?

1.e) What is Reynolds analogy?

PART - B

5 × 8 marks = 40

Answer either “a” or “b” from each question, but not both

2.a) Describe suitable numerical method for the circulation distribution on an arbitrary cambered airfoil.

OR

b) For a symmetrical airfoil, if the γ distribution is given by: γ(θ) = 2α U∞ \( \frac{1 + \cos \theta}{\sin \theta} \)

Find expression for \( c_1 \) and \( c_2 \) using above vertex distribution.

3.a) With the help of neat sketches, describe flow field around finite wing in incompressible flow. What is winglet and why it is used in wing design?

OR

b) Derive expression for \( C_D \) for small perturbation supersonic flow.

4.a) Describe area rule for the design of wing-fuselage configuration at supersonic speeds.

OR

b) What are the similarity parameters used for the study of compressible boundary layer? Under what condition the velocity and temperature profile would be similar in the above flow (explain with neat sketch)?

5.a) With the help of neat sketch explain Tollmein-Schlichting instability.

OR

b) Describe flow around spheres and circular cylinder with special emphasis on transition and flow separation.

6.a) Write short note on following:

i) Reynolds stresses  ii) Laminar sublayer iii) Turbulent drag reduction

OR

b) Sketch the flow field and pressure distribution over a typical multi-element airfoil.
Answer any five questions
All questions carry equal marks

1. Discuss the properties of symmetric and cambered airfoils. Compare the circulation distribution and aerodynamic characteristics of symmetric and cambered airfoils.

2. Prove that elliptic distribution of lift over a finite wing yields minimum induced drag.

3. Compare the subsonic and supersonic airfoils and their aerodynamic characteristics.


5. a) Derive Crocco’s relation and b) Discuss the solution of energy equation for Prandtl number unity.

6. Briefly discuss:
   a) Compressibility, turbulence and noise and Centrifugal instability.
   b) Flow around spheres and circular cylinders.

7. Discuss fully developed flows in tubes and channels.

8. Discuss airfoil design for maximum lift coefficient.

***
UNIT-I: AIRCRAFT STRUCTURAL MATERIALS
Aluminium Alloys, Steel, Titanium, plastic, glass, composite materials, properties of materials, Testing of Engineering Materials: Tensile test, Compression test, Bending Stress, Shear Test, Hardness Test, Impact Test, Stress-Strain Curve. Strain Hardening, Creep Relaxation

STRUCTURAL COMPONENTS AND LOADS OF AIRCRAFT
Loads on Structural components, Function of structural components, Fabrication of structural components, Connections; Airworthiness: Factors of Safety- flight envelope, Load factor determination, Airframe loads: Aircraft inertia loads, Symmetric maneuver loads, Normal accelerations associated with various types of maneuvers, Gust loads

UNIT-II: SHEAR FLOW AND SHEAR CENTER IN OPEN AND CLOSED THIN WALL SECTIONS
Open Sections: Shear center and elastic axis, Concept of shear flow, Beams with one axis of symmetry; Closed Sections: Bradt-Batho formula, Single and multi-cell closed box structures, Semi monocoque and mono cocque structures, Shear flow in single and multi cell mono cocque and semi mono cocque box beams subject to torsion

UNIT-III: THIN PLATE THEORY
Bending of thin plates: Pure bending of thin plates, Plates subjected to bending and twisting, Plates subject to distributed transverse load, Combined bending and in-plane loading of a thin rectangular plate, Bending of thin plates having a small initial curvature, Energy method for bending of thin plates

UNIT-IV: BENDING, SHEAR AND TORSION OF THIN-WALLED BEAMS-I
Bending and Open Thin-Walled Beams: Symmetrical bending, Unsymmetrical bending, Deflections due to bending, Calculation of section properties, Applicability of bending theory, Temperature effects

STRESS ANALYSIS OF AIRCRAFT COMPONENTS
Wing spars, Fuselages, Wings, Fuselage frames and wing ribs, laminated composite structures

UNIT-V: SMART MATERIALS AND ADAPTIVE STRUCTURES
Smart Materials Technologies and Control Applications: Control requirements, Smart Materials-Piezoelectric elements, Electrostrictive elements, Magnetostrictive transducers, Electrorheological fluids, Shape memory alloys, Fiber optic sensors, Applications of smart materials, Adaptive Structures: Adaptive aerospace structures-Structural Health Monitoring (SHM), Shape control and active flow, Damping of vibration and noise, Smart skins, Systems

TEXT BOOK

REFERENCE BOOKS
MALLAREDDY COLLEGE OF ENGINEERING & TECHNOLOGY
I Year M. Tech, ASP-I SEM
(R15D7607) MODELING AND SIMULATION OF FLUID FLOWS
(Elective-II)

UNIT-I: BASIC EQUATIONS OF FLUID DYNAMICS AND DYNAMICAL LEVELS OF APPROXIMATION
General form of a conservation law, Mass conservation equation, Momentum conservation law or equation of motion, Energy conservation equation; Navier–Stokes equations, Approximations of turbulent flows, Thin shear layer approximation, Parabolized Navier–Stokes equations, Boundary layer approximation, Distributed loss model, Inviscid flow model: Euler equations, Potential flow model.

UNIT II: MATHEMATICAL NATURE OF THE FLOW EQUATIONS AND THEIR BOUNDARY CONDITIONS
Simplified models of a convection–diffusion equation, Definition of the mathematical properties of a system of PDEs, Hyperbolic and parabolic equations: characteristic surfaces and domain of dependence, Time-dependent and conservation form of the PDEs, Initial and boundary conditions

UNIT III: DISCRETIZATION TECHNIQUES

UNIT IV: ANALYSIS OF NUMERICAL SCHEMES
Consistency, stability and error analysis of numerical schemes: Basic concepts and definitions, Von Neumann method for stability analysis, New Leapfrog, Lax-Fredrichs and Lax-Wendroff schemes for the linear convection equation, Spectral analysis of numerical errors; General Properties and High Resolution Numerical Schemes: General formulation of numerical schemes, Generation of new schemes with prescribed order of accuracy, Monotonicity of numerical schemes, Finite volume formulation of schemes and limiters

TIME INTEGRATION METHODS FOR SPACE DISCRETIZED EQUATIONS
Analysis of space-discretized systems, Analysis of time integration schemes, Selection of time integration methods, Implicit schemes for multidimensional problems: Approximate factorization method

UNIT V: ITERATIVE METHODS FOR RESOLUTION OF ALGEBRAIC SYSTEMS
Basic iterative methods, Overrelaxation methods, Preconditioning techniques, Nonlinear problems, Multigrid method.
NUMERICAL SIMULATION OF INVISCID FLOWS
Euler equations, Potential flow model, Numerical solutions for the potential equation, Finite volume discretization of the Euler equations, Numerical solutions for the Euler equation

NUMERICAL SOLUTIONS OF VISCOUS LAMINAR FLOWS

TEXT BOOK

REFERENCE BOOKS
## COURSE COVERAGE SUMMARY
FOR
MODELING AND SIMULATION OF FLUID FLOWS
(Elective-II)

<table>
<thead>
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</tr>
</thead>
</table>
1. State the conservation law for a quantity $U$. Derive scalar conservation law in the integral conservation form and comment on its properties.

(Or)

2. Discuss the salient features of the following approximations of Navier-Stokes equations
   i. Thin shear layer Approximation
   ii. Parabolized Navier-stokes approximation.

SECTION – II

3. Give the classification of partial differential equations, explaining the characteristics of each type of PDE.

(Or)

4. Discuss about hyperbolic and parabolic equation characteristic surfaces and domain of dependence.

SECTION – III

5. How do you determine the accuracy of the discretization process? What are the uses and difficulties of approximating the derivatives with higher order finite difference schemes? How do you overcome these difficulties?

(Or)

6. Apply the Galerkin method, with linear elements to the first order equation
   \[ a \frac{\partial u}{\partial x} = q \]
   Show that on a uniform mesh, $\Delta x_i + \Delta x_{i+1} = \Delta x$, we obtain the same discretization as with central differences.
   b. Differentiate between structured and unstructured grid.

SECTION – IV

7. Using Von Neumann stability analysis, derive the criterion for stability analysis of parabolic PDE. Make necessary assumptions, but state them clearly.
(Or)

8. i. Illustrate the Lax-Wendroff technique for unsteady two dimensional inviscid flow.
   ii. Explain ADI technique for solving 2D, unsteady diffusion problem.

SECTION – V

9. Apply the leapfrog scheme with the upwind space discretization of the convection equation \( u_t + a u_x = 0 \).
   This is the scheme \( u_i^{n+1} - u_i^{n-1} = 2\sigma (u_i^n - u_{i-1}^n) \) calculate the amplification matrix, and show that the scheme is unconditionally unstable.

(Or)

10. Apply a forward space differencing, with a forward time difference (Euler method) to the convective equation \( u_t + a u_x = 0 \). Analyze the stability with von Neumann’s method and show that the scheme is unconditionally unstable for \( a > 0 \), and conditionally stable \( a > 0 \). Derive also the equivalent differential equation and show why this scheme is unstable when \( a > 0 \).

* * * * * * * * *
1. i. List the basic equations of motion for a two dimensional, constant property and steady flow field.
ii. What are the boundary layer approximations? Using the order of magnitude Approach; explain how the pressure at a location along the flat plate is evaluated for Laminar boundary layer flow over a flat plate.

(Or)

2. i. Describe about boundary layer approximations including separation of boundary layer.
ii. Write a short note on various flow models.

SECTION - II

3. i. Explain the physical significance of courant freidrichs-lewy (CFL) condition through figures giving geometrical characteristic interpolation for an example of hyperbolic equations.
ii. Write a short note on
   ( a ) Simplified models of a convection-Diffusion equation.
   ( b ) Pure convection equation

(Or)

4. i. Show that the one-dimensional Navier-stokes equation without pressure gradient
\[ \frac{\partial u}{\partial t} + u \frac{\partial u}{\partial x} = \alpha \frac{\partial^2 u}{\partial x^2} \] is parabolic in x,t.
ii. Show that the system of Cauchy-Riemann equations
\[ \frac{\partial u}{\partial x} + \frac{\partial v}{\partial y} = 0 \\
\frac{\partial u}{\partial y} - \frac{\partial v}{\partial x} = 0 \] is elliptic nature.

SECTION - III

5. What is cell centered formulation? Explain with help of using control volume, semi discretization equation,
\[ \Omega \frac{\partial U}{\partial t} + \int F \cdot nds = 0. \]
ii. Discuss the properties of discretization schemes and explain upwind discretization applied to FVM.

(Or)

6. i. Solve the simplified sturn-lioville equation:
\( \frac{\partial^2 u}{\partial x^2} + y = F \) with boundary conditions \( y(0) = 0 \) and \( \frac{\partial u}{\partial y} (1) = 0 \); using Galerkin finite element method.

ii. Explain the difference between explicit and implicit methods with suitable example.

SECTION – IV

7. i. Explain in detail about an advanced addition to the accuracy barrier.

ii. What is meant by monotonicity of numerical schemes? Explain about it?

(Or)

8. i. Briefly discuss about an analysis of space-discretized systems.

ii. Mention the various iterative methods for the resolution of algebraic systems. Discuss it.

SECTION – V

9. Write short notes on the basic ideas involved in the following overrelaxation methods for the solution of algebraic systems widely used in CFD

i. Jacobi Overrelaxation

ii. Successive Overrelaxation

iii. Symmetric successive Overrelaxation

(Or)

10. Write short notes on

i. Navier stokes equations for laminar flows

ii. Numerical solutions for the euler equation

iii. Density based methods for viscous flows.

* * * * * * * * * *
Code No: 5176,J
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, February-2014
MODELING AND SIMULATION OF FLUID FLOWS
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Instructions:

i) Part A is compulsory Question for 20 marks.
ii) Part B consists of five questions with “either” “or” pattern. The student has to answer any one. However students have to answer five questions from Part B (numbered from 2 to 6)

PART - A
(Answer all sub questions)
5 x 4 marks = 20

1.a) Explain the physical Meaning of Substantial Derivative of a fluid element.
b) Discuss the concept of domain of dependence as applicable for hyperbolic partial differential equations.
c) What are the aspects to be considered for grid generation?
d) What is stability and explain its importance in CFD?
e) Write about over-relaxation methods.

PART - B
5 x 8 marks = 40

Answer either “a” or “b” from each question, but not both

2.a) Solve the second-order wave equation
\[ u_t = c^2 u_{xx} \]
on the interval \(-\infty < x < +\infty\)
with the initial data \( u(x,0) = f(x) \)
\( u_t(x,0) = g(x) \).

OR

b) Classify the following system of equations:
\[ \frac{\partial \phi}{\partial t} + 8 \frac{\partial \phi}{\partial x} = 0 \]
\[ \frac{\partial \phi}{\partial t} + 2 \frac{\partial \phi}{\partial x} = 0. \]

3.a) Derive the energy equation in terms of total energy for a viscous flow on the basis of flow model of infinitesimally small fluid element moving with the flow.

