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# GATE 2019

## ORGANIZING INSTITUTE :

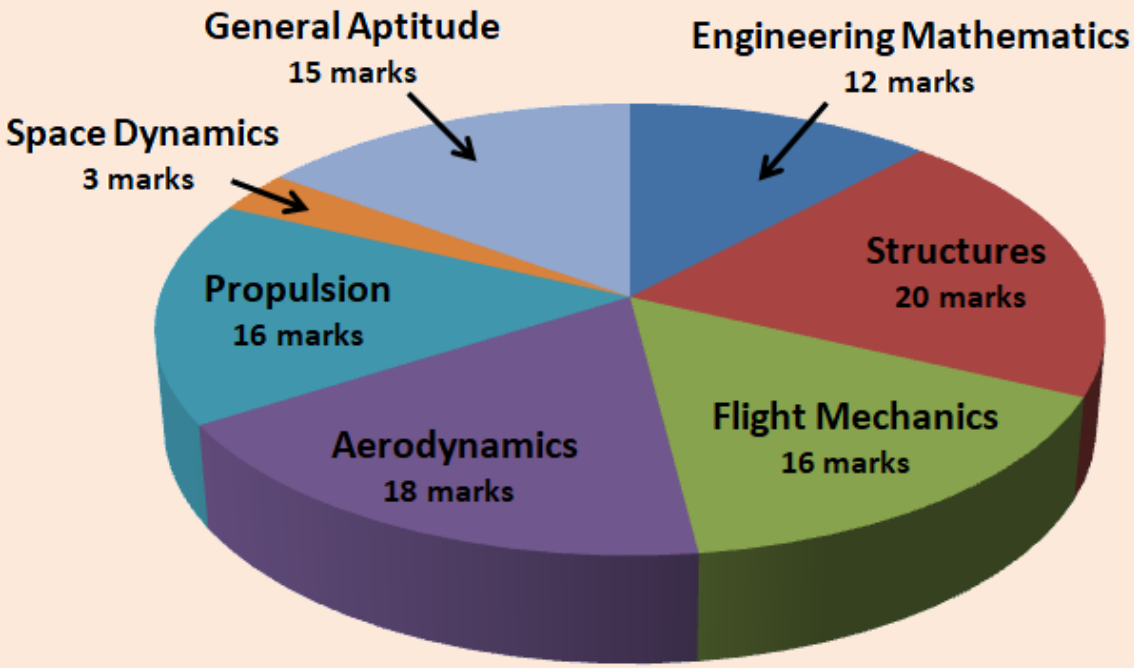
## IIT MADRAS

## Syllabus

## AEROSPACE ENGINEERING

# Analysis of GATE

# AEROSPACE ENGINEERING




***NOTE:*** *Above values coresponds to general distribution of marks for the following subjects. GATE subject wise marks every year varies from 1 to 2 marks from above values.*

*GATE AEROSPACE 2018 was less on sturctures and Flight Mechanics, more questions asked from Propulsion and Space MechanicS*

| Subject | No of Questions | Topics | Total Marks |
|---|---|---|---|
| Engineering Mathematics | 1M : 3<br>2M : 5 | • Matrices<br>• Differential and Integral Calculus<br>• Vector calculus<br>• ODE / PDE<br>• Numerical Technique<br>• Laplace transformation<br>• Fourier | 13 |
| Flight Mechanics | 1M : 7<br>2M : 5 | • Atmosphere<br>• Basics – Speeds, Altitudes and primary flight instruments<br>• Steady straight and level flight<br>• Gliding and Climbing<br>• Range and Endurance<br>• Take – off and Landing<br>• Turning flight<br>• Pull –up and pull – down maneuvre<br>• V-n diagram<br>• Longitudnal static stability<br>• Directional and Lateral static stability<br>• Dynamic Stability - modes<br>• Equations of motion<br>• Euler's angles | 17 |
| Space Dynamics | 1M : 1<br>2M : 1 | • Kepler's Law<br>• Different orbits – circular, elliptic, parabolic and hyperbolic<br>• Escape velocity<br>• Orbit in-plane transfer (Hohmann)<br>• Orbit out–off plane transfer | 3<br>(in 2018 GATE AE Space mechanics covers around 8 – 10 marks) |
| Aerodynamics | 1M : 3<br>2M : 6 | • Basic Fluid mechanics – Laminar and turbulent flow, Boundary layer, Dimensional similarity<br>• Ideal potential flow<br>• Low speed aerodynamics – aerodynamic centre, center of pressure<br>• Thin Airfoil theory<br>• Finite wing theory<br>• Gas Dynamics – Isentropic flow, CD nozzles, NSW, OSW, Expansion fans, Rayleigh flow, Fanno flow | 15 |
| Structures | 1M : 5<br>2M : 7 | • Basic Elasticity – Stress tensor, Principal stresses, Mohr's circle, Generalized Hooke's law, Plane | 19 |

