

SECTION 1.4 ATPL AIRCRAFT GENERAL KNOWLEDGE (AG)**Unit 1.4.1 AAGC: ATPL aircraft general knowledge – all aircraft categories****1. Reserved****2. Advanced aerodynamics**

2.1.1 Explain the following airspeeds;

- (a) IAS;
- (b) CAS;
- (c) EAS;
- (d) TAS.

2.1.2 Explain the aerodynamic forces acting on an aircraft in flight.

3. Airframe and systems**3.1 Actuating systems**

3.1.1 With reference to the basic principles of hydromechanics, explain and compare the following:

- (a) transmission of force by an incompressible fluid;
- (b) transmission of force by a compressible fluid.

3.2 Hydraulic systems

3.2.1 For the following:

- (a) describe the functioning of a typical hydraulic system comprising main, standby and emergency systems that have multiple pumps and services;
- (b) describe the purpose and function of the major components of a hydraulic system comprising:
 - (i) pumps;
 - (ii) accumulators;
 - (iii) reservoirs;
 - (iv) selector valves;
 - (v) check (one-way) valves;
- (c) recognise on a diagram the symbols for major components of a hydraulic system and be able to trace the functioning of a diagrammatic system (system detail at the level of typical operations manual diagram);
- (d) describe the typical services operated by a hydraulic system and for a typical system, how priority is allocated to certain services.

3.3 Fuel system

3.3.1 Jet fuels

- (a) Avtur (Jet A1) – difference from other fuel cuts:
 - (i) volatility;
 - (ii) additives (discussion only);
- (b) specific gravity:
 - (i) meaning;
 - (ii) variation with temperature;
 - (iii) effect of variation.

3.3.2 Carriage of fuel on aircraft

- (a) fuel tanks:
 - (i) individual tanks;

- (b) CG balance during fuel usage;
 - (c) problems:
 - (i) algae, corrosion, water content;
 - (d) need for venting.
- 3.3.3 Operation of fuel system
- (a) understand function of a typical multi-engine fuel system with multiple fuel tanks, tank-to-tank transfer;
 - (b) understand purpose/function of major components (for example, engine-driven pumps (HP/LP), fuel tank pumps, override/transfer pumps jettison pumps, fuel/oil heat exchange, vent lines, single-point refuelling);
 - (c) recognise on diagrams the symbols for major components and be able to trace the functioning off a diagrammatic system (system details at level of flight manual diagrams);
 - (d) understand suction feed/transfer as backup for pressure feed/transfer.
- 3.3.4 Operational considerations
- (a) fuel temperature (max/min):
 - (i) need for fuel heating (oil, bleed air);
 - (b) cooling/lubrication of pumps;
 - (c) cooling of oil/hydraulic systems:
 - (i) effect of fuel flow rates;
 - (d) minimum fuel level:
 - (i) pick-up for delivery to engine;
 - (ii) maintain oil/hydraulic cooling;
 - (iii) effects of aircraft attitude;
 - (iv) fuel jettison.
- 3.3.5 Fuel system monitoring
- (a) gauges:
 - (i) fuel contents, flow meters;
 - (ii) effect of check angle;
 - (iii) likely errors;
 - (b) warning systems;
 - (i) low fuel level, low pressure warning;
 - (c) measurement of tank contents:
 - (i) dipstick/dripstick/floatsticks;
 - (ii) importance of having aircraft level;
 - (iii) precautions in use.

3.4 Electrical systems

3.4.1 Selected components

- (a) bus:
 - (i) concept of a bus;
 - (ii) common terminology:

hot bus, emergency bus, essential bus.

- (b) circuit breaker:
 - (i) function, precautions if resetting;
 - (ii) multiple CB panels – need for identification;
 - (iii) grid system of nomenclature (for example, CB G22 on P3 panel);
- (c) battery:
 - (i) types of high performance batteries in common use;

- (ii) charge/discharge characteristics;
 - (iii) precautions needed;
 - (d) AC generation:
 - (i) advantages of AC versus DC;
 - (ii) types of generator:
 - (A) permanent magnet generator;
 - (B) field excitation generator;
 - (C) differences between them;
 - (iii) constant speed drive:
 - (A) purpose;
 - (B) disconnecting drive;
 - (e) TR unit:
 - (i) purpose;
 - (ii) function of diodes/RCRs;
 - (f) power distribution:
 - (i) connecting generator to a bus;
 - (ii) connecting multiple generators to bus system:
 - (A) split buses;
 - (B) paralleling generators;
 - (iii) priority supplies in event of partial failure.
- 3.4.2 Operation of electrical system
- (a) functioning of a typical AC-based electrical system with multiple generators, multiple AC and DC buses, APU and GPU;
 - (b) recognise on a diagram the symbols for the major components, and be able to trace the functioning of the diagrammatic system. (system detail at the level of typical Operations Manager diagram).
- 3.4.3 The aircraft structure as an electrical conductor.

4. Power plants – turbine engine

4.1 Theory of thrust

- 4.1.1 Explain the thrust formula for turbine engines and for thrust, state the functional relationship between airspeed, air density, pressure and temperature, and RPM.

4.2 Principle of operation

- 4.2.1 Describe the basic principles of jet propulsion theory with reference to the following:
 - (a) working cycle:
 - (i) gas flow;
 - (ii) changes in velocity, pressure, temperature;
 - (iii) engine pressure ratio;
 - (b) the differences and advantages of the following types of engine:
 - (i) centrifugal flow;
 - (ii) axial flow.