OR

b) Derive incompressible Navier-Stokes equation in a spherical coordinate system.
4.a) The DuFort-Frankel method for solving the heat equation requires solution of the difference equation:

\[ \frac{u_j^{n+1} - u_j^n}{2\Delta t} = \frac{\alpha}{(\Delta x)^2} (u_{j+1}^n - 2u_j^n + u_{j-1}^n) \]

Apply the Fourier stability analysis to this method and determine the stability restrictions if any.

b) Consider the non-linear equation

\[ \frac{\partial u}{\partial x} = \mu \frac{\partial^2 u}{\partial y^2} \]

where \( \mu \) is a constant.

i) Is this equation in conservative form? If not, can you suggest a conservative form for the equation?

ii) Develop a finite-difference formulation for this equation using the integral approach.

5.a) Derive the modified equation for the Lax method applied to the wave equation. Retain terms up to and including \( \theta_{Lax} \).

b) Derive the stability conditions for the FTCS method applied to the 1-D Linearized Burgers' equation.

6.a) Suggest a way that the PPNS procedure might be extended to 3-D flows.

b) The FVS method of Steger and Warming “splits” the system of equations

\[ U_t + E_x = 0 \]

into the following form:

\[ U_t + E_x = 0 \]

If this method is applied to the system of equations

\[ U = [u] \quad E = [c] \quad \theta \]

Where \( c \) is a constant, find the following quantities:

i) \( \{A\} \)

ii) \( \{B\}, \{K\} \)

iii) \( \{T\}, \{T^{-1}\} \)

iv) \( \{\lambda\}, \{\lambda^{-1}\} \)

v) \( E + E_c \)

**************
1. a) List the basic equations of motion for a two dimensional, constant property and steady flow field.
   b) What are boundary layer approximations? Using the order of magnitude approach, explain how the pressure at a location along the flat plate is evaluated for laminar boundary layer flow over a flat plate.

2. Give the classification of Partial Differential Equations, explaining the characteristics of each type of PDE.

3. a) Using the Taylor’s series approximation, derive the finite difference expressions for first order and second order differential terms of variable, Φ.
   b) Explain the Method of Weighted Residuals to solve PDEs using FEM.

4. Using the Von Neumann Stability Analysis, derive the criterion for stability Analysis of Parabolic PDE. Make necessary assumptions, but state them clearly.

5. What are the different methods of obtaining the matrix inverse? Briefly explain each one, mentioning their relative advantages and disadvantages.

6. An Aluminum rod, 2.5 cm in diameter and 15 cm long protrudes from a wall maintained at 300°C. The environment temperature is 38°C. The surface heat transfer coefficient is 17 W/m²K. Taking the mesh size as 5 cm, obtain the nodal equations, considering the fin as short. What is the type of coefficient matrix? What is the suitable matrix inversion technique? Using that technique, obtain the nodal temperatures using FDM.

7. a) Illustrate the Lax-Wendroff Technique for unsteady, two dimensional inviscid flow.
   b) Explain ADI Technique for solving 2D, unsteady diffusion problem.

8. Write short notes on the following.
   a) SIMPLE Algorithm for Pressure Linked Equations.
   b) Numerical methods for solving potential equations.
   c) Basic rules of Finite Volume Method.

*****
1.a) Briefly discuss about mass conservation equation, momentum conservation equation and the energy conservation equation.
   b) Derive the Navier-Stokes equations of a motion for a fluid flow. [12]

2.a) Describe about boundary layer approximations including separation of boundary layer.
   b) Write a short note on various flow models. [12]

3.a) Discuss about parabolic and hyperbolic equations in detail.
   b) Differentiate between finite difference formulae and implicit finite difference formulae. [12]

4.a) What is meant by finite element method and finite volume method? Explain it.
   b) Discuss about finite element Galerkin method for a conservation law. [12]

5.a) Explain in detail about Von Neuman method for stability analysis.
   b) What is the spectral analysis of numerical errors? [12]

6.a) Discuss in detail about an advanced addition to the accuracy barrier.
   b) What is meant by monotonicity of numerical schemes? Explain about it. [12]

7.a) Briefly discuss about an analysis of the space-discretized systems.
   b) Mention the various iterative methods for the resolution of algebraic systems. Discuss it. [12]

8.a) Write a short note on potential flow model.
   b) Briefly explain about finite volume discretization of the Euler equations. [12]
1. State the conservation law for a quantity $U$. Derive scalar conservation law in the integral conservation form and comment on its properties.

2. Discuss the salient features of the following approximations of Navier-Stokes equations
   i) Thin shear layer approximation
   ii) Parabolized Navier-Stokes approximation.

3. Describe the cell-centered and cell-vertex approaches of finite volume method. Compare finite element and finite volume methods and bring out their similarities and differences.

4. Define structured and unstructured grids. What are the options that can be considered for the treatment of curved solid boundaries using Cartesian type grids? Describe different configurations of body-fitted structured grids (H-mesh, C-mesh, O-mesh, I-mesh) with the help of diagrams.

5. a) State the Equivalence theorem of Lax and explain through a diagram its implication on the relationship between the three properties of consistency, stability and convergence of a numerical scheme.
   b) Explain the physical significance of Courant-Friedrichs-Lewy (CFL) condition through figures giving geometrical, characteristic interpretation for an example of hyperbolic equations.

6. State Godunov’s theorem. Discuss the concept and methodology of limiters introduced in high resolution schemes with the help of an example and relevant diagrams. Describe the essential points to remember for the practical implementation of selected limiters.

7. Write short notes on the basic ideas involved in the following overrelaxation methods for the solution of algebraic systems widely used in CFD
   iii) Jacobi over relaxation
   iv) Successive Over relaxation.
   v) Symmetric successive over relaxation.
   vi) Successive line over relaxation.

8. Explain the basic approach of Pressure Correction Methods.
UNIT I: STRUCTURAL MECHANICS-BASIC THEORY, STRUCTURAL MECHANICS-FINITE ELEMENTS

UNIT II: SPINNING STRUCTURES, DYNAMIC ELEMENT METHOD
Derivation of Equation of Motion, Derivation of Nodal Centrifugal Forces, Derivation of Element Matrices; Bar Element, Beam Element, Rectangular Pre-stressed Membrane Element, Plane Triangular Element, Shell Element.

UNIT III: GENERATION OF SYSTEM MATRICES, SOLUTION OF SYSTEM EQUATIONS
Coordinate Systems and Transformations, Matrix Assembly, Imposition of Deflection Boundary Conditions, Matrix Bandwidth Minimization, Sparse Matrix Storage Schemes; Formulation and Solution of System Equation, Sparse Cholesky Factorization.

UNIT IV: EIGENVALUE PROBLEMS, DYNAMIC RESPONSE OF ELASTIC STRUCTURES

UNIT V
NONLINEAR ANALYSIS, STRESS COMPUTATIONS AND OPTIMIZATION
Geometric Nonlinearity, Material Nonlinearity, Numerical Examples; Line Elements, Triangular Shell Elements, Solid Elements, Optimization, Examples of Applications of Optimization.

HEAT TRANSFER ANALYSIS OF SOLIDS, COMPUTATIONAL LINEAR AEROELASTICITY AND AEROSERVOElasticity

CFD-BASED AEROELASTICITY AND AEROSERVOElasticity
Computational Fluid Dynamics, Time-Marched Aeroe1astic and Aeroservoe1astic Analysis, ARMA Model in Aeroelastic and Aeroservoelastic Analysis, Numerical Examples

TEXT BOOK

REFERENCE BOOK
UNIT – I: AIRCRAFT SYSTEMS

UNIT – II: AIRCRAFT HYDRAULIC SYSTEMS
Hydraulic system services, the hydraulic circuit, actuation, the hydraulic fluid, hydraulic piping, hydraulic pump, fluid conditioning, the reservoir, emergency power sources. Aircraft applications, examples of B Ae, Airbus, Boeing implementations. The landing gear system for retraction, steering, braking and anti-skid.

ELECTRICAL SYSTEMS
Aircraft electrical system characteristics, power (AC and DC) generation, Power generation control, voltage regulation, parallel operation, supervisory and protection functions. Modern electrical power generation types, Electrical power quality. Primary power distribution, power conversion and energy storage. Secondary power distribution, power switching, load protection. Electrical loads, motors and actuators, lighting, heating, subsystem controllers, ground power. Emergency power generation. Typical civil transport aircraft electrical systems examples. Electrical load management system. Aircraft electrical wiring.

UNIT – III: ENGINE CONTROL AND FUEL SYSTEMS

PNEUMATIC SYSTEMS AND ENVIRONMENTAL CONTROL SYSTEMS.
Use of pneumatic power in aircraft, Sources of pneumatic power, the engine bleed air, engine bleed air control. Users of pneumatic power, wing and engine anti-ice, engine start, thrust reversers, hydraulic system, pitot-static systems. The need for controlled environment in aircraft. Sources of heat. Environmental control system design, ram air cooling, fuel cooling, engine bleed, bleed flow and temperature control. Refrigeration systems, air cycle and vapour cycle systems, turbo fan, boot strap, reversed boot strap systems. Humidity control. Air distribution systems. Cabin pressurisation, g tolerance, rain dispersal, anti-misting and demisting. In-flight entertainment systems.

UNIT – IV: FLIGHT CONTROL SYSTEMS
Principles of flight control, flight control surfaces, control surface actuation, flight control linkage systems, trim and feel. Power control, mechanical, direct drive, electromechanical, electro-hydrostatic actuation, multiple redundancy. The fly by wire system. Airbus and Boeing implementations, Inter-relationship of flight control, guidance and vehicle management systems. Advanced systems - integrated flight and propulsion control, Vehicle management systems. All-electric aircraft concept, more-electric aircraft power generation concepts. Impact of stealth design- examples.
SYSTEMS SAFETY, DESIGN AND DEVELOPMENT

UNIT – V: SYSTEMS ARCHITECTURE, INTEGRATION
Architectural representation of systems, merits, definitions, types, architecture modeling and trade-off. Systems integration, definitions, levels of integration, examples, management of systems integration. Aircraft system example. Verification of system requirements, tools - modeling, simulation, test rigs and prototypes, Modeling techniques - types of models and simulations. Test rigs and prototypes. Declaring verification.

Need for interoperability of evolving systems. Forward compatibility and backward compatibility, Factors affecting compatibility. System configurations. representation. configuration control – need, the process.

TEXT BOOKS

REFERENCE BOOKS
UNIT I: INTRODUCTION, VECTORS AND TENSORS

UNIT II: KINEMATICS OF CONTINUA
Introduction, Description of Motion- Configurations of a Continuous Medium, Material Description, Spatial Description, Displacement Field; Analysis of Deformation- Deformation gradient tensors, Isochoric, Homogeneous and Inhomogeneous Deformations, Change of volume and surface; Strain Measures-Cauchy-Green deformation tensors, Green strain tensor, Physical Interpretation of the Strain Components, Cauchy and Euler Strain Tensors, Principal Strains; Infinitesimal Strain Tensor and Rotation Tensor- Infinitesimal Strain Tensor, Physical Interpretation of Infinitesimal Strain Tensor Components, Infinitesimal Rotation Tensor, Infinitesimal Strains in Cylindrical and Spherical Coordinate Systems; Rate of Deformation and Vorticity Tensors- Definitions, Relationship between D and E, Polar Decomposition Theorem, Compatibility Equations, Change of Observer- Material Frame Indifference.

UNIT III: STRESS MEASURES

CONSERVATION OF MASS, MOMENTA AND ENERGY

UNIT IV: CONSTITUTIVE EQUATIONS

**LINEARIZED ELASTICITY**

**UNIT V: FLUID MECHANICS AND HEAT TRANSFER**

**LINEAR VISCOELASTICITY**

**TEXT BOOK**


**REFERENCE BOOKS**

# COURSE COVERAGE SUMMARY FOR CONTINUUM MECHANICS

**(OPEN ELECTIVE-I)**

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<tr>
<th>TEXT BOOK</th>
<th>Chapters in Text Book</th>
<th>Units / Topics Covered</th>
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<th>PUBLISHERS</th>
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<td>An Introduction to Continuum Mechanics</td>
<td>1-9</td>
<td>1-5</td>
<td>J.N. Reddy</td>
<td>Cambridge University Press</td>
<td>2007</td>
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Code No: 5176C
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech I Semester Examinations, February - 2014
CONTINUUM MECHANICS
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Instructions:
(i) Part A is compulsory Question for 20 marks.
(ii) Part B consists of five questions with “either–or” pattern. The student has to answer any one. However students have to answer five questions from Part B (numbered from 2 to 6).

