

APPENDIX 'E'

AIRCRAFT & ENGINE – TECHNICAL GENERAL

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

1. Aircraft General Knowledge

1.1 Airframe and Systems - Aeroplanes

- 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
 - Basics 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 (Aeroplane) and control surfaces, powerplant, 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) Direct Current (DC); Direct /Alternating Current (DC/AC)
 - General
 - electric circuits
 - voltage, current, resistance
 - Ohm's law
 - resistive circuits
 - resistance as a function and 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

 - Reverser 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
 - streamtube
 - 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 α
 - normal values of C_{Lmax} , α_{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 α
- 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 α
 - 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 – 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 α_{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
 - attitude (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
 - 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

- I) 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
 - 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 β
- 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 ϕ
- The roll moment coefficient C_L
- Contribution of angle of slip β
- 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 attach 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
 - frises ailerons
 - differential aileron deflection
 - coupling ailerons to ruder 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

2.5 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 slip angle 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