5. Engine instruments

5.1 Displays

- 5.1.1 Describe the basic features of the following commonly available types of displays:
 - (a) pointer-and-dial;
 - (b) vertical strip;

- (c) EICAS.
- 5.1.2 Explain the purpose of monitoring engine parameters in regards to the following:
 - (a) comparison of engine performance;
 - (b) trends;
 - (c) identification of malfunctions/failures.
- 5.1.3 In relation to identifying an engine gauge with its engine:
 - (a) explain the desirability of being able to rapidly identify the correct gauge engine combination; and
 - (b) give examples of good/bad instrumentation layouts; and
 - (c) describe the consequence of engine misidentification.

6. Flight instrumentation systems

6.1 Application of computers used in aircraft

- 6.1.1 Describe how the following computer-based systems and technologies are used in aircraft:
 - (a) flight management systems;
 - (b) performance management systems;
 - (c) fly-by-wire aircraft.

6.2 Electronic flight instrument system (EFIS)

- 6.2.1 In relation to EFIS:
 - (a) describe the advantages of EFIS compared to conventional system; and
 - (b) list typical inputs and outputs; and
 - (c) describe typical data inputs; and
 - (d) describe typical control panels and display units; and
 - (e) provide examples of typical aircraft installation.

6.3 Flight management system (FMS)

- 6.3.1 In relation to a typical FMS:
 - (a) describe the advantages of FMS compared to conventional system; and
 - (b) explain the general principles of operation; and
 - (c) list the typical inputs and outputs; and
 - (d) describe typical control panel and display units; and
 - (e) provide examples of typical aircraft installations.

6.4 Total air temperature (TAT) gauge

- 6.4.1 In relation to TAT:
 - (a) explain the purpose and operation of TAT gauges and the following terms:
 - (i) ram rise;
 - (ii) recovery factor; and
 - (b) describe typical indicators of a TAT gauge in relation to malfunctions.

7. Warning and recording equipment

7.1 Ground Proximity Warning Systems (GPWS)

- 7.1.1 In relation to typical GPWS:
 - (a) explain the purpose and operation of GPWS; and
 - (b) describe the modes of operation and operating envelopes; and
 - (c) describe hard and soft aural and visual warnings; and
 - (d) list the typical inputs and outputs; and

- (e) describe the limitations and restrictions in function and use; and
- (f) describe typical GPWS displays and control panels.

7.2 Airborne Collision Avoidance System (ACAS)

- 7.2.1 Explain the basic concepts of ACAS operation.
- 7.2.2 Describe the effect on ACAS operation for each mode of operation that can be selected on the TCAS/Transponder control panel selected by the flight crew.
- 7.2.3 Describe the limitation of ACAS for tracking aircraft fitted with Mode A/C transponders.
- 7.2.4 Describe the range of the altitude band in which traffic are displayed in normal operation.
- 7.2.5 Explain the traffic display visual symbology used to determine the possibility of conflict with other aircraft and associated aural warnings.
- 7.2.6 Describe how 'proximate' aircraft are displayed on the traffic display.
- 7.2.7 Describe the aural and visual alerts for the following:
 - (a) 'intruder' aircraft;
 - (b) 'threat' aircraft.
- 7.2.8 Describe pilot actions in response to the following:
 - (a) ACAS Traffic Advisory (TA) alert;
 - (b) ACAS Resolution Advisory (RA) alerts.
- 7.2.9 State the standard phraseology pilots should use to communicate with ATC in the following cases:
 - (a) in response to an ACAS RA alert;
 - (b) on cessation of a RA alert.
- 7.2.10 Explain the requirements for complying with ACAS RA instructions as overriding Air traffic Control (ATC) directions.
- 7.2.11 Describe the reporting/notification obligations when ACAS alerts are generated.

7.3 Digital Flight Data Recorder (DFDR)

- 7.3.1 In relation to a typical DFDR system:
 - (a) explain the purpose and function of DFDR; and
 - (b) describe the typical data coverage available; and
 - (c) describe the physical appearance of a set of gauges of typical recorder and recorded data.

7.4 Health Usage Monitoring System (HUMS)

- 7.4.1 Explain the purpose and function of HUMS, including the following:
 - (a) actuation;
 - (b) down loading.

7.5 Cockpit Voice Recorder (CVR)

- 7.5.1 In relation to a typical CVR system:
 - (a) explain the purpose and function of a CVR; and
 - (b) describe a typical audio/radio channel coverage available in a multi-seat flight deck environment; and
 - (c) describe the physical appearance of a set of gauges of a typical recorder and control panel.

7.6 Master Warning Systems (MWS)

- 7.6.1 In relation to a typical MWS:
 - (a) explain the purpose and function of the system; and
 - (b) describe the typical warning systems incorporated or covered by a MWS; and

- (c) describe the aural and visual outputs for the following:
 - (i) warnings;
 - (ii) cautions;
- (d) describe the features of a typical displays;
- (e) explain take-off inhibiting of MWS outputs.

7.7 Fire Detection, Warning, Extinguishing Systems

- 7.7.1 Describe the following in relation to fire detection, warning and extinguishing systems:
- (a) types of systems commonly used in aircraft; and
 - (b) typical warnings; and
 - (c) system limitations; and
 - (d) actuation mechanisms; and
 - (e) effects.

8. Global Navigation Satellite Systems

8.1 GNSS operation

- 8.1.1 For the following, describe:
- (a) the principles of operation, performance limitations and errors of a GNSS system, including:
 - (i) methods of position fixing using a GNSS system;
 - (ii) the GNSS operating procedures which provide safeguards against navigational error and loss of situational awareness;
 - (iii) GNSS operating procedures for typical navigational tasks using a specific type of aircraft equipment;
 - (iv) indications of waypoint passage;
 - (v) GNSS operational and serviceability checks;
 - (vi) the human factors limitations associated with the use of GNSS equipment;
 - (vii) the requirements applicable to pilots and equipment for GNSS operations.