PART - A
(Answer all sub questions)
5 × 4 marks = 20

1. a) Provide a physical interpretation of the Divergence Theorem.
   b) Determine the gradient of \( u = x^2z - 4xz^2 \) at point (1.5, 3, –1.5) along the direction \( 3i - 2j - 3k \).
   c) The stress tensor throughout a continuum is given with respect to Cartesian axes as
      \[
      \sigma = \begin{bmatrix}
      4x & x & 0 \\
      6x & 0 & 6z \\
      0 & 3x & 0
      \end{bmatrix}
      \]
      Determine the stress vector (or traction) at the point \( P(3, 2, 3) \) of the plane that is tangent to the cylindrical surface \( x^2 + y^2 = 5 \) at \( P \).
   d) What is Airy’s Stress function? Explain its significance.
   e) Derive the differential form of Momentum equation.

PART - B

Answer either “a” or “b” from each question, but not both
5 × 8 marks = 40

2. a) For the following stress tensor \( \tau = \begin{bmatrix}
5 & 3 & 0 \\
-4 & 9 & 0 \\
0 & 0 & 5
\end{bmatrix} \)
   i) Determine directly the three invariants \( I_1, I_2, \) and \( I_3 \) of the following stress tensor.
   ii) Determine the principal stresses and the principal stress directions.
   iii) Show that the transformation tensor of direction cosines transforms the original stress tensor into the diagonal principal axes stress tensor.
   iv) Re-compute the three invariants from the principal stresses.
   v) Split the stress tensor into its spherical and deviator parts.
   vi) Show that the first invariant of the deviator is zero.

OR

b) Linear and finite strain tensors can be decomposed into the sum or product of two other tensors.
   i) Which strain tensor can be decomposed into a sum, and which other one into a product.
   ii) Why is such decomposition performed?
3 a) A continuum body undergoes the deformation $x_1 = X_1 + A X_2$, $x_2 = X_2 + A X_3$, $x_3 = X_3 + A X_1$, where $A$ is a constant.

i) Compute the deformation tensor $C$.

ii) Use the computed $C$ to determine the Lagrangian finite strain tensor $E$.

iii) Compute the Eulerian strain tensor $E$ and compare with $E$ for very small values of $A$.

OR

b) For a plane stress problem characterized by the following stress tensor

$$\sigma = \begin{pmatrix} 8 & 3 \\ 3 & 5 \end{pmatrix}$$

Use Mohr’s circle to determine the principal stresses, and show on an appropriate figure the orientation of those principal stresses.

4 a) A continuum body undergoes the deformation $x_1 = 4X_1$, $x_2 = -1.2X_3$, $x_3 = 1.2X_1$ and the Cauchy stress tensor for this body is $\tau = \begin{pmatrix} 150 & 0 & 0 \\ 0 & 0 & 0 \\ 0 & 0 & 0 \end{pmatrix}$ MPa

i) Determine the corresponding first Piola-Kirchhoff stress tensor.

ii) Determine the corresponding second Piola-Kirchhoff stress tensor.

iii) Determine the pseudo stress vector associated with the first Piola-Kirchhoff stress tensor on the $e_1$ plane in the deformed state.

iv) Determine the pseudo stress vector associated with the second Piola-Kirchhoff stress tensor on the $e_1$ plane in the deformed state.

OR

b) If the stress tensor at point $P$ is given by $\sigma = \begin{pmatrix} 12 & -3 & 6 \\ -3 & 5 & 2 \\ 0 & 2 & 4 \end{pmatrix}$ Determine the traction (or stress vector) $t$ on the plane passing through $P$ and parallel to the plane $ABC$ where $A(6, 0, 0)$, $B(0, 4, 0)$ and $C(0, 0, 2)$.

5 a) The state of stress at a point of structural steel is given by $\tau = \begin{pmatrix} 7 & 3 & 0 \\ 3 & -2 & 0 \\ 0 & 0 & 5 \end{pmatrix}$ MPa

with $E = 207$ GPa, $\mu = 88$ GPa, and $\nu = 0.3$.

i) Determine the engineering strain components.

ii) If a five centime cube of structural steel is subjected to this stress tensor, what would be the change in volume?

OR

b) Determine the stress tensor at a point where the Lagrangian strain tensor is given by $E = \begin{pmatrix} 70 & 60 & 30 \\ 60 & 80 & 0 \\ 30 & 0 & 70 \end{pmatrix}$ and the material is steel with $E = 119.2$ GPa and $\mu = 79.2$ GPa.
6. a) The wall of a refrigerator is constructed of fiberglass insulation \( (k = 0.035 \text{ W/m} \cdot \text{°C}) \) sandwiched between two layers of 1-mm-thick sheet metal \( (k = 15.1 \text{ W/m} \cdot \text{°C}) \). The refrigerated space is maintained at 3°C and the average heat transfer coefficients at the inner and outer surfaces of the wall are 4 W/m² \cdot °C and 9 W/m² \cdot °C respectively. The kitchen temperature averages 25°C. It is observed that condensation occurs on the outer surfaces of the refrigerator when the temperature of the outer surface drops to 20°C. Determine the minimum thickness of fiberglass insulation that needs to be used in the wall in order to avoid condensation on the outer surfaces.

b) A composite wall includes 10 mm thick hardwood siding, 50 mm by 135 mm hardwood studs on 0.712 m centers with glass fiber insulation (paper faced 31 kg/m³), and a 15 mm layer of gypsum (vermiculite) wall board. What is the thermal resistance associated with a wall that is 3.2 m high by 7.2 m wide (having 15 studs each 2.9 m high).
1. a) Establish the following identity using the index notation: \( \text{div} (\mathbf{A} \times \mathbf{B}) = \nabla \times \mathbf{A} \cdot \mathbf{B} - \nabla \times \mathbf{B} \cdot \mathbf{A} \)
   b) For an arbitrary second order tensor \( \mathbf{S} \), determine the expression for \( \nabla \times \mathbf{S} \).

2. Derive the expressions for the components of Green – Lagrange strain tensor in cylindrical coordinate system.

3. The components of a stress dyadic at a point, referred to the Cartesian system, are
   Find the principal stress and the principal plane associated with the maximum stress.

4. Derive the energy equation for one-dimensional flow.

5. Derive the Newtonian constitutive equation for stress tensor in a fluid motion.

6. Derive Michell’s equations for an elastic system.

7. Derive the Navier – Stokes equations in Cartesian coordinate system.

8. Write short notes on
   a) Maxwell element
   b) Creep response
   c) Kelvin – Voigt element.

* * * * * * * *
UNIT-I: FUNDAMENTALS OF JET PROPULSION
Aircraft Propulsion, Thermodynamic relations and cycles involved, Classification of Air breathing Engines, Ideal and Real Cycle Analysis - Turbojet and Turbofan, Effects of Altitude, Mach number, Aircraft Performance and Engine Performance analysis, Aircraft Engine Design, Methods employed for Thrust Augmentation and Jet Engine Noise suppression.

UNIT-II: INLETS AND NOZZLES
Types of Inlets, Combined Area Changes and Friction, Supersonic Inlet Design Considerations, Engine Starting, Effect of Additive Drag, Types of nozzles, Performance Map, Non-ideal equations for Various Nozzles, Effects of Pressure Ratios on Engine Performance, Performance Maps, Methods and advantages in reversing the Thrust, Types of Thrust Vectoring.

COMBUSTION CHAMBER

UNIT-III: COMPRESSORS AND TURBINES
Classification of Compressors, Euler’s Turbo-Machinery Equations, components of axial flow compressor, stage, Velocity Triangles, Single-Stage Energy Analysis, Variable Stators, Radial Equilibrium and Streamline Analysis Method; Centrifugal Compressors- Geometry, Velocity triangles, Impeller Design, Performance Maps;

RAMJETS

UNIT-IV: HYPersonic AIR-BREATHING PROPULSION

UNIT-V: DESIGN OF GAS TURBINE ENGINE

**SYSTEM MATCHING AND ANALYSIS**

Matching of Gas Turbine Components, Cycle Analysis of one and two spool engines, Gas Generator, Component Modeling, Solution of Matching Problem, Dynamic or Transient behavior, Matching of Engine and Aircraft, Use of Matching and Cycle analysis in Second stage design

**TEXT BOOKS**

5. Aircraft propulsion, Ahmed sayeed,

**REFERENCE BOOK**

SECTION - I
1. Explain about the single spool, double spool and multi spool turbofan engine concept with neat diagrams.  
   (Or)

2. A Brayton cycle operates with a regeneration of 78% effectiveness. The air at the inlet to the compressor is 
   at 0.1 MPa and 340°C, the pressure ratio is 6.5 and the maximum cycle temperature 950°C. If the compressor 
   and turbine have efficiencies of 85 percentages each, find the percentage increase in the cycle efficiency due 
   to regeneration.

SECTION – II
3. Explain the methods and advantages in reversing the thrust.  
   (Or)

4. What is the concept of thrust vector control (TVC)? How it helps in improving the efficiency of engine? 
   Explain different types of thrust vector control.

SECTION – III
5. (i) A centrifugal compressor has a pressure ratio of 4:1 with an isentropic efficiency of 80% when running at 
   15000 rpm and inducing air at 293 K. Curved vanes at the inlet give the air a pre whirl of 25ºc to the axial 
   direction at all radii. The tip diameter of the eye of the impeller is 250 mm. the absolute velocity at inlet is 
   150 m/sec and impeller diameter is 600 mm. calculate the slip factor. 
   (ii) Explain with neat diagrams the single stage performance characteristics and multistage performance 
   characteristics. 
   (Or)

6. An ideal ramjet is flying at Mach 3.4 where the ambient temp is 300 K. The fuel has a heating value of 64,000 
   KJ/Kg and the temp inside the combustion chamber is 2780K. Find the jet exit velocity and fuel ratio. If the 
   air mass flow through the engine is 260 kg / sec, what is the thrust produced and thrust specific fuel 
   consumption? For air γ = 1.4 and C_p = 1.0035 KJ/Kg K which are assumed to remain constant. Take 
   isentropic temperature ratio for M = 3 is 0.566.
SECTION – IV
7. Explain with the neat diagrams the experimental and testing facilities required to estimate the scramjet engine performance.

(Or)
8. Explain the role of scramjet engine in space plane applications. Also explain the current problems in hypersonic scramjet engine.

SECTION – V
9. Explain the major considerations in engine component design. Also discuss with neat diagrams various types of combustion systems.

(Or)
10. Explain with suitable notations and symbols the cycle analysis of one and two spool engines.

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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - I Semester supplementary Examinations, Aug 2016
Air- Breathing Propulsion
(ASP)

Time: 3 hours Max. Marks: 75

Note: This question paper Consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

SECTION - I
1. What For an ideal cycle of a reciprocating IC engine, in which heat is added to the working medium air at constant volume the following working conditions are given. P_a = 1 bar, T_a = 330 K, Compression ratio 4 , pressure ratio 4, for one Kg of working medium find out (i) Amount of heat added and rejected (ii) Thermal efficiency of Carnot cycle for the given working conditions (iii) thermal efficiency of the cycle (iv) The indicative mean effective pressure.

(Or)

2. Explain with all notations the analysis of piston engine in terms of Power, Friction Horse Power (FHP), Break horse power ( BHP), Indicative horse power (IHP), Volumetric efficiency (\(\eta_{VO}\)), Propulsive efficiency (\(\eta_{p}\)) and motor efficiency (\(\eta_{m}\)).

SECTION – II
3. Explain different types of nozzles used in air breathing and non-air breathing propulsion.

(Or)

4. Derive the non-ideal equations for various nozzles. Also plot the performance parameters to support the comments.

SECTION – III
5. Describe the velocity triangles with neat sketches for axial flow compressor and also bring the performance parameters .

(Or)

6. What is the major difference between ramjet engine and other aircraft engines? Explain the construction, design and performance of ramjet.

SECTION – IV
7. Enumerate the hypersonic scramjet engine methods of analysis.

(Or)

8. Explain with neat diagrams hypersonic intakes and supersonic combustors.

SECTION – V
9. Explain the aircraft mission analysis. Also explain what are factors involved in engine selection.