| | | | |
|---|---|---|---|
| | | stress, plane strain, Airy's stress function, Thin walled pressure vessels<br>• Structure idealization<br>• Bending- Symmetrical and unsymmetrical bending, bending stresses, shear stresses, S.F. and B.M. diagram, deflection of beams, Shear flow and Shear centre<br>• Columns<br>• Theory of failures<br>• Vibration – Damped and undamped, free and forced system 1 DOF system, Free 2 DOF system, Continuous vibration<br>• Energy methods | |
| Propulsion | 1M : 6<br>2M : 6 | • Thermodynamics Bsics<br>• Axial flow compressor<br>• Axial flow turbine<br>• Centrifugal flow compressor<br>• Jet propulsion – Turbojet Turbofan, Ramjet, Turboprop<br>• Combustion chamber<br>• Rocket Rpopulsion | 18 |
| General Aptitude | 1M:5<br>2M:5 | • Verbal Ability<br>• Numerical Ability | 15 |
| **Total** | **65** | | **100** |

# Syllabus for General Aptitude (GA)

***(COMMON TO ALL PAPERS)***

**Verbal Ability:** English grammar, sentence completion, verbal analogies, word groups, instructions, critical reasoning and verbal deduction.

**Numerical Ability:** Numerical computation, numerical estimation, numerical reasoning and data interpretation.

***Sample Questions***

**Verbal Ability**

**Q.1.** Choose the appropriate answer to complete the following sentence:
To those of us who had always thought him timid, his --------- came as a surprise.
(A) intrepidity (B) inevitability (C) inability (D) inertness
**Ans. (A)**

**Q.2.** Choose the appropriate answer to complete the following sentence:
Medicine is to illness as law is to _____
(A) discipline (B) anarchy (C) treason (D) etiquette
**Ans. (B)**

**Q.3**. Read the following paragraph:
"The ordinary form of mercury thermometer is used for temperature ranging from –40oF to 500oF. For measuring temperature below –40oF, thermometers filled with alcohol are used. These are, however, not satisfactory for use in high temperatures. When a mercury thermometer is used for temperature above 500oF, the space above the mercury is filled with some inert gas, usually nitrogen or carbon dioxide, placed in the thermometer under pressure. As the mercury rises, the gas pressures is increased, so that it is possible to use these thermometers for temperatures as high as 1000oF." With what, besides mercury, would a thermometer be filled if it was designed to be used for measuring temperature of about 500oF?
(A) Pyrometer (B) Inert gas (C) Iron and brass (D) Gas
**Ans. (B)**

**Q.4.** The cost of manufacturing tractors in Korea is twenty percent less than the cost of manufacturing tractors in Germany. Even after transportation fees and import taxes are added, it is still cheaper to import tractors from Korea to Germany than to produce tractors in Germany.

Which of the following assertions is best supported by the above information?

(A) Labour costs in Korea are twenty percent below those in Germany.
(B) Importing tractors into Germany will eliminate twenty percent of the manufacturing jobs in Germany.
(C) The costs of transporting a tractor from Korea to Germany is more than twenty percent of the cost of manufacturing the tractor in Korea.

(D) The import taxes on a tractor imported from Korea to Germany is less than twenty percent of the cost of manufacturing the tractor in Germany.
**Ans. (D)**

**Numerical Ability**

**Q.5.** In a survey, 3/16 of the people surveyed told that they preferred to use public transport while commuting daily to office. 5/8 of the people surveyed told that they preferred to use their own vehicles. The remaining 75 respondents said that they had no clear preference. How many people preferred to use public transport?
(A) 75 (B) 100 (C) 125 (D) 133
**Ans. (A)**

**Important Note for Candidates: In each of the following subjects the topics have been divided into two categories – Core Topics and Special Topics. The corresponding sections of the question paper will contain 90% of their questions on Core Topics and the remaining 10% on Special Topics.**

## Section1: Engineering Mathematics

**Core Topics:**

**Linear Algebra**: Vector algebra, Matrix algebra, systems of linear equations, rank of a matrix, eigen values and eigen vectors.
**Calculus:** Functions of single variable, limits, continuity and differentiability, mean value theorem, chain rule, partial derivatives, maxima and minima, gradient, divergence and curl, directional derivatives. Integration, Line, surface and volume integrals. Theorems of Stokes, Gauss and Green.