Unit 1.4.2 AAGA: ATPL aircraft general knowledge – aeroplane**1. Reserved****2. Advanced aerodynamics****2.1 Review of terminology**

2.1.1 Definitions

- (a) Mach No;
- (b) reference speeds, including M_{CRIT} , V_{MO} , M_{MO} , V_S .

2.2 Aerodynamic forces

- (a) review forces acting in flight;
- (b) balance of forces in trimmed asymmetric flight;
- (c) V_{MCA} and V_{MCG} .

2.3 Shock waves

- (a) reasons for their formation at subsonic speeds;
- (b) their effect on the handling and operation of the aircraft;
- (c) high-speed buffet and its possible similarity to low-speed buffet and speedbrake buffet.

2.4 Performance and speed

- (a) manoeuvring and gust envelope;
- (b) changes to C_L and C_D with increasing speed at constant angle of attack;
- (c) performance degradation, the effect of Mach drag on thrust required and fuel flow;
- (d) aileron reversal;
- (e) effects of wing sweep back;
- (f) maximising low-speed performance (use windshear on take-off as discussion case).

2.5 Performance and altitude

- (a) effect of high altitude on:
 - (i) buffet boundaries;
 - (ii) stall and stability;
 - (iii) manoeuvring capability (inertia effects);
- (b) stall and V_{MCA} considerations with engine failure at high altitude.

3. Airframe and systems**3.1 Flight controls**

3.1.1 Review flight controls

- (a) primary flight controls:
 - (i) ailerons; and
 - (ii) elevators; and
 - (iii) rudder;
- (b) secondary flight controls:
 - (i) spoilers/airbrakes;
 - (ii) trim systems;
 - (iii) flying tail, stabiliser trim.

3.1.2 Leading edge flaps

- (a) review trailing edge flaps;
- (b) leading edge flaps/devices:
 - (i) purpose/function of leading edge flaps;

- (ii) types in common use;
- (iii) typical interconnection with trailing edge flaps;
- (c) common methods of operation:
 - (i) hydraulic;
 - (ii) electric;
 - (iii) pneumatic (outline knowledge only is required; actuating systems are at later section).

3.1.3 Powered controls

- (a) methods of transmitting demand to control surfaces;
- (b) feedback;
- (c) feel, natural or artificial;
- (d) possibility or availability of manual reversion.

3.2 Landing gear

3.2.1 Wheel systems

- (a) arrangements:
 - (i) multi-wheel;
 - (ii) bogie wheel;
 - (iii) effects on PCN/ACN;
- (b) main components;
- (c) brief outline of typical retract/extend operation:
 - (i) normal, alternate, emergency operation;
 - (ii) landing gear doors may be disabled under some conditions.

3.2.2 Wheels and tyres

- (a) wheels and brake energy limits, thermal plugs;
- (b) cooling charts, minimum turn-around times.

3.2.3 Braking systems

- (a) typical multi-wheel systems:
 - (i) typical sources of power for normal, alternate, emergency use;
 - (A) hydraulic supply and back-up;
 - (B) emergency air bottles.
- (b) parking brake;
- (c) principles of operations/limitations of:
 - (i) anti-skid system;
 - (ii) auto brake system.

3.2.4 Hydroplaning

- (a) cause and effect;
- (b) factors affecting hydroplaning, including speed formulae.

3.2.5 Steering systems

- (a) types available:
 - (i) rudder pedal steering;
 - (ii) hand/wheel/tiller steering;
 - (iii) body-gear steering on some aircraft;
- (b) degree of steering commonly available with each:
 - (i) understand that some steering systems are incompatible with asymmetric brake and/or power, while others are improved by them.

3.3 Actuating systems

- 3.3.1 Pneumatic systems
 - (a) basic system knowledge as for hydraulics;
 - (b) compare system differences with hydraulic system;
 - (c) compare operating differences with hydraulic system;
 - (i) speed of response;
 - (ii) force available;
 - (iii) supply of operating fluid;
 - (iv) weight of system.

3.4 Airconditioning and pressurisation

- 3.4.1 Typical air supply system
 - (a) power sources:
 - (i) engine driven compressors;
 - (ii) bleed air:
 - (A) gas turbine compressor;
 - (B) turbo charger compressor;
 - (b) typical services provided;
 - (c) availability of services;
 - (d) possibility of limitations under take-off or asymmetric power conditions, or during engine start.
- 3.4.2 Airconditioning system
 - (a) types of systems:
 - (i) freon;
 - (ii) air cycle machine;
 - (b) brief outline of operation of system;
 - (i) single zone cabin;
 - (ii) multiple zones;
 - (c) purpose of/necessity for humidifiers.
- 3.4.3 Pressurisation system
 - (a) terminology:
 - (i) cabin altitude, differential pressure;
 - (b) brief outline of operation of typical system:
 - (i) supply;
 - (ii) outflow valves;
 - (iii) overpressure and negative pressure relief;
 - (iv) control of cabin altitude and rate (no detail of internal mechanism of controller required);
 - (c) normal pressurised zones in the aircraft;
 - (d) rapid decompression, cabin altitude warning.

3.5 Ice and rain protection

- 3.5.1 Distinction between anti-ice and de-ice system.
- 3.5.2 Pneumatic systems (brief coverage only)
 - (a) where used:
 - (i) leading edges;
 - (b) limitations.
- 3.5.3 Thermal ice protection
 - (a) where used:

- (i) propellers, flying surfaces, air intakes, pitot and other sensors, windshields;
 - (b) methods:
 - (i) electrical, air, oil;
 - (c) limitations.
- 3.5.4 Fluid ice protection
- (a) where used:
 - (i) inflight leading edge of flying surfaces, propellers, windshield;
 - (ii) ground de-icing;
 - (b) limitations.
- 3.5.5 Rain removal from windscreen
- (a) methods:
 - (i) wipers;
 - (ii) fluid dispersant;
 - (iii) air jets.
- 3.5.6 Effects on aeroplane performance (discussion only)
- (a) ice accumulations;
 - (b) use of ice control systems.