(Or)

10. How second stage design will help in improving the engine efficiency? Explain in detail.
UNIT-I: FUNDAMENTALS OF ROTOR AERODYNAMICS, BLADE ELEMENT ANALYSIS
Momentum theory analysis in hovering flight, Disk loading and power loading, Induced inflow ratio, Thrust and power coefficients, Comparison of theory with measured rotor performance, Non-ideal effects on rotor performance, Figure of merit, Induced tip loss, Rotor solidity and blade loading coefficients, Momentum analysis in axial climb and descent, Momentum analysis in forward flight, Blade Element Analysis in hover and axial flight, forward flight

UNIT-II: ROTATING BLADE MOTION
Types of rotors, Equilibrium about the flapping hinge and lead-lag hinge, Equations of motion for a flapping blade, Blade feathering and the swashplate, Dynamics of a lagging blade with a hinge offset, Coupled flap-lag motion, Other types of rotors, Introduction to rotor trim
HELCOPTER PERFORMANCE: Hovering and axial climb performance, Forward flight performance, Performance analysis, Autorotational performance, Vortex ring state(VRS), Ground effect, Performance in maneuvering flight, Factors influencing performance degradation

UNIT-III: AERODYNAMIC DESIGN OF HELICOPTERS
Overall design requirements, Conceptual and preliminary design processes, Design of the main rotor, Fuselage aerodynamic design issues, Empennage design, Role of wind tunnels in aerodynamic design, Design of tail rotors, Other anti-torque devices, High speed rotorcraft, Smart rotor systems, Human-powered helicopter, Hovering micro air vehicles AERODYNAMICS OF ROTOR AIRFOILS: Helicopter rotor airfoil requirements, Reynolds number and Mach number effects, Airfoil shape definition, Airfoil pressure distribution, Aerodynamics of a representative airfoil section, Pitching moment and related issues, Drag, Maximum lift and stall characteristics, Advanced rotor airfoil design, Representing static airfoil characteristics, Circulation controlled airfoils, Very low Reynolds number airfoil characteristics, Effects of damage on airfoil performance

UNIT-IV: UNSTEADY AIRFOIL BEHAVIOR

UNIT-V: DYNAMIC STALL
Flow morphology of dynamic stall, Dynamic stall in the rotor environment, Effects of forcing conditions on dynamic stall, Modeling of dynamic stall, Torsional damping, Effects of sweep angle, airfoil shape on dynamic stall, Three dimensional effects on dynamic stall, Time-varying velocity effects on dynamic stall, Prediction of in-flight airfoils, Stall control
ROTOR WAKES AND BLADE TIP VORTICES, ROTOR-AIRFRAME INTERACTIONAL AERODYNAMICS

Characteristics of rotor wake in hover and forward flight, Vortex models of rotor wake, Aperiodic wake developments, General dynamic inflow models, Descending flight and vortex ring state, Wake developments in maneuvering flight; Rotor-fuselage interactions, Rotor-empennage interactions, Rotor-tail rotor interactions

TEXT BOOK
I. MATLAB/ SIMULINK FUNDAMENTALS FOR AEROSPACE APPLICATIONS

MATLAB introduction, Plotting and graphics: Plot, log and semi-log plots, polar plots, Subplots, axis, mesh, contour diagrams, flow diagrams, movies, MATLAB Toolboxes: Continuous transfer functions, root locus, Nichols chart, Nyquist chart, linear quadratic regulator, state-space design, digital design, Aerospace toolbox; M Cells, Structures and M-files, MEX-files,

Standard Simulink libraries, Simulink aerospace blockset, Building Simulink linear models: transfer function modeling in Simulink, zero pole model, state-space model; Simulink LTI viewer and usage of it, equivalent Simulink LTI models, Single-Input, Single-Output(SISO) design tool, Building Multi-Input, Multi-Output models, Building Simulink S-functions; Stateflow introduction: Opening, executing, and saving stateflow models, constructing a simple stateflow model, using a stateflow truth table

II. SOFTWARE DEVELOPMENT FOR SIMULATION OF FLUID FLOWS

Generation of structured and unstructured grids in two and three dimensions Solution of Burgers equation using explicit MacCormack method
Blasius solution for laminar boundary layer over a flat plate Riemann solver for shock tube problem

III. FLOW SIMULATION USING FLUENT

Simulation of Flow past airfoils and wings
Simulation of Compressible flow in convergent-divergent nozzle Simulation of compressible flow in a compressor

REFERENCES
Computational Fluid Dynamics, T. J. Chung, Cambridge University Press, 2002
M.TECH AEROSPACE ENGINEERING
I YEAR II SEMESTER
## M.TECH AEROSPACE ENGINEERING
### I YEAR II SEMESTER

### QUESTION BANK

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UNIT-I: THE KINEMATICS AND DYNAMICS OF AIRCRAFT MOTION

UNIT-II: MODELING THE AIRCRAFT

MODELING, DESIGN AND SIMULATION TOOLS

UNIT-III: AIRCRAFT DYNAMICS AND CLASSICAL CONTROL DESIGN
Aircraft Rigid Body Modes, The Handling Qualities Requirements, Stability Augmentation Systems, control augmentation system, auto pilots and Nonlinear Simulation.

UNIT-IV: MODERN DESIGN TECHNIQUES
Assignment of Closed-Loop Dynamics, Linear Quadratic Regulator with Output Feedback, Tracking a Command, Modifying the Performance Index, Model Following Design, Linear Quadratic Design with Full State Feedback, Dynamic Inversion Design.

UNIT-V: ROBUSTNESS AND MULTIVARIABLE FREQUENCY DOMAIN TECHNIQUES
Multivariable Frequency Domain Analysis, Robust Output Feedback Design, Observers and the Kalman Filter.

DIGITAL CONTROL
Simulation of Digital Controllers, Discretization of Continuous Controllers, Modified Continuous Design, Implementation Considerations.

TEXT BOOK
## COURSE COVERAGE SUMMARY FOR AIRCRAFT CONTROL AND SIMULATION

<table>
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<tr>
<th>TEXT BOOK TITLE</th>
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<td>Aircraft control and simulation</td>
<td>1-7</td>
<td>1-5</td>
<td>brian l. stevens and frank l.lewis</td>
<td>john wiley &amp; sons</td>
<td>2003</td>
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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - II Semester Regular Examinations, Aug 2016
Aircraft Control and Simulation
(ASP)

Roll No 1 5 N 3 1 D 7 6 1 0

Time: 3 hours
Max. Marks: 75

Note: This question paper consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

1. Find the Eigen values and Eigen vectors of the given rotation matrix:
   \[ A = \begin{bmatrix} -\sin \phi & \cos \phi & 1 \\ \cos \phi & \sin \phi & 0 \\ 0 & 0 & 0 \end{bmatrix} \]
   (Or)

2. Explain in detail the translational motion of the centre of mass. Define direction cosine matrix and derive it from quaternions.

SECTION – II

3. What is Neutral point? Explain in detail. (Or)
4. Explain in detail the Euler rotations. Explain the vector rotation by Quaternions?

SECTION – III

5. Use the Laplace transform to find the step response of the given transfer function:
   \[ \frac{s + 2\alpha}{s^2 + s + 1} \]
   With \( \alpha \) as a parameter.
   (Or)

6. Describe the aerodynamic forces acting on an aircraft and their variations with Mach number and angle of attack in wind axes.

SECTION – IV

7. Write in detail about “Modern Robust Design”.
   (Or)

8. Explain
   (a) Tracker Problem,
   (b) Dynamic Inversion.

SECTION – V

9. Explain the advantages and disadvantages of Digital Control.
   (Or)

10. Discuss briefly about the Multi variable frequency domain analysis.
MTECH AEROSPACE QUESTION BANK

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech II Semester Examinations, August-2014
AIRCRAFT CONTROL AND SIMULATION
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Note: This question paper contains two parts A and B.
Part A is compulsory which carries 20 marks. Answer all questions in Part A.
Part B consists of 5 Units. Answer any one full question from each unit.
Each question carries 8 marks and may have a, b, c as sub questions.

PART - A
(Answer all sub questions)

1. a) Prove the distributive property of the rotation matrix with cross product operation.
b) Assuming that neither α-dot nor β-dot dependence is present in the force equations; write down the steps for the calculations that must typically be performed in an explicit state model.
c) Describe an electro-mechanical control system of an aircraft.
d) Discuss in brief, the ‘regulator problem’ and ‘tracker problem’ as applied to modern control theory.
e) Explain the terms, sensitivity and cosensitivity along with their role in design of control system of an aircraft.

PART - B

2. a) What do you mean by an inertial frame of reference and state an example of a perfect inertial frame?
b) Explain in detail the different components of acceleration of a body arising from reference of motion of the body in rotating frame to inertial frame of reference.

OR

3. a) Derive the equations of motion (Euler’s equation) for the rotational motion of a rigid body.
b) Why state space representation is preferred for non linear systems?

4. Describe the aerodynamic forces acting on an aircraft and their variations with Mach number and angle of attack in wind axes and body axes.

OR

5. a) Describe how Laplace Transform solution for state equation is obtained?
b) Define two aerodynamic angles needed to specify aerodynamic forces and moments.

6. a) Describe the three popular numerical integration algorithms used for analysis of systems.
b) Draw simple lag and simple lead networks and write their transfer functions along with state equations.

OR

7. a) Explain how the transfer function of an aircraft dynamics is developed and based on this, explain the short period and phugoid modes of an aircraft.
b) Describe the terms Autopilot and Flight Management System.
8.a) Explain Linear Quadratic Regulator (LQR).
   b) What are the disadvantages of classical control?

9.a) Discuss the condition for convergence of LQ solution algorithms.
   b) What is gain scheduling?

10. Discuss the method of model reduction by partial fraction.

11.a) Discuss the separation principle in Control Design.
   b) What is the need for discretization of continuous controllers in a digital control system?

---0000---
1. a) Derive the rotation formula for vector rotation.
   b) Derive the equation of Coriolis. [12]

2. Describe the forces and moments on an aircraft in static equilibrium. Derive the expression for the pitch moment coefficient derivative of an aircraft with respect to angle of attack, in terms of the force and moment coefficient derivatives of wing and horizontal stabilizer. [12]

3. Describe Bode magnitude and phase plots for a quadratic lag transfer function $\frac{\omega_n^2}{s^2 + 2\zeta s + \omega_n^2}$. [12]

4. Bring out the relationship between the pitch rate of an aircraft and its elevator deflection angle, discuss the purpose and method of providing pitch-axis stability augmentation. [12]

5. Describe a lateral-directional control augmentation system. [12]

6. Explain
   a. Pole-placement,
   b. Regulator problem,
   c. Servo design [12]

7. a) Discuss briefly about Multi-variable frequency domain analysis.
    b) Discuss briefly, with the help of a block diagram and a numerical example, the frequency response of a second order system with and without rate feedback. [12]

8. Explain sampling, hold devices and computational delays in digital control. [12]
1. (a) Explain in detail, the different components of acceleration of a body arising from reference of motion of the body in rotating frame to inertial frame of reference.
   b) Derive the equations of motion (Euler’s equation) for the rotational motion of a rigid body.

2. (a) Describe the aerodynamic forces acting on an aircraft and their variations with Mach number and angle of attack in wind axes and body axes.
   b) Using these, determine the expressions for the corresponding stability derivatives.

3. (a) Explain the process of reduction of differential equations to state-space model, with the help of SISO (Single input, single output) and state equation diagrams.
   b) Describe how Laplace Transform solution for state equation is obtained.

4. (a) Describe an electro-mechanical control system of an aircraft.
   b) Describe transfer function, poles and zeroes.
   c) Derive the longitudinal transfer function of an aircraft and obtain the modes.

5. (a) Explain how the transfer function of an aircraft dynamics is developed as based on this, explain the short period and phugoid modes of an aircraft.
   b) Discuss pitch rate control augmentation.

6. (a) Explain linear quadratic regulator (LQR).
   b) Discuss the conditions for convergence of LQ solution algorithms.

7. (a) Explain Linear Quadratic Gaussian Design.
   Discuss the separation principle in Control Design.

8. Discuss Data discretization and control simulation scheme.

********
UNIT-I: INTRODUCTION TO EXPERIMENTAL METHODS
Characteristics of Measuring systems: Readability, Sensitivity, Hysteresis, Accuracy, Precision: Calibration, Standards, Experiment planning, Causes and types of experimental errors, Statistical analysis of experimental data

UNIT II: FLOW MEASUREMENTS
Pressure Measurement: Manometer, Pressure transducers, Scanning valves; Temperature Measurement: Thermometers, Thermocouples, Thermopiles, Keil probes; Velocity Measurement: Pitot probes, Hot wires, 7 hole probes, Laser Doppler Velocimetry (LDV), Particle Image Velocimetry (PIV), Doppler Global Velocimetry (DGV); Turbulence Measurements: LDV, Hot wire anemometers, Root Mean Square (RMS), Spectrum;
FLOW VISUALIZATION
Path-, Streak-, Stream-, and Time lines, Direct visualization, Surface flow visualization, Flow field visualization, Data driven visualization

UNIT-III: FORCES AND MOMENTS FROM WIND TUNNEL BALANCE MEASUREMENTS: Types of wind tunnels, Aeronautical wind tunnels, Wind tunnel data systems, Balances, Balance requirements and specifications, External balances and internal balances
STRESS AND STRAIN MEASUREMENTS
Stress and strain, Strain measurements, Strain gauge types, Basic characteristics of a strain gage, Electrical resistance strain gauges, Rosette analysis, Strain gauge sensitivity, Stress gauges

UNIT IV: MOTION AND VIBRATION MEASUREMENT
Two simple vibration instruments, Principles of seismic instrument, Practical considerations for seismic instruments, Sound measurements
MOTION AND INERTIAL MEASUREMENTS
Applications of accelerometer sensors, Acceleration sensing principles, Pendulous accelerometer (open and closed loop), Micro-machined accelerometer, Piezoelectric accelerometer, Rate gyroscope principles, Rate-integrating gyroscope principles, Micro-gyro sensors, Laser gyros

UNIT-V: SPACECRAFT ATTITUDE DETERMINATION SENSORS
Infrared earth sensors-Horizon Crossing Sensors, Sun sensors, Star sensors, Rate and rate integrating gyros, Magnetometers
TEXT BOOKS

# COURSE COVERAGE SUMMARY FOR AEROSPACE SENSORS AND MEASUREMENT SYSTEMS

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>CHAPTERS IN TEXT BOOK</th>
<th>UNITS/TO PICS COVERED</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
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<tr>
<td>Experimental methods for engineers</td>
<td>2,3, 7, 10, 11</td>
<td>1</td>
<td>J.P.Holman</td>
<td>Tata Mc Graw Hill</td>
<td>2004</td>
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<tr>
<td>Low speed wind tunnel testing</td>
<td>1-5</td>
<td>2,3</td>
<td>Jewel B Barlow, William H.Rae Jr, Alan pope</td>
<td>John wiley third edition</td>
<td>1999</td>
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<tr>
<td>Space craft dynamics and control –A practical engineering approach</td>
<td>1-5</td>
<td>5</td>
<td>Marcel J.sidi</td>
<td>Cambridge university press</td>
<td>1997</td>
</tr>
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</table>
**SECTION - I**

1. What are the different types of experimental errors? Explain each in detail.

2. A certain steel bar is measured with a device which has a known precision of ±5mm to -5mm when a large number of measurements is taken. How many such measurements are necessary to establish the mean length ‘a’ with a 5 percent of significance such that \( a = a+/- 0.2 \text{mm} \).

