

**APPENDIX 'D'**

**AIRCRAFT & ENGINE – TECHNICAL GENERAL**

**THE SYLLABUS OF AIRCRAFT & ENGINE – TECHNICAL GENERAL  
AS FOLLOWS :**

**1. Aircraft and Engines**

**1.1 Airframe and Systems**

- Fuselage
  - types of construction
  - stress
- Wings
  - types of construction
  - structural components
  - stress
- Stabilizing surfaces
  - vertical, horizontal and V-tail surfaces
  - 'flutter'
  - compensation system
  - mach trim
- Landing Gear
  - types
  - locking devices and emergency extension systems
  - accidental retraction prevention devices
  - position, movement lights and indicators
  - nose wheel steering
  - wheels and tyres (limitations)
  - braking systems
    - parking brake
    - mode of operation of anti-skid system
    - mode of system of auto brake system
    - operation, indications and warning systems
- Flight Controls
  - Primary controls:
    - elevator, aileron and rudder
    - trim
    - mode of actuation (mechanical, hydraulic, electrical, fly-by-wire)
    - operation, indicators, warning devices and controls)
    - efforts to transmit

- Secondary controls:
  - leading and trailing edge lift augmentation devices
  - lift dumping and speed brakes
  - variable elevator
  - mode of actuation (mechanical, hydraulic, electrical, fly-by-wire)
  - operation, indicators, warning devices and controls)
  - danger situations and potential failures
- Hydraulics
  - Basic principles of hydromechanics
    - hydraulic fluids
    - schematic construction and functioning of hydraulic systems
  - Hydraulic system
    - main, standby and emergency system
    - operation, indicators, warning system
    - ancillary system
  - Pneumatic system
    - power sources
    - schematic construction
    - potential failures, warning devices
    - operation, indicators, warning systems
    - pneumatic operated systems
  - Air-conditioning systems
    - construction, functioning, operation, indicators and warning devices
    - heating and cooling
    - temperature regulation
    - automatic and manual
    - ram air ventilation
    - schematic construction
  - Anti-ice systems
    - aerofoil and control surfaces, power plant, air intakes, windshield
    - schematic construction, operating limitations and initiation, timing of de-icing system usage
    - ice warning system

- Pressurization
  - cabin altitude, maximum cabin altitude, differential pressure
  - pressurized zones in the aircraft
  - safety devices and warning systems
  - rapid decompression, cabin altitude warning
  - emergency procedures
- Non-pneumatic operated de-ice and anti-ice systems
  - schematic construction, functioning and operation of:
    - air intake
    - propeller-pitot, static pressure sensor and stall warning devices
    - windshield
    - rain repellent system
- Fuel system
  - Fuel tanks
    - structural components and types
    - location of tanks on single-and-multi-engine aircraft
    - sequence and types of re-fuelling
    - unusable fuel
  - Fuel feed
    - gravity and pressure feed
    - crossfeed
- Fuel system monitoring
  - operating, indicators, warning systems
  - fuel management (sequencing of fuel tank switching)
  - dip stick

## **1.2 Electrics**

- a) Director Current (DC); Direct /Alternating Current (DC/AC)
  - General
  - electric circuits
  - voltage, current, resistance
  - Ohm's law
  - resistive circuits
  - resistance as a function of temperature
  - electrical power, electrical work
  - fuses (function, type and operation)
  - the electrical field
  - the capacitor (function) system, shock absorbers)

- Batteries
    - types, characteristics
    - capacity
    - uses
    - hazards
  - Magnetism
    - permanent magnetism
    - electromagnetism:
      - relay, circuit breaker, solenoid valve (principle, function and applications)
      - electromagnetic power
      - electromagnetic induction
  - Generators
    - alternator:
      - principle, function and applications
      - monitoring devices
      - regulation, control and protection
      - modes of excitation
    - starter generator
  - Distribution
    - current distribution (buses)
    - monitoring of electrical flight instruments/systems:
      - ammeter, voltmeter
      - annunciators
    - electrical consumers
    - DC power distribution:
      - construction, operation and system monitoring
      - elementary switching circuits
  - Inverter
  - The aircraft structure as an electrical conductor
- b) Alternating Current (AC)
- General
    - single and multi-phase AC
    - frequency
    - phase shift

- AC components
  - Generators
    - 3-phase generator
    - brushless generator
    - generator drive:
      - constant speed drive
      - integrated drive
  - AC power distribution
    - operation and monitoring
    - protection circuits, paralleling of Ac-generators
  - Transformers
    - function
    - types and applications
  - Transformer/rectifier units
- d) Basic knowledge of computers
- Logic circuits
  - Logical symbols
  - Switching circuits and logical symbols