3.6 Fuel system

- 3.6.1 Carriage of fuel on aircraft
- (a) structural consequences:
 - (i) wing bending;
 - (ii) zero-fuel weight;
 - (iii) CG movement;
 - (b) understand suction feed and gravity feed/transfer as backup for pressure feed/transfer.
- 3.6.2 Operational considerations
- (a) minimum fuel levels:
 - (i) pick-up for delivery to engine;
 - (ii) maintain oil/hydraulic cooling;
 - (iii) effect of aircraft attitude (for example, missed approach);
 - (b) fuel jettison:
 - (i) legislation;
 - (ii) precautions to be observed;
 - (iii) minimum fuel after jettison (stand-pipes).

4. Power plants – turbine engine

4.1 Principle of operation

- (a) types of engine:
 - (i) differences and advantages;
 - (ii) bypass ratio;
- (b) turboprop:
 - (i) advantages and limitations/problems.

4.2 Engine constructions

- (a) intake (subsonic only):
 - (i) location on airframe relative to free-stream airflow;
 - (ii) location relative to engine (for example, B727 centre engine);
 - (iii) vulnerability to icing;

- (b) compressor:
 - (i) purpose/function of compressor;
 - (ii) centrifugal;
 - (A) single/multiple;
 - (iii) axial;
 - (A) single/twin;
 - (iv) inlet guide vanes;
 - (v) vulnerability to icing;
 - (vi) bleed air provisions;
 - (vii) compressor stalling:
 - (A) causes, symptoms, avoidance;
 - (B) unloading compressor during start;
- (c) fan:
 - (i) purpose and function of fan;
 - (ii) relationship to compressor;
 - (iii) inlet guide vanes;
 - (iv) reverse thrust;
- (d) combustion system:
 - (i) purpose and function of combustion system;
 - (ii) combustion chamber:
 - (A) individual;
 - (B) annular;
 - (iii) fuel injectors;
 - (iv) igniters;
 - (v) air/fuel ratios;
- (e) turbine:
 - (i) purpose/function of turbine;
 - (ii) single, twin, and triple turbines:
 - (A) for example, driving two-stage compressor with fan;
 - (iii) thermal and mechanical stress;
 - (iv) effects of damage;
 - (v) monitoring turbine temperature:
 - (A) desired to monitor inlet temperature;
 - (B) difficulties/compromise in monitoring;
 - (C) terminology – EGT, TGT, TIT;
 - (vi) reverse thrust mechanisms:
 - (A) cascade, buckets;
 - (B) safety interlocks;
- (f) exhaust:
 - (i) purpose and function of exhaust;
 - (ii) sources of noise;
 - (iii) hushkits.

4.3 Turbo-prop

- (a) drive train from engine:
 - (i) flight range; and
 - (ii) ground range;
- (b) control of propeller:

- (i) variable speed engine;
- (ii) constant speed engine;
- (c) reverse thrust:
 - (i) concept of zero thrust;
- (d) feathering;
- (e) propeller brake.

4.4 Auxiliary power unit (APU)

- (a) purpose/function of APU;
- (b) types commonly available;
- (c) outputs available;
- (d) availability determined by AFM:
 - (i) use in flight;
 - (ii) start in flight;
 - (iii) outputs available in flight.

4.5 Operational considerations

- (a) use of reverse thrust:
 - (i) effectiveness with decreasing speed;
 - (ii) instability of airflow in reverse at low ground speeds;
 - (iii) monitoring and precautions;
 - (iv) deliberate or inadvertent use in flight (where not permitted by AFM);
- (b) use of bleed air:
 - (i) effect on thrust and performance;
 - (ii) engine indications:
 - (A) EGT;
 - (B) RPM;
 - (C) EPR.

4.6 Engine starting

- (a) air-driven starters:
 - (i) characteristics;
 - (ii) sources of air;
 - (iii) failure to disconnect;
- (b) critical engine RPM:
 - (i) initiating fuel flow/ignition;
 - (ii) self-sustaining RPM;
 - (iii) stable idle;
- (c) typical engine start sequence;
- (d) typical start malfunctions:
 - (i) cause and remedy for each of the following:
 - (A) fails to light off;
 - (B) hot start;
 - (C) hung start;
 - (D) fails to stabilise at idle;
 - (E) starter fails to disengage;
 - (F) torching/tailpipe fire.

5. Engine instruments

5.1 EPR gauge

- (a) inputs;
- (b) displays:
 - (i) analogue and digital readout;
 - (ii) setting target EPR:
 - (A) manual and auto settings;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.2 Torque meter

- (a) inputs and methods of functioning;
- (b) types of indicators and units of torque;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.3 RPM indicator

- (a) types of display:
 - (i) RPM or percentage;
 - (ii) 100% not necessarily a limit and markings;
- (b) multiple RPM displays – N1, N2, N3:
 - (i) conventional order of numbering;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.4 Turbine temperature indicator

- (a) types of display:
 - (i) analogue;
 - (ii) digital;
- (b) overtemp warnings;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.5 Fuel consumption

- (a) flowmeters:
 - (i) analogue and digital indications;
 - (ii) importance on start-up and shutdown;
- (b) fuel-used gauges:
 - (i) may be separate or incorporated with flowmeter;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

6. Automatic flight control system (AFCS)**6.1 Autopilot (AP)**

- (a) purpose/function of AP;
- (b) common types (different axes);
- (c) components;
- (d) typical heavy aircraft AP controller;
- (e) command and manual modes, including typical submodes:
 - (i) ALT/HDG/IAS/MACH/VS hold;
 - (ii) VORLOC/ILS/INS tracking;
 - (iii) FMS coupling;
 - (iv) autoland and auto-go-around;
- (f) typical limitations/restrictions.