**SECTION - II**

3. Explain path lines, streak lines, stream lines and time lines in a fluid flow.

4. Explain in detail the working of Laser Doppler Velocimetry (LDV) and mention its use in turbulence measurements.

**SECTION - III**

5. Describe the three-component foil balances.

6. Explain the working principle of electrical strain gauge for strain measurement.

**SECTION - IV**

7. What are the vibrational measuring instruments and explain the working principle of any one instrument.

8. A cantilever beam of span 3m of steel of cross sectional area 10mm×20mm is subjected to a free end transverse load of 4KN along the depth. Determine the natural frequency of vibration. If the beam used as a simply supported beam load at center and also determine frequency and vibration.

**SECTION - V**

9. Explain the working of horizon crossing sensors and Magnetometers with an example.

10. Describe briefly where and bow the rate and rate integrating gyros are used. Also explain the working of them.
Code No: 5176R
Jawaharlal Nehru Technological University Hyderabad
M.Tech II Semester Examinations, August-2014
Aerospace Sensors and Measurement Systems
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Note: This question paper contains two parts A and B. Part A is compulsory which carries 20 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 8 marks and may have a, b, c as sub questions.

PART - A

1. a) The resistance of a certain size of copper wire is given as \( R = R_0 [1 + \alpha (T - 20)] \)
   where \( R_0 = 6 \Omega \) ± 0.3% is the resistance at 20°C, \( \alpha = 0.004^\circ C^{-1} \pm 1\% \) is the temperature coefficient of resistance, and the temperature of the wire is \( T = 30 \pm 1^\circ C \). Calculate the resistance of the wire and its uncertainty.
   b) Explain the principle of operation of a laminar flow meter.
   c) Define torque and explain how it is measured.
   d) Give a brief account of traveling plane waves and standing waves.
   e) What is are the parameters obtained from magnetometer readings and explain their significance in determining attitude of spacecraft.

PART - B

2. List out any eight factors to be considered in the initial phase of planning an experiment.
   OR

3. Illustrate the general experimental procedure to be followed by engineers as an effective way of product development.
   OR

4. Explain the working of a Pitot Probe and the role played by it as a part of the Airdata System on an aircraft.
   OR

5. a) Describe the working of principle of Particle Image Velocimetry?
   b) Define: i) Path line ii) Streak lines iii) Stream lines and iv) Time lines.
   OR

6. What are the necessary characteristics of a strain gauge? With the help of relevant equations describe the operation of electrical resistance strain gauge.
   OR

7. Explain in detail the significance of wind tunnel testing of aircraft model.
   OR

8. a) Explain the operating principle of rate integrating gyro.
   b) A small seismic instrument is to be used for measurement of linear acceleration. It has \( \omega_0 = 100 \text{ rad/s} \) and a displacement sensing transducer which detects a maximum of ±0.1 in. Calculate the maximum acceleration that may be measured with this instrument and the uncertainty in the measurement, assuming \( \omega_0 \) is known exactly.
   OR

9. Explain in detail the working of a closed loop pendulous accelerometer.
   OR

10. Explain the working of a single axis analog sun sensor.
    OR

11. Describe the working of a horizon crossing sensor with a neat sketch.
----0000----
1. a) Define the terms sensitivity and calibration of an instrument with an example.
   b) Give different types of errors that occur during measurement with an instrument. Suggest minimizing these errors.

2. a) What is meant by positive displacement flow meter? Explain any one of the positive displacement flow meters with neat sketch.
   b) Explain neatly with a sketch, the working of a Doppler Global Velocimetry (DGV).

3. a) Explain path lines, streak lines, stream lines and time lines in a fluid flow.
   b) Explain the different methods used for flow field visualization.

4. a) Explain aerodynamic wind tunnels.
   b) Describe the three-component Roof balances.

5. a) Explain the working principle of electrical strain gauge for strain measurement.
   b) A rectangular rosette is mounted on a steel plate having \( E = 200 \, \text{GPa} \) and Poisson’s ratio \( = 0.3 \). The three strains are measured as

   \[
   \varepsilon_1 = +500 \, \mu\text{mm/mm} \quad \varepsilon_2 = +400 \, \mu\text{mm/mm} \quad \varepsilon_3 = -100 \, \mu\text{mm/mm}
   \]

   Calculate the principal strains and stresses, the maximum shear stress, and the orientation angle for the principal axis of the stress.

6. a) Describe basic concept of seismic instrument.
   b) A cantilever beam of span 3 m of steel of cross sectional area 10 mm x 20 mm is subjected to a free end transverse load of 4 kN, along the depth. Determine the natural frequency of vibration. If the beam used as a simply supported beam loading at center, determine the frequency and vibration.

7. a) Explain with neat sketch the working principle of pendulous accelerometer (Open and closed loop).
   b) Explain the construction, principle of working and salient features of Piezo-electric type accelerometer.

8. Write short notes on
   a) Rate gyros
   b) Magnetometers
   c) Sun sensors.
MTECH AEROSPACE QUESTION BANK

Answer any five questions
All questions carry equal marks

1. a) What are the different types of experimental errors?
   b) Explain how to perform statistical analysis of experimental data. [6+6]

2. a) Explain neatly with a sketch, the working of a Laser Doppler Anemometer (LDA).
   b) Explain with neat sketch, the working of Hot wire Anemometer. [6+6]

3. a) Explain path lines, streak lines, stream lines and time lines in a fluid flow.
   b) Explain the surface flow visualization. [6+6]

4. a) What are the different types of wind tunnels? Explain with neat sketches.
   b) Explain with neat sketch the working principle of an internal balance for measuring the lift force [6+6]

5. a) Explain about the rectangular strain gauge Rosettes.
   b) A delta rosette is mounted on a steel plate having $E=200$ GPa and Poisson’s ratio=0.3. The three strains are measured as
      
      \[ \varepsilon_1 = +400 \mu \text{mm/mm} \]
      \[ \varepsilon_2 = +84 \mu \text{mm/mm} \]
      \[ \varepsilon_3 = -250 \mu \text{mm/mm} \]
      
      Calculate the principal strains and stresses, the maximum shear stress, and the Orientation angle for the principal axis of the stress. [6+6]

6. a) What are the vibrational measuring instruments and explain the working principle of any one instrument.
   b) Why an active band analyzer is used in sound measurement? Explain. [6+6]

7. a) Explain with neat sketch the working principle of Micro-machined accelerometer.
   b) Explain the construction, principle of working and salient features of Micro-gyro sensors [6+6]

8. Explain
   a) Infrared Earth Sensors
   b) Horizon Crossing Sensors
   c) Star sensors [4+4+4]

********
1. a) Explain statistical analysis of experimental data.
   b) A certain steel bar is measured with a device which has a known precision of ± 5 mm to – 5 mm when a large number of measurements is taken. How many such measurements are necessary to establish the mean length ‘a’ with a 5 percent of significance such that \[ a = a + / - 0.2 \text{ mm}. \]

2. Describe the following flow measurement systems
   a) Pressure transducers
   b) Thermocouples
   c) Particle velocimetry.

3. a) Define path lines, streak lines, time lines and stream lines.
   b) Describe the various methods of surface flow visualization.

4. Describe three external balances for measurements in wind tunnel.

5. a) What are the vibrational measuring instruments and explain the working principle of any one instrument.
   b) Cantilever beam of span 3m made of steel of cross sectional area 10mm x 20mm is subjected to a free end transverse load of 4KN, along the depth. Determine the natural frequency of vibration. If the beam used as a simply supported beam loading at center, determine the frequency of vibration.

6. a) Explain the working principle of piezoelectric sensors to measure acceleration.

7. Write short notes on the following
   i. Infrared earth sensors
   ii. Magnetometers.

8. A rectangle rosette is mounted on a steel plate having \( E = 2 \times 10^5 \text{ N/mm}^2 \) and \( \mu = 0.3 \). The three strains are measured as
   \[ \varepsilon_1 = +500 \mu \text{ mm/mm} \]
   \[ \varepsilon_2 = +400 \mu \text{ mm/mm} \]
   \[ \varepsilon_3 = -100 \mu \text{ mm/mm} \]
   Calculate the principal strains and stress and maximum shear stress. Locate the axis of the principle stress.
UNIT-I: PRINCIPLES OF AEROSPACE DESIGN
Historical Perspective on aerospace design, Traditional manual approaches to design and design iteration, Design teams, Advances in modeling techniques, Tradeoffs in aerospace system design, Design automation, evolution and innovation, Design search and optimization, Take-up of computational methods, Design oriented Analysis: Geometry modeling and design parameterization, Computational mesh generalization, Analysis and design of coupled systems

UNIT-II: ELEMENTS OF NUMERICAL OPTIMIZATION-I
Single variable optimizers- line search, Multi variable optimizers: Population versus single point methods, Gradient based methods, Noisy/Approximate function values, Non-gradient based algorithms, Termination and convergence aspects, Constrained optimization, Problem transformations, Lagrange multipliers, Feasible directions method, Penalty function methods, Combined Lagrangian and penalty function methods, Sequential quadratic programming, Chromosome repair

UNIT-III: ELEMENTS OF NUMERICAL OPTIMIZATION-II
Meta models and Response surface methods: Global versus local meta models, Meta modeling tools, Simple RSM examples, Combined approaches-Hybrid searches and meta heuristics, Multi-objective optimization, Multi-objective weight assignment techniques, Methods for combining goal functions, fuzzy logic and physical programming, Pareto set algorithms
Sensitivity Analysis: Finite-difference methods, Complex variable approach, Direct methods, Adjoint methods, Semi-analytical methods, Automatic differentiation

UNIT-IV: APPROXIMATION CONCEPTS
Local approximations, Multipoint approximations, Black-box modeling, Generalized linear models, Sparse approximations techniques, Gaussian process interpolation and regression, Data parallel modeling, Design of experiments, Surrogate modeling using variable fidelity models, Reduced basis methods

DESIGN SPACE EXPLORATION-SURROGATE MODELS
Managing surrogate models in optimization: Trust regions, Space mapping approach, Surrogate assisted optimization using global models, Managing surrogate models in evolutionary algorithms

UNIT-V: DESIGN IN THE PRESENCE OF UNCERTAINTY
Uncertainty modeling and representation, Uncertainty propagation, Taguchi methods, Welch-Sacks method, Design for six sigma, decision theoretic formulations, Reliability-based optimization, Robust design using information-gap theory, Evolutionary algorithms for robust design

MULTI-DISCIPLINARY OPTIMIZATION
Multi-disciplinary analysis, Fully integrated optimization, System decomposition and optimization, Simultaneous analysis and design, Distributed analysis optimization formulation, Collaborative optimization, Concurrent subspace optimization, Co-evolutionary architectures

TEXT BOOK
COURSE COVERAGE SUMMARY FOR

COMPUTATIONAL APPROACHES TO AEROSPACE VEHICLE DESIGN

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>CHAPTERS IN TEXT BOOK</th>
<th>UNITS/TOPICS COVERED</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
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<tr>
<td>Computational approaches for Aerospace design – the pursuit of excellence</td>
<td>1-3</td>
<td>1-5</td>
<td>Andy J Keane Prasanth B Nair</td>
<td>John wiley &amp; sons</td>
<td>2005 ISBN 10:0-470-855440-1</td>
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</tbody>
</table>
MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
Computational Approaches to Aerospace Vehicle Design
(ASP)