### **1.3 Power Plant**

a) Piston engine

General

- design type
- Principle of the 4-stroke internal combustion engine
- Mechanical component

Lubrication system

- function
- schematic construction
- monitoring instruments and indicators
- lubricants

Air cooling

- system monitoring
- cylinder head temperature

- cowl flaps

#### Ignition

- schematic construction and function
- types of ignition
- magneto check

#### Engine fuel supply

- carburetor (construction and mode of operation, carburetor icing)
- fuel injection (construction and mode of operation)
- alternate air

#### Engine performance

- pressure / density altitude
- performance as a function of pressure and temperature

#### Power augmentation devices

- turbocharger, supercharger (construction and effect on engine performance)

#### Fuel

- types, grades
- detonation characteristics, octane rating
- colour coding
- additives
- water content, ice formation
- fuel density
- alternate fuels, differences in specifications, limitations

#### Mixture

- rich and lean mixture
- maximum power and fuel economy mixture setting

#### Propeller

- fixed pitch and constant speed propeller
- principles and operation of propellers on single and multi-engine aircraft
- propeller check
- propeller efficiency as a function of airspeed
- aircraft and engine protection (propeller operation: ground/ air, coarse/fine pitch limitations)

#### Engine handling and manipulation

- power setting, power range
- mixture setting

- operational limitations

Operational criteria

- maximum and minimum RPM
- (induced) engine vibration and critical RPM
- remedial action by abnormal engine start run-up and inflight

b) Turbine engine

- principles of operation
- types of construction
  - turboprop
  - turbojet
  - turbofan

c) Engine construction

- Air inlet
  - function
- Compressor
  - function
  - construction and mode of operation
  - effects of damage
  - compressor stall and surge (cause and avoidance)
- Diffuser
  - function
- Combustion chamber
  - function, types and working principles
  - mixing ratios
  - fuel injectors
  - thermal load
- Turbine
  - function, construction and working principles
  - thermal and mechanical stress
  - effects of damage
  - monitoring of exhaust gas temperature
- Jet pipe
  - function
  - different types
  - noise silencing devices



- Pressure, temperature and airflow in a turbine engine
  - Reverse thrust
    - function, types and principles of operation
    - degree of efficiency
    - use and monitoring
  - Performance and thrust augmentation
    - water injection, principles of operation
    - use and system monitoring
  - Bleed air
    - effect of use of bleed air on thrust, exhaust temperature, RPM and pressure ratio
  - Auxiliary gearbox
    - function
- d) Engine systems
- Ignition
    - function, types, components, operation, safety aspects
  - Starter
    - function, type, construction and mode of operation
    - control and monitoring
    - self sustaining and idle speeds
  - Engine start malfunctions
    - cause and avoidance
  - Fuel system
    - schematic diagrams, components
    - operation and monitoring
    - malfunctions
  - Lubrication
    - components
    - operation and monitoring
    - malfunctions
  - Fuel
    - effects of temperature
    - impurities
    - additives

- Thrust
  - thrust formula
  - flat rated engine
  - thrust as a function of airspeed, air density, pressure, temperature and RPM
  - power plant operation and monitoring
- e) Auxiliary Power Unit (APU)
  - General
    - function, types
    - location
    - operation and monitoring
  - Ram air turbine
    - function

#### **1.4 Emergency Equipment**

- a) Doors and emergency exits
  - evacuation slides, general usage or as life rafts or flotation devices
- b) Smoke detection
  - location, indicators, function test
- c) Fire detection
  - location, warning mode, function test
- d) Fire fighting equipment
  - location, operation, contents, gauge, function test
- e) Aircraft oxygen equipment
  - drill, use of equipment in case of rapid decompression
  - oxygen generators
- f) Hydraulic systems
  - components, fluids
  - operation, indication, warning systems
  - auxiliary systems
- g) Emergency equipment
  - portable, hand-held fire extinguisher
  - smoke mask, smoke protection hood]
  - portable oxygen system
  - emergency locator beacon, transmitter

- life jacket, life raft
- pocket lamp, emergency lighting
- megaphone
- cash axe
- fireproof gloves
- emergency flotation system

## **2. Principles of Flight**

### **2.1 Subsonic Aerodynamics**

#### **a) Basics Laws and Definitions**

- Laws and definitions
  - units
  - laws of Newton
  - ideal gas equation
  - equation of impulse
  - equation of continuity
  - Bernoulli's theorem
  - static pressure
  - dynamic pressure
  - viscosity
  - density
  - IAS, CAS, EAS, TAS
- Basics about airflow
  - stationary airflow
  - not stationary airflow
  - streamline
  - stream tube
  - two-dimensional airflow
  - three-dimensional airflow
- Aerodynamic forces on surfaces
  - resulting air force
  - lift
  - drag
  - angle of attack
  - forces and equilibrium of forces during climb, level, descent and turn
- Shape of an aerofoil
  - thickness of chord ratio
  - chordline
  - camberline