6.2 Flight Director (FD)

- (a) purpose/function of FD;

- (b) common types of presentation:
 - (i) V-bars;
 - (ii) cross-bars;
- (c) typical components;
- (d) typical heavy aircraft FD controller;
- (e) typical modes of operation; mode indicator.

6.3 Auto-throttle (AT)

- (a) purpose/function of AT;
- (b) typical modes of operation:
 - (i) thrust hold;
 - (ii) speed hold;
 - (iii) VNAV coupling;
- (c) auto-derate of take-off power;
- (d) typical engage/disengage/go-around controls;
- (e) typical limitations/restrictions.

6.4 Autoflight

- (a) relationship between AT, FD and AP;
- (b) relationship between FMS and AT/FD/AP;
- (c) redundancy requirements for autoland.

6.5 Flight envelope protection in autoflight

- (a) types for protection available:
 - (i) high speed; low speed;
 - (ii) alpha floor;
 - (iii) flap/gear speed protection;
- (b) functioning of typical system:
 - (i) inputs; and
 - (ii) outputs;
- (c) modified functioning during flare and touchdown;
- (d) alternate law, reversionary modes.

6.6 Associated autosystems

- (a) yaw damper:
 - (i) purpose and function of yaw damper:
 - (A) typical low and high speed behaviour requiring installation of yaw damper;
 - (ii) method of functioning:
 - (A) input and output;
 - (iii) series and parallel types;
 - (A) advantages and disadvantages of each type;
 - (iv) typical yaw damper controls;
- (b) automatic pitch trim:
 - (i) purpose and function of auto-trim;
 - (ii) input and output;
 - (iii) typical auto-trim controls;
- (c) thrust computation:
 - (i) purpose and function of thrust computation system;
 - (ii) input and output;
 - (iii) relationship to FMS.

7. Warning and recording equipment**7.1 Overspeed Warning System**

- (a) components:
 - (i) inputs; and
 - (ii) outputs;
- (b) may be selectable according to weight/CG/fuel distribution;
- (c) typical selectors and warning indicators:
 - (i) aural warnings; and
 - (ii) visual warnings.

7.2 Stall Warning

- (a) purpose/function of system;
- (b) components of a typical heavy aircraft system:
 - (i) ADC inputs, including AOA;
 - (ii) stick shaker and pusher;
 - (iii) visual and aural warnings.

7.3 Take-off Warning System (TWS)

- (a) Purpose and function of TWS;
- (b) typical items monitored;
- (c) aural/visual warnings.

Unit 1.4.3 AAGH: ATPL aircraft general knowledge – helicopter**1. Reserved****2. Advanced aerodynamics****2.1 Review of terminology**

2.1.1 Definitions

- (a) reference speeds, including V_{TOSS} , CDP, landing decision point (LDP);
- (b) define; tip path, tip path plane, axis of rotation, shaft axis, disc area, chord line, pitch angle, angle of attack, coning angle, feathering, feathering axis, disc loading, blade loading, solidity, flapping, dragging, teetering rotor, articulated rotor, semi rigid rotor.

2.1.2 Aerodynamic forces

- (a) Effect of RAF on angle of attack, induced airflow and effects, total reaction, rotor thrust, torque, torque reaction, rotor thrust/rotor drag ratio, forces opposing weight, factors influencing rotor thrust, Bernoulli's theorem, Hookes joint effect.

2.1.3 Stability

- (a) static and dynamic stability;
- (b) stability during hover;
- (c) stability during forward flight;
- (d) effect of off-set flapping hinges;
- (e) effect of stabiliser bar;
- (f) effect of centre of gravity (CG);
- (g) effects of altitude and speed on stability;
- (h) effect of horizontal stabilizer.

2.1.4 Forward flight

- (a) arrangement of forces and effects of CG position;
- (b) basic aspects-tilting the disc through cyclic;
- (c) dissymmetry of lift, dissymmetry lift elimination through flapping;
- (d) flapback, designs to reduce flapping amplitude, Delta-3 hinge, offset pitch horn;
- (e) reverse flow, transitional lift, inflow roll.

2.1.5 Climbing and descending

- (a) forces in a vertical climb;
- (b) horse power available (HPAV) curve and factors affecting the HPAV: altitude, DA, collective setting;
- (c) rate and angle of climb and relationship to HPAV and horse power required (HPREQ) curve;
- (d) effect of wind, altitude, and sling loads on rate and angle of climb;
- (e) forces in a vertical descent;
- (f) over pitching;
- (g) rate and angle of descent and relationship to HPAV and HPREQ curves;
- (h) effect of wind, all up weight (AUW), altitude and sling loads on rate and angle of descent.

2.1.6 Hovering

- (a) definition;
- (b) hover in and out of ground effect (IGE, OGE);
- (c) factors affecting ground effect, height, DA, AUW, nature of surface, slope, wind, recirculation.