Roll No 1 5 N 3 6 2

Time: 3 hours
Max. Marks: 75

Note: This question paper consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

** SECTION – I **

1. Discuss in detail about the principles of aerospace design automation, evolution and innovation.
15M

(Or)

2. (a) Discuss about the role of optimization in design.
(b) What is the need of a mesh? Can we obtain computational results without mesh justify?
5M
(c) What are the advances in modelling techniques of aerospace design?
5M

** SECTION – II **

3. Discuss the salient features of penalty function method for constrained optimization used in aerospace vehicle design.
15M

(Or)

4. Discuss in detail about
(a) Population versus single point methods
(b) Gradient based methods

** SECTION – III **

5. Explain multi-objective optimization in the context of aerospace vehicle design with examples.
8M
(b) Discuss direct and eigen vector methods of multi-objective weight assignment.
7M

(Or)

6. Give a comparative study of different local search application strategies in hybrid metaheuristics.
15M

** SECTION – IV **

7. Discuss the relevance of local & Multipoint approximation models in aerospace vehicle design & explain the approach based on intervening variables for building approximation models.
15M

(Or)

8. Discuss the key issues involved with the use of surrogate assisted evolutionary algorithm with the best possible solutions.
15M

** SECTION – V **

9. How Uncertainty can be classified? Explain uncertainty modelling using probabilistic approach and fuzzy set theory with examples?
15M

(Or)

10. Explain simultaneous analysis and design(SAND) formulation for multidisciplinary design optimization and discuss its advantages and disadvantages as compared with fully integrated optimization approach.
15M

**********
MTECH AEROSPACE QUESTION BANK

R13

Code No: 5176Q
JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech II Semester Examinations, August-2014
COMPUTATIONAL APPROACHES TO AEROSPACE VEHICLE DESIGN
(Aerospace Engineering)

Time: 3 Hours
Max. Marks: 60

Note: This question paper contains two parts A and B. Part A is compulsory which carries 20 marks. Answer all questions in Part A. Part B consists of 5 Units. Answer any one full question from each unit. Each question carries 8 marks and may have a, b, c as sub questions.

PART - A

1. a) Write a short note on Design automation.
   b) Explain the role of Chromosome repair in numerical optimization
   c) Explain with help of a diagram the principle of response surface method and steps involved in its implementation.
   d) Discuss the steps involved in the trust region algorithm for surrogate-assisted optimization in unconstrained problems.
   e) Briefly explain the Information-gap theory for robust design approach for Aerospace vehicle design.

   5 × 4 marks = 20

PART - B

2. Explain the role of parameterization in design and discuss about how spline based approach and morphing helps in manipulating geometrical shapes in design?

3. List out the number of aspects to be considered in aircraft design. Also explain the four fundamental components on which the decision-making process of aerospace vehicle design is to be built.

4. Discuss the salient features of feasible directions method for constrained optimization used in aerospace vehicle design.

5. Explain non gradient based algorithms aspects of a numerical optimization and their common approaches.

   OR

6. Explain how finite difference approach is used in conducting sensitivity analysis bringing out its attractive features and strategies used to handle truncation and condition errors?

   OR

7. Explain Multi Objective Optimization Technique. Discuss direct and eigenvector methods of multi-objective weight assignment.

8. What is black-box surrogate modeling approximation concept? Explain the steps involved in it.

   OR

9. Explain the approach based on intervening variables for building approximation models for Aerospace vehicle design.
1. Discuss the combined approaches-Hybrid Searches and Meta Heuristics.

2. Discuss the following uncertainty modeling techniques
   a) Six-sigma method and
   b) Welch-Sacks method.

3. Compare different types of sensitivity analysis techniques and discuss about case studies involving aerodynamic and aero structural analyses.

4. Explain in detail the collaborative optimization using a flow chart and discuss its computational aspects and theoretical properties.

5. Discuss variable metric and conjugate gradient methods for a multi-variable optimizer.

6. Discuss the issues involved in the analysis and design of coupled systems. Explain through a schematic diagram the blackboard-based multi-disciplinary optimization process work flow.

7. Discuss basic steps involved in stage wise unconstrained optimization of computationally expensive functions using global surrogates; also explain surrogate assisted optimization using global models.

8. Explain the basic building blocks from which an adaptive mesh control scheme can be assembled. Discuss mesh generation quality and adaptation.

**********
MTECH AEROSPACE QUESTION BANK

JAWAHARLAL NEHRU TECHNOLOGICAL UNIVERSITY HYDERABAD
M.Tech II SEMESTER EXAMINATIONS, OCTOBER/NOVEMBER-2012
COMPUTATIONAL APPROACHES TO AEROSPACE VEHICLE DESIGN
(AEROSPACE ENGINEERING)

Time: 3 hours
Max. Marks: 60

Answer any five questions
All questions carry equal marks

1. Discuss traditional manual approaches to design and design iteration.

2. Explain the following Optimizers:
   a) Optimization with a Single Discrete Variable.
   b) Optimization with hybrid search.

3. Compare Global and Local Meta models.

4. Describe Complex Variable Approach of sensitivity analysis.

5. Describe Multipoint Approximation techniques.

6. Explain the following related to the Space Mapping Approach:
   a) Mapping Functions.
   b) Global/Space Mapping.

7. How the Uncertainty Propagation can be estimated using the following methods?
   Explain.
   a) Simulation Methods.
   b) Taylor Series Approximations.

8. Explain Fully Integrated Optimization (FIO).
1. Write about the methods for combining goal functions, fuzzy logic and physical programming. [12]

2. Explain in detail about design automation, evolution and innovation [12]

3. Explain what is black-box surrogate modeling and the steps involved in it [12]

4. Explain the role of parameterization in design, and discuss about how spline based approach and morphing help in manipulating geometrical shapes in design. [12]

5. Discuss traditional manual approaches to design and design iteration. [12]

6. Explain termination and convergence aspects of a numerical optimization and their common approaches. [12]

7. Explain Meta models and response surface methods and discuss with a schematic diagram of significant number of important decisions in Meta model based search procedure. [12]

8. Discuss concurrent subspace optimization with a flowchart and the steps in the process of CSO for a multi disciplinary optimization. [12]
1. Describe the four fundamental components on which the decision-making process of aerospace vehicle design is built and explain with the help of a diagram how this process is represented as a spiral. List out the number of aspects to be considered in aircraft design.

2. What are the differences between population based and single point based design optimization methods? Explain the steps involved in Quasi-Newton or variable metric methods.

3. Why meta-models are important in aerospace design optimization? Explain through a diagram the principle of response surface method and steps involved in its implementation.

4. What is the importance of sensitivity analysis to aerospace vehicle design based on computational approaches? Explain how finite difference approach is used in conducting sensitivity analysis bringing out its attractive features and strategies used to handle truncation and condition errors.

5. Explain the salient features of neural networks and radial basis function approximation techniques with the help of diagrams.

6. What are the issues involved in surrogate-assisted optimization? Discuss the steps involved in the trust region algorithm for surrogate-assisted optimization in unconstrained problems.

7. Explain the notion of robust design from a probabilistic view point with the help of an illustration followed by a diagram. Discuss the salient features of Taguchi method for robust design giving outline of the method and explaining the three stages involved in the design process.

8. What is Multidisciplinary Design Optimization (MDO) and what is its importance? Discuss Collaborative Optimization (CO) architecture used in MDO application using diagram.
UNIT I: GENERAL CHARACTERIZATION OF HYPERSONIC FLOWS
Defining hypersonic flow, Characterizing hypersonic flow using fluid dynamic phenomenon. Basic Equations of Motion: Equilibrium and non-equilibrium flows, Equilibrium conditions, Dependent variables, Transport properties, Continuity, momentum and energy equations, General form of the equations of motion in conservation form.

UNIT II: DEFINING THE AEROTHERMODYNAMIC ENVIRONMENT
Empirical correlations complemented by analytical techniques, General comments about CFD, Computations based on a two layer flow model, Techniques treating entire shock layer in a unified fashion, Calibration and validation of the CFD codes

EXPERIMENTAL MEASUREMENTS OF HYPERSONIC FLOWS
Ground-based simulation of hypersonic flows, Ground-based hypersonic facilities, Experimental data and model design considerations, Flight tests, Importance of interrelating CFD, ground-test data and flight-test data

UNIT III: STAGNATION-REGION FLOW FIELD
Stagnating streamline, Stagnation-point convective heat transfer, Radiative heat flux
PRESSURE DISTRIBUTION:
Newtonian flow models, Departure from the Newtonian flow field, Shock-Wave / Boundary Layer (Viscous) Interaction for two-dimensional compression Ramps, Tangent-Cone and Tangent-Wedge approximations, Need for more sophisticated models, Pressure distributions for a reacting gas, Pressures in separated regions

UNIT IV: BOUNDARY LAYER AND CONVECTIVE HEAT TRANSFER
Boundary Conditions, Metric or equivalent cross-section radius, Convective heat transfer and skin friction, Effects of surface catalycity, Base heat transfer in separated flow
VISCOUS INTERACTIONS:
Compression ramp flows, Shock/Shock interactions, Flow field perturbations around swept fins, Corner flows, Examples of Viscous Interactions for Hypersonic Vehicles: X-15, Space shuttle orbiter, Hypersonic air-breathing aircraft

UNIT V: AERODYNAMIC FORCES AND MOMENTS & DESIGN CONSIDERATIONS OF HYPERSONIC VEHICLES
Newtonian Aerodynamic Coefficients, Re-entry capsule aerodynamics, Shuttle orbiter aerodynamics, X-15 Aerodynamics, Hypersonic aerodynamics of research plane, Dynamic stability considerations; Design Considerations: Reentry vehicles, Design philosophy, Design considerations for rocket-launched/glide reentry vehicles, airbreathing vehicles, combined rocket/airbreathing powered vehicles, Design of a new vehicle

TEXTBOOK
REFERENCE BOOKS

2. *Basics of Aerothermodynamics*, Ernst Heinrich Hirshchel, Springer-Verlag, 2005
UNIT- I: AIR TRAFFIC MANAGEMENT
Introduction: Air traffic services provided to aircraft operators, Government responsibilities, Flight rules and airspace organization, Airways and procedures, Phases of flight, Subsystems of ATM system, Facilities and operation, System capacity, Airborne collision avoidance systems, Future trends, Capacity driven operational concept of ATM.

UNIT-II: ECONOMICS OF CONGESTION
Impact of ATM on airspace user economic performance, Effects of schedule disruptions on the economics of airline operations, modeling of an airline operations control center.

COLLABORATIVE DECISION MAKING
Effect of shared information on pilot controller and controller- controller interactions, Modeling of distributed human decision making in traffic flow management operations.

UNIT-III: AIRPORT OPERATIONS AND CONSTRAINTS
Analysis, modeling and control of ground operations at airports, Collaborative optimization of arrival and departure traffic flow management strategies at airports.

AIRSPACE OPERATIONS AND CONSTRAINTS
Performance measures of air traffic services, Identification of airport and airspace capacity constraints.

UNIT-IV: SAFETY AND FREE FLIGHT
Accident risk assessment for advanced air traffic management, Airborne separation assurance systems. Human factors

COGNITIVE WORKLOAD ANALYSIS AND ROLE OF AIR TRAFFIC CONTROLLER: Task load measures of air traffic controllers, Technology enabled shift in controller roles and responsibilities.

UNIT-V: AIRCRAFT SELF SEPARATION
Cooperative optimal airborne separation assurance in free flight airspace, Automatic dependent surveillance broadcast system - operational evaluation.

TEXT BOOKS
### COURSE COVERAGE SUMMARY FOR

**ADVANCED TOPICS IN AIR TRAFFIC MANAGEMENT SYSTEMS**  
*(ELECTIVE-III)*

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>CHAPTERS IN TEXT BOOK</th>
<th>UNITS/TOPICS COVERED</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
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<tr>
<td>Air transportation systems engineering</td>
<td>1-10</td>
<td>1-5</td>
<td>Donohue, G L et al</td>
<td>AIAA</td>
<td>2003 ISBN 1-56347-474-3</td>
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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - II Semester Regular Examinations, Aug 2016
Advanced Topics in Air Traffic Management Systems
(ASP)

Code No: R15D7617-152

Roll No: 15 31D7610

Time: 3 hours
Max. Marks: 75

Note: This question paper consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

******

SECTION – I

1. What are the subsystems of Air Traffic Management system? Explain.
   (Or)

2. Explain in detail about the “Capacity driven operational concept of ATM”.

SECTION – II

3. What is the impact of air traffic management on airspace user economic performance?
   (Or)

4. Discuss about the modeling of distributed human decision making in traffic flow management operations.

SECTION – III

5. Explain the collaborative optimization of arrival and departure traffic flow management strategies at airports.
   (Or)


SECTION – IV

7. What are the various methods used for accident risk assessment?
   (Or)

8. What is TOPAZ model? Why it is important in safety and free flight?

SECTION – V

9. What are the various methods used for accident risk assessment?
   (Or)

10. Explain the functionality of automatic dependent surveillance broadcast system.

******
1. a) Write a detailed note on various phases associated with flight.
   b) What do you know about air traffic services provided to aircraft operators?