- nose radius
- camber
- angle of attack
- angle of incidence
  
- The wing shape
  - aspect ratio
  - root chord
  - tip chord
  - tapered wings
  - shape of wing surface
  - mean aerodynamic chord (MAC)
  
- b) The two-dimensional airflow about an aerofoil
  - streamline pattern
  - stagnation point
  - pressure distribution
  - centre of pressure
  - lift and downwash
  - drag and wake (loss of impulse)
  - influence of angle of attack
  - flow separation at high angles of attack
  - the lift-graph
  
- c) The coefficients
  - The lift coefficient  $C_L$ 
    - the lift formula
    - $C_L - \alpha$  graph
    - $C_{Lmax}$  and  $\alpha$
    - normal values of  $C_{Lmax}$ ,  $\alpha_{crit}$ , stall, and the slope of the  $C_L$  / A.o.A curve
  
  - The drag coefficient  $C_D$ 
    - the drag formulas:
    - zero lift drag
    - lift induced drag
    - $C_D - \alpha$  graph
    - $C_L - C_D$  graph, profile polar
    - $C_L - C_D$  ratio
    - normal values of the  $C_L - C_D$  ratio
  
- d) The three-dimensional airflow about an aeroplane

- Streamline pattern
  - span-wise flow and causes
  - tip vortices and local  $\alpha$
  - tip vortices and angle of attack
  - up-wash and down-wash due to tip vortices
  - span-wise lift distribution
  - wake turbulence behind an aircraft (causes, distribution, duration of the phenomenon)
- Induced drag
  - influence of tip vortices on the angle of attack
  - the induced local  $\alpha$
  - influence of induced angle of attack on the direction of the lift vector
  - induced drag and angle of attack
  - induced drag and speed
  - induced drag and wing aspect ratio
  - induced drag and wing planform
  - induced drag coefficient
  - induced drag coefficient and angle of attack
  - influence of the induced drag on the  $C_L - \alpha$  graph
  - influence of the induced drag on the  $C_L - C_D$  graph, airplane lift drag ratio
  - influence of plan of section
  - winglets
  - wing span loading
  - influence of wing twist
- e) The total drag
  - influence of change of camber
    - the parasite drag
    - profile drag
    - interference drag
  - friction drag
  - The profile drag and speed
  - the induced drag and speed
  - the total drag
  - the total drag and speed
  - minimum drag
  - the drag – speed graph
- f) The ground effect

- effect on  $C_{Di}$
- effect on  $\alpha_{crit}$
- effect on  $C_L$
  
- Effect on take-off and landing characteristics of an aircraft
  
- g) The relation between the lift coefficient and the speed for constant lift
  - as a formula
  - in a graph
  
- h) The stall
  - Flow separation at increasing angles of attack
    - the boundary layer:
      - laminar layer
      - turbulent layer
      - transition
    - separation point
    - influence of angle of attack
  - influence on:
    - pressure distribution
    - location of centre of pressure
  - $C_L$
  - $C_D$
  - pitch moments
  - down-wash at horizontal stabilizer
  
  - buffet
  - use of controls
  
- The stall speed
  - in the lift formula
  - 1g stall speed
  
- influence of:
  - the centre of gravity
  - power setting
  - altitude / IAS
  - wing loading
  
- load factor  $n$ :
  - definition

- turns
- forces
- The initial stall in span-wise direction
  - influence of plan form
  - aerodynamic twist (wash out)
  - geometric twist
  - use of ailerons
  - influence of fences, vortilons, saw teeth and vortex generators
- Special phenomena of stall
  - the power-on stall
  - climbing and descending turns
  - swept back wings
  - super- or deep-stall, stick pusher
  - canards
  - T-tailed aircraft
  - avoidance of spins:
    - spin development
    - spin recognition
    - spin recovery
  - ice (in stagnation point and on surface):
    - absence of stall warning
    - abnormal behaviour of the stall
    - stabilizer stall
  - Stall warning
    - importance of stall warning
    - speed margin
    - buffet
    - stall strip
    - flapper switch
    - AOA vane
    - AOA probe
    - stick shaker
    - recovery from stall
- i)  $C_{Lmax}$  augmentation
  - Trailing edge flaps and the reasons for use in take-off and landing
    - different types of flaps:
      - split flap
      - plain flap