2.1.7 Turning

- (a) centripetal force and angle of bank;

- (b) rate and radius of turn, relationship of angle of bank;
 - (c) steep turn, load factor, power requirement;
 - (d) forces in climbing and descending turns;
 - (e) effect of attitude and bank angle on rate and radius of turn;
 - (f) effect of AUW on rate/radius;
 - (g) effect of wind when turning around a ground feature;
 - (h) effects of slipping and skidding.
- 2.1.8 Autorotation
- (a) definition;
 - (b) autorotative forces/drag;
 - (c) effects of airflow on vertical autorotation;
 - (d) effects of airflow on forward autorotation;
 - (e) rate of descent requirements for autorotation:
 - (i) minimum rate of descent, maximum air range;
 - (f) effect of weight, altitude, temperature.
- 2.1.9 Rotor blades
- (a) feathering, taper, washout, lift distribution;
 - (b) flapping, flapping to equality;
 - (c) dragging;
 - (d) changing blade CG;
 - (e) limits of rotor RPM.
- 2.1.10 Tail rotor
- (a) principles of operation – pitch control;
 - (b) primary and additional purpose;
 - (c) auto rotation;
 - (d) tail rotor drift;
 - (e) tail rotor roll;
 - (f) tail rotor flapping, shrouded rotors.
- 2.1.11 Ground resonance
- (a) definition;
 - (b) causes of ground resonance;
 - (c) recovery action.
- 2.1.12 Vortex ring state
- (a) how vortex rings develop;
 - (b) effect of ROD-flow and tip vortex action on rotor thrust;
 - (c) effects of power and airspeed on vortex ring state;
 - (d) flight conditions leading to vortex ring state;
 - (e) tail rotor vortex ring state;
 - (f) loss of tail rotor effectiveness (LTE).
- 2.1.13 Retreating blade stall
- (a) conditions which could cause retreating blade stall;
 - (b) effect of reverse flow, effect of airspeed on stall angle;
 - (c) factors effecting the advancing blade;
 - (d) symptoms and recovery from retreating blade stall;
 - (e) methods to minimize retreating blade stall (swept tips);
 - (f) effect of altitude on VNE.

- (g) forward speed limiting factors.
- 2.1.14 Blade sailing, dynamic roll-over, mast bumping
 - (a) definitions;
 - (b) cause of blade sailing and prevention;
 - (c) forces in dynamic roll-over;
 - (d) avoidance of dynamic roll-over;
 - (e) factors effecting mast bumping/flapping amplitude;
 - (f) avoidance of mast bumping.

3. Airframe and systems

3.1 Flight controls

- 3.1.1 Review flight controls:
 - (a) primary flight controls;
 - (i) pitch and roll (cyclic), yaw, collective;
 - (ii) trim systems;
 - (iii) canted tail rotor;
 - (iv) sweep back on tips;
 - (v) shrouded tail rotor.
- 3.1.2 Aerodynamic enhancements:
 - (a) canted tail rotor;
 - (b) sweep back on tips;
 - (c) shrouded tail rotor;
 - (d) tail surfaces, fins, end plates, stabilators.
- 3.1.3 Powered controls:
 - (a) methods of transmitting demand to control surfaces;
 - (b) feedback;
 - (c) natural and artificial feel;
 - (d) possibility/availability of manual reversion.

3.2 Airconditioning

- 3.2.1 Typical air supply system:
 - (a) power sources:
 - (i) engine, transmission, driven compressor;
 - (ii) bleed air;
 - (iii) gas turbine compressor;
 - (iv) turbo-charger compressor;
 - (b) typical services provided;
 - (c) availability of services:
 - (i) possibility of limitations during take-off and landing or during engine start.
- 3.2.2 Airconditioning system
 - (a) types of systems:
 - (i) freon;
 - (ii) air cycle machine;
 - (b) brief outline of operation of system:
 - (i) single zone; and
 - (ii) multi-zone;
 - (c) purpose and need for humidifier.

3.3 Ice and rain protection

- 3.3.1 Distinction between anti-ice and de-ice systems.

3.4 Landing gear

- 3.4.1 Wheel systems

- (a) main components;
- (b) brief outline of typical retract and extend operation:
 - (i) normal operation;
 - (ii) alternative operation;
 - (iii) emergency operation.

- 3.4.2 Wheels and tyres

- (a) Wheel and brake energy limits.

- 3.4.3 Braking systems

- (a) typical systems;
- (b) typical sources of power for normal, alternate and emergency systems -hydraulic supply and backup emergency air bottles;
- (c) parking brake.

- 3.4.4 Steering systems

- (a) types available:
 - (i) tail rotor steering (pedals);
 - (ii) differential braking;
- (b) degree of steering available with each-possibility of rollover.

3.5 Actuating systems

- 3.5.1 Basic principles of hydromechanics

- (a) principle of transmission of force by an incompressible fluid;
- (b) brief comparison with use of a compressible fluid.

- 3.5.2 Thermal ice protection

- (a) where used:
 - (i) flying surfaces;
 - (ii) air intakes;
 - (iii) pitot and other sensors;
 - (iv) windshields;
- (b) methods:
 - (i) electric;
 - (ii) air;
 - (iii) oil;
- (c) limitations.

- 3.5.3 Fluid ice protection

- (a) where used:
 - (i) ground de-icing;
- (b) limitations.

- 3.5.4 Rain removal from windscreen

- (a) wipers.

- 3.5.5 Effects on helicopter performance

- (a) ice accumulation;
- (b) use of engine air bleed ice control systems.

4. Power plants – turbine engine

4.1 Engine design

- (a) types of engine:
 - (i) differences and advantages;
 - (ii) centrifugal flow;
 - (iii) axial flow;
 - (iv) bypass engine;
 - (v) bypass ratio;
- (b) power train:
 - (i) fixed shaft – 'clutch';
 - (ii) free power turbine;
 - (iii) twin pack, combining gear box;
 - (iv) torque sharing.