2. a) Suppose a flight has been affected by some disruption in its departure schedule. Indicate its implications on the economics of airline operations.
   b) Illustrate alternatives available to the airlines to handle disruptions.

3. Assuming pilot-controller interaction, explain how the following information could be shared.
   a) Shared weather information
   b) Shared traffic information
   c) Shared intent information
   d) Shared effective information

4. Suggest a collaborative optimization methodology to establish arrival and departure traffic flow management strategies at airports.

5. a) Illustrate various performance measures associated with air traffic services.
   b) Enumerate airspace capacity constraints one has to pay attention to for an identified airport.

6. Bring out salient features associated with the accident risk assessment in the existing and advanced versions of air traffic management programs. Do you think human factors have a role to play in these programs? If so, discuss in brief.

7. Explain in detail the cognitive workload analysis and role of an air traffic controller. Further, mention various responsibilities of an air traffic controller.

8. a) Explain in detail operational methodology and planning algorithm associated with cooperative optimal airborne separation assurance in free-flight airspace.
   b) Write short notes on operational evaluation of ADS broadcast system. Describe the method of test associated with it.
1. a) Discuss in detail about ‘Airborne collision avoidance systems’.
   b) Elaborate on Flight rules and organizing the airspace effectively for aircraft movements.

2. a) What is the role of ATM on airspace user and its impact on his economic performance?
   b) Explain the modeling structure and hypothesis that is necessary in modeling of an airline operations control center.

3. Assuming controller-controller interaction, explain how the following information could be shared.
   a) Intra-facility shared information
   b) Cross-facility shared information

4. How do you analyze, model and control the ground operations at an airport? Take the help of simple sketches to support your answer.

5. Write a detailed note on ‘identification of an airport and studying its airspace capacity Constraints.’

6. a) with the help of neat sketches wherever necessary, explain in detail the airborne separation assurance systems
   b) Discuss in detail the influence of human factors on the air traffic management strategies in practice that deal with safety and free flight

7. a) What do you understand by the task load measures of air traffic controllers?
   b) Write short notes on technology enabled shift in controller roles and responsibilities.

8. a) write a detailed note on the working principles of an ‘automatic dependent surveillance broadcast system’ associated with aircraft self separation methods.
   b) Write short notes on operational evaluation of ADS broadcast system. Mention about rule evaluation criteria in airborne separation system.
UNIT-I: ORBIT DYNAMICS

UNIT-II: ORBITAL MANEUVERS

ATTITUDE DYNAMICS AND KINEMATICS
Angular momentum and inertia matrix, Rotational kinetic energy of a rigid body, Moment of inertia matrix in selected axis frame, Euler’s moment equations, Characteristics of rotational motion of a spinning body, Attitude kinematics equations of motion of a spinning body, Attitude dynamic equations of motion for a nonspinning satellite

UNIT-III: GRAVITY GRADIENT STANILIZATION
Basic attitude control equation, Gravity gradient attitude control.

SINGLE- AND DUAL-SPIN STABILIZATION
Attitude stabilization during the ΔV stage, Active nutation control, Estimation of fuel consumed during active nutation control, Despinning and denutation of a satellite, Single spin stabilization, dual spin stabilization

UNIT-IV: ATTITUDE MANEUVERS IN SPACE
Equations for basic control laws, Control with momentum exchange devices, Magnetic attitude control, Magnetic unloading of momentum exchange devices, Time-optimal attitude control, Technical features of the reaction wheel.

MOMENTUM-BIASED ATTITUDE STABILIZATION
Stabilization with and without active controls, Roll-yaw attitude control with two momentum wheels, Reaction thruster attitude control

UNIT-V: REACTION THRUSTER ATTITUDE CONTROL
Set up of reaction thruster control, Reaction torques and attitude control loops, feed back control loops, Reaction attitude control via pulse width modulation, Reaction control system using only four thrusters, Reaction control and structural dynamics.

TEXT BOOK

REFERENCES
1. Modern Spacecraft Dynamics & Control, M. H. Kaplan, Wiley, 1976,
UNIT-I: ROLE OF NAVIGATION IN FLIGHT VEHICLE MISSION - NAVIGATION SYSTEMS

UNIT-II: TERRESTRIAL-RADIO-NAVIGATION SYSTEMS
General principles, System design considerations, Point source systems, hyperbolic systems
SATELLITE RADIO NAVIGATION: System configuration, Basics of satellite radio navigation, Orbital mechanics and clock characteristics, Atmospheric effects on satellite signals, NAVSTAR Global Positioning System, Global Orbiting Navigation Satellite System(GLONASS), GNSS integrity and availability

UNIT-III: INERTIAL NAVIGATION
Principles of Inertial navigation system, alignment Instruments, Platforms, Mechanization equations, INS Errors and Mixed systems, Alignment, Fundamental limits
AIR-DATA INSTRUMENTS & SYSTEMS, ATTITUDE AND HEADING REFERENCES
Air-Data Systems: Air-data measurements, Air-data equations, Air-data systems, Specialty designs, Calibration and system test; Attitude and Heading References: Basic instruments, Vertical references, Heading-direct indicating compass and direction indicators, gyro magnetic compass horizontal simulation indicators, altitude-and alignment –Datum compasses,magnetic compass deviation, compass switching procedures

UNIT-IV: DOPPLER AND ALTIMETER RADARS, LANDING SYSTEMS
Doppler Radars: Functions and applications, Doppler radar principles and design approaches, Signal characteristics, Doppler radar errors, Equipment configurations, Radar Altimeters: Functions and applications, General principles, Pulsed radar altimeters, FM-CW radar altimeter, Phase-coded pulsed radar altimeters; Landing Systems: Low-visibility operations, Mechanics of landing, Automatic landing systems, Instrument landing systems, Microwave-landing system, Satellite landing systems, Carrier landing systems,

UNIT-V: MULTISENSOR INTEGRATED NAVIGATION SYSTEMS
Inertial system characteristics, Integrated stellar-inertial systems, Integrated Doppler- inertial systems, Airspeed-damped inertial system, Integrated stellar-inertial-doppler system, Position update of an inertial system, Noninertial GPS multisensor navigation systems, Filtering of measurements, Kalman filter basics, Open-loop and closed loop Kalman filter mechanizations, GPS-INS mechanization, Practical considerations, Federated system architecture
AIR TRAFFIC MANAGEMENT
Services provided to aircraft carriers, Government responsibilities, Flight rules and airspace organization, Airways and procedures, Phases of flight, Subsystems, Facilities and operations, System capacity, Airborne Collision Avoidance Systems
TEXT BOOKS


UNIT-I: INDIAN SPACE TRANSPORTATION SYSTEM DEVELOPMENT
Evolution of ISRO, organization and structure of ISRO, Goals, objectives, evolution of Indian carrier rockets- PSLV, GSLV, Chandrayan, Mangalyan

UNIT II: TRANSPORTATION SYSTEM ARCHITECTURE, INFRASTRUCTURES AND U.S. SPACE SHUTTLE
Introduction, Historical drivers for space infrastructure, Political considerations, National mission model, Private sector and commercialization, Development of commercial space transportation architecture and system concepts, Cost drivers for space transportation architecture options, Recommended improvements to space transportation architectures, Planning for future space infrastructure, Transportation Infrastructure for moon and mars missions U.S. Space Shuttle: Introduction, Historical background, Development of shuttle system, Orbiter development, Current shuttle vehicle and operations, Shuttle evolution and future growth,

UNIT-III: EXPENDABLE SPACE TRANSPORTATION SYSTEMS AND REUSABLE SPACE LAUNCH VEHICLES
Introduction, Expendable launch vehicle design, History behind existing Expendable Launch Vehicles, Evolving the expendable launch vehicle, Reusable space launch vehicles: Background—Previous efforts at hypersonic flight, Early aerospace plane conceptual studies, The X-series of research aircraft, Challenges facing manned aerospace planes, Manned reusable systems development programs-Past and Ongoing., NASA reusable launch vehicle studies in 1990s., Hypersonic waveriders, Importance of vehicle health management, Future reusable space launch vehicles

OPERATIONS AND SUPPORT SYSTEMS
Introduction, Launch operations definition, Shuttle mission operations, Facility requirements for launch operations, Obstacles to streamlining launch operations, Evolutionary launch operations strategies, Designing for future expendable launch vehicle launch operations, Improving Existing Launch Operations, Future launch operations

UNIT IV: SYSTEMS AND MULTIDISCIPLINARY DESIGN OPTIMIZATION
Introduction, Launch vehicle conceptual design problem, Modeling needs, Optimization strategies and applications, Collaborative work environment of the future

SYSTEMS TECHNOLOGY DEVELOPMENT
Introduction, Vehicle technologies, Propulsion technologies, Ground and mission operations technologies, Assessing technological options, Technology transfer and commercialization, Applying a commercial development process for access to space
UNIT V: PROGRAM PLANNING, MANAGEMENT, AND EVALUATION
Introduction, Management Trends, Good Project Management as Team Building and a Balancing Act, Types of Project Management, Configuration Management, Risk Management, Earned value management, Total Quality Management, Managing ultra-large projects

FUTURE SYSTEMS
Introduction, Next generation space transportation systems, Accelerator concepts, nuclear fission and fusion based concepts, Antimatter-based propulsion concepts, Solar propulsion concepts, Laser and beamed energy propulsion Concepts, Magnetic Monopoles Concept, Field and Quantum Effect Propulsion Concepts.

Text Book
# COURSE COVERAGE SUMMARY FOR
# SPACE TRANSPORTATION SYSTEMS

**(ELECTIVE-IV)**

<table>
<thead>
<tr>
<th>TEXT BOOK TITLE</th>
<th>CHAPTERS IN TEXT BOOK</th>
<th>UNITS/TOPICS COVERED</th>
<th>AUTHOR</th>
<th>PUBLISHERS</th>
<th>EDITION &amp; YEAR</th>
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<tbody>
<tr>
<td>Space Transportation: A system approach to</td>
<td>1-7</td>
<td>1-5</td>
<td>Walter Hammond</td>
<td>AIAA Education series</td>
<td>1999</td>
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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution - UGC, Govt. of India)
M.Tech. I Year - II Semester: Regular Examinations, Aug 2016
Space Transportation Systems

Code No: R15D7620-152

MAX MARKS: 75
Time: 3 hours

Note: This question paper consists of 5 Sections. Answer FIVE Questions, Choosing ONE Question from each SECTION and each Question carries 15 marks.

SECTION - I
1. Briefly, illustrates the activities of the basic systems management process
(Or)
2. What were the tools and methodologies were followed to make the mission Mangalyaan a great success?

SECTION - II
3. Write short notes on:
   a. Hypothesized infrastructure.
   b. Integrated Space plan.
   c. Terrestrial independence.
(Or)
4. Explain how the transportation infrastructure for moon and mars missions differ.

SECTION - III
5. What are facilities required for the launch operations and explain them in brief?
(Or)
6. Write the short notes on:
   a. Shuttle Flight Operations
   b. Orbiter Processing
   c. Transfer and launch

SECTION - IV
7. Briefly explain the basic market research steps.
(OR)
8. Explain the process levels involved in technology investment prioritization process.

SECTION - V
9. Write short notes on:
   a. Risk Management
   b. Total Quality Management
   c. Configuration Management
(Or)
10. Write short notes on:
   a. Magnetic Monopoles Concept
   b. Field and Quantum Effect Propulsion Concepts
   c. Laser and Beamed Energy Propulsion Concepts

************
1. Write about the following Engineering management system in an spacecraft
   a) Project management
   b) Risk management.

2. Explain about the following optimization strategies
   a) Parametric methods
   b) HOLIST design optimization
   c) Gradient methods.

3. Write about the propulsion system consideration for Interstellar flight.

4. What is system engineering? Explain all the nine steps involved in the cyclic process of systems engineering.

5. Write in detail about the future expendable launch vehicle and discuss about its launch operations with the help of a flow chart.

6. Discuss the history and development of the Delta Series of Launch Vehicles.

7. Discuss the infra structure required for future Mars missions.

8. Write about the following
   a. Applications of manned reusable launch vehicles
   b. Transatmospheric vehicle development.
1. Discuss the vehicle, propulsion technologies that will lower the launch operation costs in space transportation [12]

2. Explain about any two next generation concepts of space transportation systems. [12]

3. Write in detail about the following with examples [12]
   a) Inertial confinement fusion
   b) Magnetic confinement fusion

4. Write in detail about the X-series of research aircraft and the challenges faced by them and explain its characteristics [12]

5. Discuss in detail about the cost estimating technique [12]

6. Explain the balanced multidisciplinary design process in space transportation system with the help of a flow chart [12]

7. Discuss the conceptual design procedure of a typical expendable launch vehicle. [12]

8. Discuss the importance of vehicle integrated health management. [12]
1. Answer the following:
   a. What are systems engineering? Explain all the nine steps involved in the cyclic process of systems engineering.
   b. Name the three major phases that are part of the design process and give a description of each of the phases.