- slotted flap
    - fowler flap
    - their influence on the  $C_L - \alpha$  graph
    - their influence on the  $C_L - C_D$  graph
    - flap asymmetry
    - influence on pitch movement
  - Leading edge devices and the reasons for use in take-off and landing
    - different types:
      - Krueger flaps
      - variable camber flaps
      - slats
    - their influence on the  $C_L - \alpha$  graph
    - their influence on the  $C_L - C_D$  graph
    - slat asymmetry
    - normal/automatic operation
  - Vortex generators
    - aerodynamic principles
    - advantages
    - disadvantages
- j) Means to decrease the  $C_L - C_D$  ratio, increasing drag
- Spoilers and the reasons for use in the different phases of flight
    - different functions:
      - flight spoilers (speedbrakes)
      - ground spoilers (lift dumpers)
      - roll spoilers
      - spoiler-mixer
    - their influence on the  $C_L - \alpha$  graph
    - their influence on the  $C_L - C_D$  graph and ratio
  - Speedbrakes as a means of increasing drag and the reasons for use in the different phases of flight
    - the influence on the  $C_L - C_D$  graph ratio
- k) The boundary layer
- Different types



- laminar
- turbulent
- Their advantages and disadvantages on pressure drag and friction drag
- l) Special circumstances
  - Ice and other contamination
    - ice in stagnation point
    - ice on the surface (frost, snow, clear ice)
    - rain
    - contamination of the leading edge
    - effects on stall
    - effects on loss of controllability
    - effects on control surface movement
    - influence on high lift devices during take-off, landing and low speeds
    - affect on lift/drag ratio
  - Deformation and modification of airframe, ageing aircraft

## **2.2 Transonic Aerodynamics**

- The Mach number definition
  - speed of sound
  - influence of temperature and altitude
  - compressibility
- Normal shockwaves
  - $M_{crit}$  and exceeding  $M_{crit}$
  - Influence of:
    - mach number
    - control deflection
    - angle of attack
    - aerofoil thickness
    - angle of sweep
    - area ruling
    - $C_L - \alpha$  graph
    - $C_{Lmax}$
    - $C_D$
    - $C_L - C_D$
- Aerodynamic heating
- Shock stall / Mach buffet

- Influence on:
  - drag
  - pitch (Mach trim):
    - contribution of:
      - movement of the centre of pressure
      - angle of sweep
      - down-wash
- Buffet margin, aerodynamic ceiling
- Means to avoid the effects of exceeding  $M_{crit}$ 
  - Vortex generators
  - Supercritical profile
    - shape
    - influence of aerofoil shape on shockwaves
    - advantages and disadvantages of supercritical aerofoil

## **2.3 Stability**

### **a) Condition of equilibrium in stable horizontal flight**

- precondition for static stability
- sum of moments
  - lift and weight
  - drag and thrust
- sum of forces
  - in horizontal plane
  - in vertical plane

### **b) Methods of achieving balance**

- Wing and empennage (tail and canard)
- control surfaces
- Ballast or weight trim

### **c) Longitudinal stability**

- Basics and definitions
- Static stability, positive, neutral and negative
- precondition for dynamic stability
- dynamic stability, positive, neutral and negative
- damping:

- phugoid
- short period
  
- effect of high altitude on dynamic stability
- static stability
- neutral point/location of neutral point
  - definition
  
- Contribution of:
  - aircraft geometry
  - down-wash
    - a.c. of the wing
  
- Location of centre of gravity
  - aft limit, minimum stability margin
  - forward position
  - effects on static and dynamic stability
  
- The  $C_M - \alpha$  graph
- Contribution of:
  - location of centre of gravity
  - control deflection
  
  - major aircraft parts (wings, fuselage, tail)
  - configuration:
  - flap deflection
  - gear extension
  
- The elevator position – speed graph (IAS)
- Contribution of;
  - location of centre of gravity
  - trim (trim tab)
  - trim (stabilizer trim)
  - Mach number/Mach trim
  - friction in the system
  - down spring
  - bob weight
  
- The manoeuvring /stick force per g
  
- Contribution of:
  - location of centre of gravity
  - trim
  - down spring
  - bob weight