4.2 Engine construction

- (a) intake:
 - (i) purpose and /function of intake;
 - (ii) location relative to engine;
 - (iii) vulnerability to icing;
- (b) compressor:
 - (i) purpose and function of compressor;
 - (ii) centrifugal, axial;
 - (iii) single, twin, and multiple:
 - (A) inlet guide vanes;
 - (B) vulnerability to icing;
 - (C) bleed air provisions;
 - (D) compressor stalling;
 - (iv) causes, symptoms, avoidance;
 - (v) unloading compressor during start.
- (c) combustion system:
 - (i) purpose (function of combustion system);
 - (ii) combustion chamber;
 - (iii) individual/annular:
 - (A) fuel injectors;
 - (B) igniters;
 - (C) air/fuel ratios.
- (d) turbine:
 - (i) purpose/function of turbine;
 - (ii) thermal and mechanical stress;
 - (iii) effects of damage;
 - (iv) monitoring turbine temperature;
 - (v) need to monitor inlet temperature;
 - (vi) difficulties/compromise in monitoring;
 - (vii) terminology – TIT, ITT, TGT, etc.
- (e) exhaust:
 - (i) purpose/function of exhaust;
 - (ii) sources of noise;

- (iii) EGT, JPT;
- (f) torque measuring/torque sharing:
 - (i) governor inputs.

4.3 Auxiliary power unit (APU)

- (a) purpose/function of APU;
- (b) types commonly available;
- (c) outputs available;
- (d) availability determined by AFM:
 - (i) use in flight;
 - (ii) start in flight;
 - (iii) outputs available in flight.

4.4 Operational considerations

- (a) use of bleed air;
 - (i) effect on performance;
 - (ii) engine indications;
 - (iii) EGT, RPM.

4.5 Engine starting

- (a) electrical starters;
 - (i) source of power;
 - (ii) cross tie requirements;
- (b) critical engine RPM:
 - (i) initiating fuel flow/ignition;
 - (ii) self-sustaining RPM;
 - (iii) stable idle;
- (c) typical engine start sequences;
- (d) typical start malfunctions:
 - (i) cause and remedy;
 - (ii) fails to light off;
 - (iii) hot start;
 - (iv) hung start;
 - (v) fails to stabilise at idle;
 - (vi) starter fails to disengage;
 - (vii) torching/tailpipe fire;
- (e) starter/generator:
 - (i) principle of operation and function.

5. Engine instruments

5.1 Torque meter

- (a) inputs and methods of functioning;
- (b) types of indicators and units of torque;
- (c) typical appearance of a set of gauges in a modern multi-engine helicopter.

5.2 RPM indicator

- (a) types of display:
 - (i) RPM, percent;
 - (ii) 100% not necessarily a limit-biasing;
- (b) multiple RPM displays – N1, N2, NR:

- (i) conventional order of numbering;
- (c) typical appearance of a set of gauges in a modern multi-engine helicopter.

5.3 Temperature indicator

- (a) types of display:
 - (i) analogue/digital;
- (b) over temperature warnings;
- (c) typical appearance of a set of gauges in a modern multi-engine helicopter.

5.4 Fuel consumption

- (a) flow meters:
 - (i) analogue/digital indications;
 - (ii) importance on start-up and shutdown;
- (b) fuel-used gauges:
 - (i) may be separate or incorporated with flow meter;
- (c) typical appearance of a set of gauges in a modern multi-engine helicopter.

5.5 Inflight tracking

- 5.5.1 Principles of operation.

5.6 Monitoring systems

- (a) indicators, units;
- (b) warning systems;
- (c) mechanical and electrical remote signal transmission systems;
- (d) HUMS operation and indication.

6. Stability augmentation and autoflight control, system (AFCS)

6.1 AFCS

- (a) purpose/function of AP:
 - (i) common types (different axes)/inputs;
 - (ii) pitch;
 - (iii) collective;
 - (iv) other;
- (b) components;
- (c) typical AP controller;
- (d) command and manual modes:
 - (i) typical submodes;
 - (ii) Stability Augmentation System (SAS);
 - (iii) attitude retention system (ARS/ATT);
 - (iv) ALT/HDG/IAS hold;
 - (v) VOR/LOC/ILS/INS/GNSSGNSS tracking;
 - (vi) FMS coupling;
 - (vii) auto hover;
- (e) typical limitations/restrictions.

6.2 Flight director (FD)

- (a) purpose/function of FD;
- (b) common types of presentation:
 - (i) V-bars;
 - (ii) cross-bars;

- (c) typical components;
- (d) typical FD controller;
- (e) typical modes of operation:
 - (i) mode indicator.

6.3 Autoflight

- (a) relationship between FD and AP;
- (b) relationship between FMS and FD/AP;
- (c) redundancy requirements.

7. Warning and recording equipment

7.1 Auto Voice Activated Decision System (AVADS)

- (a) AVADS:
 - (i) principles of operation;
 - (ii) warnings;
 - (iii) limitations.

7.2 Rotor overspeed and underspeed warning system components

- (a) inputs;
- (b) outputs.

7.3 Health Usage Monitoring System (HUMS)

- (a) actuation;
- (b) down loading.

Unit 1.4.4 AAGP: ATPL aircraft general knowledge – powered-lift – *Reserved*

Unit 1.4.5 FAGC: FE aircraft general knowledge – all categories**1. Reserved****2. Advanced aerodynamics****2.1 Terminology**

2.1.1 Definitions

- (a) Mach No;
- (b) reference speeds, including MCRIT, VMO, MMO, Vs.

2.2 Aerodynamic forces

- (a) forces acting in flight;
- (b) V_{MCA} and V_{MCG} .

2.3 Shock waves

- (a) reasons for their formation at subsonic speeds;
- (b) their effect on the handling and operation of the aircraft;
- (c) high-speed buffet and its possible similarity to low-speed buffet and speedbrake buffet.