2. Answer the following:
   a. List and explain each of the cost drivers that influence Space Transportation System architecture design.
   b. Describe the following aspects of the current space shuttle vehicle and its Operations
      (i) Orbiter
      (ii) Avionics
      (iii) External tank
      (iv) Solid rocket boosters.

3. Answer the following:
   a. Give a brief history of development of the Ariane family of launch vehicles by mentioning the various vehicle versions.
   b. Describe in detail the three challenges faced by designers of manned aerospace planes.

4. Define launch operations. List the six launch operations steps. Elaborate on all five of the shuttle mission operations.

5. List the steps involved in the conceptual design process of a launch vehicle. Discuss the need for modeling of the launch vehicles during the design process. Also, discuss the various aspects involved in successful modeling of a launch vehicle.

6. Explain the importance of market research in space programs. Write and explain the six basic steps that should be followed for conducting market research.

7. List and explain the 14 Deming points of good quality management as applicable to space programs.

8. Discuss the concepts behind the nuclear fusion based propulsion technology development. Describe inertial confinement fusion and magnetic confinement fusion. Write about the Daedalus project in fusion propulsion development.

*******
UNIT-I: NEWTONIAN MECHANICS

UNIT-II: PRINCIPLES OF ANALYTICAL MECHANICS

CONCEPTS FROM LINEAR SYSTEM THEORY

UNIT-III: LUMPED-PARAMETER STRUCTURES

CONTROL OF LUMPED-PARAMETER SYSTEMS. CLASSICAL APPROACH

UNIT-IV: CONTROL OF LUMPED-PARAMETER SYSTEMS. MODERN APPROACH

UNIT-V: DISTRIBUTED-PARAMETER STRUCTURES, EXACT AND APPROXIMATE METHODS

CONTROL OF DISTRIBUTED STRUCTURES
Closed-Loop Partial Differential Equation of Motion, Modal Equations for Un damped Structures, Mode
Controllability and Observability, Closed-Loop Modal Equations, Independent Modal-Space Control, Coupled Control, Direct Output Feedback Control, Systems with Proportional Damping, Control of Discretized Structures, Structures with General Viscous Damping.

**TEXT BOOK**


**REFERENCE BOOKS**

MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY

I Year M. Tech, ASP-II SEM

(R15D7622) TACTICAL MISSILE DESIGN
(OPEN ELECTIVE-II)

UNIT-I: INTRODUCTION / KEY DRIVERS IN DESIGN PROCESS
Tactical Missile characteristics, Conceptual design process, Examples of State-of-the-Art missiles, Aerodynamic configuration sizing parameters, Examples of alternatives in establishing mission requirements, Baseline missile

UNIT-II: AERODYNAMIC CONSIDERATIONS IN TACTICAL MISSILE DESIGN
Missile diameter tradeoff, Nose fineness tradeoff, Boat-tail, Lifting body versus axi-symmetric body, Wings versus no wings, Normal force prediction for surfaces, Wing aerodynamic center prediction, Wing drag prediction, Surface plan form geometry tradeoffs, Flight control alternatives, Maneuver alternatives, Roll orientation, Static stability, Tail area sizing, Stability and control conceptual design criteria, Body buildup

PROPULSION CONSIDERATIONS IN TACTICAL MISSILE DESIGN
Propulsion alternatives assessment, Ideal ramjet Mach number and temperature technology limit, Ramjet specific impulse prediction, Ramjet thrust prediction, Ramjet engine/booster integration, Ramjet inlet options, Ramjet inlet spillage, Inlet shock loss, Ramjet missile drag due to booster integration, Fuel alternatives, Rocket motor performance, Solid motor grain alternatives, Solid rocket thrust control, Solid propellant material alternatives, Motor case alternatives, Rocket nozzle material alternatives

UNIT-III: WEIGHT CONSIDERATIONS IN TACTICAL MISSILE DESIGN
Benefits of lighter weight missile, Subsystem weight sensitivity to flight performance, Missile weight prediction, Centre-of-gravity and moment-of-inertia prediction, Factor of safety, Micro-Machined Electro-Mechanical Systems(MEMS), Manufacturing processes, Airframe material alternative, Aerodynamic heating prediction, Insulation trades, Insulation material alternatives, Structure design, Seeker dome materials, Thermal stress, Localized aerodynamic heating

FLIGHT PERFORMANCE CONSIDERATIONS IN TACTICAL MISSILE DESIGN
Flight performance envelope, Equations of motion modeling, Driving parameters for flight performance, Cruise flight performance, Steady state flight, Flight trajectory shaping, Turn radius, Coast flight performance, Boost flight performance, Intercept lead angle and velocity, Comparison with performance requirements

UNIT-IV: MEASURES OF MERIT AND LAUNCH PLATFORM INTEGRATION
Robustness, Warhead lethality, Miss distance, Carriage and launch observables, Other survivability considerations, Reliability, Cost, Launch platform integration

Sizing Examples: Air-to-Air range requirements, Wing sizing for maneuverability, Weight and miss distance harmonization, Ramjet missile range robustness, Ramjet propulsion/fuel alternatives, Ramjet missile surface impact velocity, Computer-Aided sizing for conceptual design, Verification process

UNIT-V: DEVELOPMENT PROCESS, SUMMARY AND LESSONS LEARNED
Development Process: Technology Assessment/Roadmap, Phases of Development/Design maturity, Tactical-missile follow-on programs, Subsystem integration, Examples of technology development, Examples of State-of-the-Art advancement, New technologies for tactical missiles; Summary and Lessons Learned: Iterate-the-System-of-Systems Analysis, Exploit diverse skills, Apply creative skills, Identify high-payoff measures of merit,
Start with a good baseline design, Conduct balanced tradeoffs, Evaluate a broad range of alternatives, Refine the design, Evaluate technology risk, Maintain real-time documentation, Develop good documentation, Utilize group skills, Balance the tradeoff of importance versus priority, Iterate the configuration design, Configuration sizing conceptual design criteria

**TEXT BOOK**

## COURSE COVERAGE SUMMARY
### FOR
### TACTICAL MISSILE DESIGN

(OPEN ELECTIVE-II)

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<td>TACTICAL MISSILE DESIGN</td>
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<td>EUGENE L. FREEMAN</td>
<td>AIAA EDUCATION SERIES</td>
<td>I EDITION, 2001</td>
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MALLA REDDY COLLEGE OF ENGINEERING & TECHNOLOGY
(Autonomous Institution – UGC, Govt. of India)
M.Tech. I Year - II Semester Regular Examinations, Aug 2016
Space Transportation Systems

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SECTION – III

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    b. Field and Quantum Effect Propulsion Concepts
    c. Laser and Beamed Energy Propulsion Concepts

************
UNIT-I: DESCRIPTION OF FLOWS AT HIGH ANGLES OF ATTACK
Introduction, Finite lifting wing of medium and high aspect ratio at low subsonic speeds, Low aspect ratio rectangular wing at low subsonic speeds, Slender delta type wings, Flow over elongated slender bodies, Aircraft type configurations, Vortex breakdown, Non-steady aerodynamics at high angles of attack on slender configurations, Effect of separation at high angles of attack in hypersonic flows

UNIT-II: TOPOLOGY OF SEPARATING AND REATTACHING VORTICAL FLOWS
Equations for vortical flows, Topological concepts for the analysis of vortical flows,

LINEAR AERODYNAMICS OF WINGS AND BODIES
Equations for potential subsonic flows, Equations for the lifting wing at low speeds, Linear panel methods for the calculation of the subsonic aerodynamic coefficients for wings and bodies, Low and higher order linear panel methods for subsonic and supersonic flows, Comparison of various panel methods

UNIT-III: VORTEX FLOWS AND THE ROLLED UP VORTEX WAKE
Vortex core of the rolled up wake, Rolled up tip vortices, Rolling up of vortex wake behind wings, Bursting of rolled up vortices

Nonlinear Aerodynamics Of Wings And Bodies At High Angles Of Attack: Analytical and semi-empirical methods for calculations of the non-linear aerodynamic characteristics

UNIT-IV: NONLINEAR PANEL METHODS FOR AIRCRAFT AND MISSILE CONFIGURATIONS AT HIGH ANGLES OF ATTACK
Nonlinear Vortex Lattice Method (NVLM) for subsonic flows, Free vortex sheet method for subsonic flows, NVLM for supersonic flows

SOLUTIONS OF EULER EQUATIONS FOR FLOWS OVER CONFIGURATIONS AT HIGH ANGLES OF ATTACK
Euler equations, Numerical methods of solution of the Euler equations: Grid generation methods, Finite volume methods, Finite difference methods, finite element methods, multigrid calculations with Cartesian grids and local refinements, Euler computations on three-dimensional configurations at high angles of attack

UNIT-V: SOLUTIONS OF NAVIER-STOKES EQUATIONS FOR FLOWS OVER CONFIGURATIONS AT HIGH ANGLES OF ATTACK:
Formulation of the Navier-Stokes equations, Numerical methods for solutions of Navier-Stokes equations, Method of solution of the thin layer equations, Grid topology, boundary and initial conditions, Solutions of Navier-Stokes equations for flows in three-dimensional configurations at high angles of attack

TEXT BOOK
UNIT-I: INTRODUCTION TO OPTIMIZATION
Classification of systems, Parameter Optimization: Distance problem, General parameter optimization problem, Optimal Control Theory: Distance problem, Acceleration problem, Navigation problem, General optimal control problem, Conversion of an optimal control problem into a parameter optimization problem, Necessary conditions and sufficient conditions

UNIT-II: PARAMETER OPTIMIZATION-I
Unconstrained Minimization: Taylor series and differentials, Function of one, two and n independent variables; Constrained Minimization-Equality Constraints: Function of two constrained variables-Direct and Lagrange Multiplier approaches, Distance problem, Function of n constrained variables

UNIT-III: DIFFERENTIALS IN OPTIMAL CONTROL AND CONTROLLABILITY
Differentials in Optimal Control: Standard optimal control problem, Differential of the state equation, Relation between δ and d, Differential of the final condition, Differential of the integral, Controllability: Fixed final time, Solution of the linear equation, controllability condition, Controllability-free final time, Navigation problem

UNIT-IV: FREE FINAL TIME, FREE INITIAL TIME AND STATES
Free Final Time: First differential conditions, Tests for a minimum, second differential, neighboring optimal paths, second differential conditions, Distance and navigation problems, Free Initial Time and States: Problem statement, First differential conditions, Tests for a minimum, Second differential conditions, Minimum distance from a parabola and a line, Parameters as states, Navigation problem

UNIT-V: CONTROL DISCONTINUITIES AND PATH CONSTRAINTS
Control Discontinuities Problem statement, First differential conditions, Tests for s minimum, Second differential, Neighboring optimal path, Second differential conditions, Supersonic airfoil of minimum pressure drag; Path

Constraints: Integral constraint, State equality constraint, Control inequality constraint, Acceleration problem,
State inequality constraint

**Approximate Solutions of Optimal Control Problems**: Optimal control problem with a small parameter, Application to a particular problem, Application to a general problem, Solution by the sweep method, Navigation problem

**TEXT BOOK**


**REFERENCE BOOK**

I Year M. Tech, ASP-II SEM (R15D7682) DIGITAL SIMULATION LAB-II

I. SOFTWARE DEVELOPMENT FOR THE FOLLOWING USING FINITE ELEMENT METHODS
   Thin walled beams Plate bending
   Beams analysis Trusses analysis
   Thin shells analysis

II. AEROSPACE STRUCTURAL ANALYSIS USING ANSYS
    Structural analysis of aircraft wing
    Structural analysis of aircraft wing (Composite material) Analysis of fuselage
    Rocket motor case analysis
    Structural and thermal analysis of rocket nozzles Fractural mechanics of crack propagation

i. SIMULATION EXPERIMENTS IN DYNAMICS AND CONTROL USING MATLAB AND SIMULINK
   Simulation of Aircraft motion-longitudinal dynamics, lateral dynamics
   Six-degrees-of-freedom simulation of aircraft motion with illustration of F-16 model Simulation of reentry vehicle dynamics for ballistic reentry and maneuvering reentry
   Simulation of non-linear control system for controlling roll dynamics of a fighter aircraft
   Simulation of the following relating to satellite attitude dynamics:
      Torque free rotation of axisymmetric and asymmetric spacecraft
      Attitude maneuvers of spin-stabilized spacecraft

REFERENCES
   Modern Control Design with MATLAB and Simulink, A. Tewari