- Stick force per g and the limit load factor
    - category of certification
  - Special circumstances
    - ice:
      - effects of flap extension
      - effects of stabilizer ice
  - rain
  - deformation of airframe
- d) Static directional stability
- Slip angle  $\beta$
  - Yaw moment coefficient  $C_N$
  - $C_N - \beta$  graph
  - Contribution of :
    - location of centre of gravity
    - angle of sweep of the wing
    - fuselage at high angles of attack
    - strakes
    - dorsal fin and angle of sweep of fin
    - major aircraft parts
- e) Static lateral stability
- Bank angle  $\phi$
  - The roll moment coefficient  $C_L$
  - Contribution of angle of slip  $\beta$
  - The  $C_L - \beta$  graph
  - Contribution of:
    - angle of sweep of wing
    - ventral fin
    - location of the wing
    - dihedral / anhedral
  - Effective lateral stability
- f) Dynamic lateral stability
- effects of asymmetric propeller slipstream
  - Tendency to spiral dive
  - Dutch roll
    - causes
    - Mach
    - yaw damper

- Effects of altitude on dynamic stability

## **2.4 Control**

### **a) General**

- Basics, the Three Planes and Three Axis
- Camber change
- Angle of attack change

### **b) Pitch Control**

- Elevator
- Down-wash effects
- Ice on tail
- Location of centre of gravity

### **c) Yaw Control**

- Pedal/Rudder ratio changer
- Moments due to engine thrust
  - direct
  - induced
- Engine failure
  - rudder limitations at asymmetric thrust
  - meaning of  $V_{MCA}$ ,  $V_{MCG}$

### **d) Roll Control**

- Ailerons
  - inboard ailerons
  - outboard ailerons
  - function in different phases of flight
- Spoilers
- Adverse yaw
- Means to avoid adverse yaw
  - frise ailerons
  - differential aileron deflection
  - coupling ailerons to rudder by spring
  - roll spoilers
  - effects of asymmetric propeller slip stream

### **e) Interaction in different planes (yaw/roll)**

- limitations of asymmetric power

f) Means to reduce control forces

- Aerodynamic balance
  - nose balance
  - horn balances
  - internal balances
  - balance tab, anti-balance tab
  - servo tab
  - spring tab
- Artificial
  - power assisted controls
  - fully powered controls
  - artificial feel:
    - inputs:
      - dynamic pressure q
      - stabilizer setting

g) Mass Balance

- reasons to balance
- means

h) Trimming

- reasons to trim
- trim tabs
- stabilizer trim/trim rate versus IAS
  - position of centre of gravity influence on trim/stabilizer setting for take-off

**2.4** Limitations

a) Operating limitations

- flutter
- aileron reversal
- gear/flap operating
- $V_{MO}$ ,  $V_{NO}$ ,  $V_{NE}$
- $M_{MO}$

b) Manoeuvring envelope

- Manoeuvring load diagram
  - load factor

- accelerated stall speed
- $V_A$ ,  $V_C$ ,  $V_D$
- manoeuvring limit load factor/certification category
- Contribution of:
  - mass
  - altitude
  - Mach number

**c) Gust Envelope**

- Gust load diagram
  - vertical gust speeds
  - accelerated stall speed
  - $V_B$ ,  $V_C$ ,  $V_D$
  - gust limit load factor
  - $V_{RA}$
- Contribution of:
  - mass
  - altitude
  - Mach number

**2.5 Propellers**

**a) Conversion of engine torque to thrust**

- meaning of pitch
- blade twist
- fixed pitch and variable pitch/constant speed
- propeller efficiency versus speed
- effects of ice on propeller

**b) Engine failure or engine stop**

- Windmilling drag
  - influence on yaw moment when asymmetric power
- Feathering
  - influence on glide performance
  - influence on yaw moment when asymmetric power

**c) Design feature of power absorption**

- aspect ratio of blade
- diameter of propeller
- number of blades

- propeller noise
- d) Moments and couples due to propeller operation
  - Torque reaction
  - Gyroscopic precession
  - Asymmetric slipstream effect
  - Asymmetric blade effect

**2.6 Flight Mechanics**

- a) Forces action on an airplane
  - Straight horizontal steady flight
  - Straight steady climb
  - Straight steady descent
  - Straight steady glide
  - Steady coordinated turn
    - bank angle
    - load factor
    - turn radius
  - angular velocity
  - rate one turn
- b) Asymmetric Thrust
  - Moments about the vertical axis
  - Influence of bank angle
    - overbanking
    - finstall
  - Influence of aircraft weight
  - Influence of use of ailerons
  - Influence of special propeller effects on roll moments
    - propeller torque
    - propeller wash on flaps
  - Influence of slipangle on roll moments
  - $V_{MCA}$
  - $V_{MCL}$
  - $V_{MCG}$
  - Influence of altitude
- c) Emergency Descent



- Influence of configuration
  - Influence of chosen mach number and IAS
  - Typical points on polar curve
- d) Windshear