**Differential Equations:** First order linear and nonlinear differential equations, higher order linear ODEs with constant coefficients. Partial differential equations and separation of variables methods.

**Special Topics:**
Fourier Series, Laplace Transforms, Numerical methods for linear and nonlinear algebraic equations, Numerical integration and differentiation.

## Section 2: Flight Mechanics

**Core Topics:**

**Basics:** Atmosphere: Properties, standard atmosphere. Classification of aircraft. Airplane (fixed wing aircraft) configuration and various parts.

**Airplane performance:** Pressure altitude; equivalent, calibrated, indicated air

speeds; Primary flight instruments: Altimeter, ASI, VSI, Turn-bank indicator. Drag polar; takeoff and landing; steady climb & descent, absolute and service ceiling; cruise, cruise climb, endurance or loiter; load factor, turning flight, V-n diagram; Winds: head, tail & cross winds.

**Static stability:** Angle of attack, sideslip; roll, pitch & yaw controls; longitudinal stick fixed & free stability, horizontal tail position and size; directional stability, vertical tail position and size; dihedral stability. Wing dihedral, sweep & position; hinge moments, stick forces;

**Special Topics:**
Dynamic stability**:** Euler angles; Equations of motion; aerodynamic forces and moments, stability & control derivatives; decoupling of longitudinal and lateral-directional dynamics; longitudinal modes; lateral-directional modes.

## Section 3: Space Dynamics

**Core Topics:**

Central force motion, determination of trajectory and orbital period in simple cases.

**Special Topics:**
Orbit transfer, in-plane and out-of-plane.

## Section 4: Aerodynamics

**Core Topics:**

**Basic Fluid Mechanics:** Conservation laws: Mass, momentum (Integral and differential form); Potential flow theory: sources, sinks, doublets, line vortex and their superposition; Viscosity, Reynold's number.

**Airfoils and wings:** Airfoil nomenclature; Aerodynamic coefficients: lift, drag and moment; Kutta-Joukoswki theorem; Thin airfoil theory, Kutta condition, starting vortex; Finite wing theory: Induced drag, Prandtl lifting line theory; Critical and drag divergence Mach number.

**Compressible Flows:** Basic concepts of compressibility, Conservation equations; One dimensional compressible flows, Fanno flow, Rayleigh flow; Isentropic flows, normal and oblique shocks, Prandtl-Meyer flow; Flow through nozzles and diffusers.

**Special Topics:**
Elementary ideas of viscous flows including boundary layers; Wind Tunnel Testing**:** Measurement and visualization techniques.

## Section 5: Structures

**Core Topics:**

**Strength of Materials**: States of stress and strain. Stress and strain transformation. Mohr's Circle. Principal stresses. Three-dimensional Hooke's law. Plane stress and strain; Failure theories: Maximum stress, Tresca and von Mises; Strain energy. Castigliano's principles. Analysis of statically determinate and indeterminate trusses and beams. Elastic flexural buckling of columns.

**Flight vehicle structures:** Characteristics of aircraft structures and materials. Torsion, bending and flexural shear of thin-walled sections. Loads on aircraft.

**Structural Dynamics:** Free and forced vibrations of undamped and damped SDOF systems. Free vibrations of undamped 2-DOF systems.

**Special Topics:**
Vibration of beams. Theory of elasticity: Equilibrium and compatibility equations, Airy's stress function.

## Section 6: Propulsion

**Core Topics:**

**Basics:** Thermodynamics, boundary layers and heat transfer and combustion thermochemistry.

**Thermodynamics of aircraft engines:** Thrust, efficiency and engine performance of turbojet, turboprop, turbo shaft, turbofan and ramjet engines, thrust augmentation of turbojets and turbofan engines. Aerothermodynamics of non-rotating propulsion components such as intakes, combustor and nozzle.

**Axial compressors:** Angular momentum, work and compression, characteristic performance of a single axial compressor stage, efficiency of the compressor and degree of reaction.

**Axial turbines:** Axial turbine stage efficiency

**Centrifugal compressor**: Centrifugal compressor stage dynamics, inducer, impeller and diffuser.

**Rocket propulsion**: Thrust equation and specific impulse, vehicle acceleration, drag, gravity losses, multi-staging of rockets. Classification of chemical rockets, performance of solid and liquid propellant rockets.

**No Special Topics**