2.4 Performance and speed

- 2.4.1 performance degradation, the effect of Mach drag on thrust required and fuel flow.

3. Airframe and systems**3.1 Flight Controls**

3.1.1 Review flight controls:

- (a) primary flight controls:
 - (i) ailerons, elevators, rudder;
- (b) secondary flight controls:
 - (i) spoilers/airbrakes;
 - (ii) trim systems:

flying tail, stabiliser trim.

3.1.2 Leading edge flaps:

- (a) review trailing edge flaps;
- (b) leading edge flaps/devices:
 - (i) purpose/function of LE flaps;
 - (ii) types in common use;
 - (iii) typical interconnection with TE flaps;
- (c) common methods of operation:
 - (i) hydraulic, electric, pneumatic (outline only; actuating systems are at later section).

3.1.3 Powered controls:

- (a) methods of transmitting demand to control surfaces;
- (b) feedback;
- (c) feel, natural/artificial;
- (d) possibility/availability of manual reversion.

3.2 Landing gear

3.2.1 Wheel systems;

- (a) arrangements:
 - (i) multi-wheel;

- (ii) bogie wheel;
 - (iii) effects on PCN/CAN;
- (b) main components;
- (c) brief outline of typical retract/extend operation:
 - (i) normal, alternate, emergency operation;
 - (ii) LG doors may be disabled under some conditions;

3.2.2 Wheels and tyres

- (a) wheels and brake energy limits, thermal plugs;
- (b) cooling charts, minimum turn-around times.

3.2.3 Braking systems

- (a) typical multi-wheel systems:
 - (i) typical sources of power for normal, alternate, emergency use:
 - (A) hydraulic supply and back-up;

emergency air bottles.

- (b) parking brake;
- (c) principles of operations/limitations of:
 - (i) anti skid system;
 - (ii) auto brake system.

3.2.4 Steering systems

- (a) types available:
 - (i) rudder pedal steering;
 - (ii) hand/wheel/tiller steering;
 - (iii) body-gear steering on some aircraft;
- (b) degree of steering commonly available with each:
 - (i) understand that some steering systems are incompatible with asymmetric brake and/or power, while others are improved by them.

3.3 Actuating systems

3.3.1 Pneumatic systems

- (a) basic system knowledge as for hydraulics;
- (b) compare system differences with hydraulic system;
- (c) compare operating differences with hydraulic system:
 - (i) speed of response;
 - (ii) force available;
 - (iii) supply of operating fluid;
 - (iv) weight of system.
- (d) airconditioning and pressurisation.

3.3.2 Typical air supply system

- (a) power sources:
 - (i) engine driven compressors;
 - (ii) bleed air:
 - (A) gas turbine compressor;

turbo charger compressor;

- (b) typical services provided;
- (c) availability of services;
- (d) possibility of limitations under take-off or asymmetric power conditions, or during engine start.

- 3.3.3 Airconditioning system
 - (a) types of systems:
 - (i) freon;
 - (ii) air cycle machine;
 - (b) brief outline of operation of system;
 - (i) single zone cabin;
 - (ii) multiple zones;
 - (c) purpose of/necessity for humidifiers.
- 3.3.4 Pressurisation system
 - (a) terminology:
 - (i) cabin altitude, differential pressure;
 - (b) brief outline of operation of typical system:
 - (i) supply;
 - (ii) outflow valves;
 - (iii) overpressure and negative pressure relief;
 - (iv) control of cabin altitude and rate (no detail of internal mechanism of controller required);
 - (c) normal pressurised zones in the aircraft;
 - (d) rapid decompression, cabin altitude warning.

3.4 Ice and rain protection

- 3.4.1 Distinction between anti-ice and de-ice system.
- 3.4.2 Pneumatic systems (brief coverage only)
 - (a) where used:
 - (i) leading edges;
 - (b) limitations.
- 3.4.3 Thermal ice protection
 - (a) where used:
 - (i) propellers;
 - (ii) flying surfaces;
 - (iii) air intakes;
 - (iv) pitot and other sensors;
 - (v) windshields;
 - (b) methods:
 - (i) electrical;
 - (ii) air;
 - (iii) oil;
 - (c) limitations.
- 3.4.4 Fluid ice protection
 - (a) where used:
 - (i) inflight leading edge of flying surfaces, propellers, windshield;
 - (ii) ground de-icing;
 - (b) limitations.
- 3.4.5 Rain removal from windscreen
 - (a) methods:
 - (i) wipers;
 - (ii) fluid dispersant;

(iii) air jets.

3.4.6 Effects on aeroplane performance (discussion only)

- (a) ice accumulations;
- (b) use of ice control systems.

3.5 Fuel system

3.5.1 Carriage of fuel on aircraft

- (a) structural consequences:
 - (i) wing bending;
 - (ii) zero-fuel weight;
 - (iii) CG movement;
- (b) understand suction feed and gravity feed/transfer as backup for pressure feed/transfer.

3.5.2 Operational considerations

- (a) minimum fuel levels:
 - (i) pick-up for delivery to engine;
 - (ii) maintain oil/hydraulic cooling;
 - (iii) effect of aircraft attitude (for example, missed approach);
- (b) fuel jettison:
 - (i) legislation;
 - (ii) precautions to be observed;
 - (iii) minimum fuel after jettison (stand-pipes).

4. Power plants – turbine engine

4.1 Principle of operation

- (a) types of engine:
 - (i) differences and advantages;
 - (ii) bypass ratio;
- (b) turboprop:
 - (i) advantages; and
 - (ii) limitations; and
 - (iii) problems.

4.2 Engine constructions

- (a) intake (subsonic only):
 - (i) location on airframe relative to free-stream airflow;
 - (ii) location relative to engine (for example, B727 centre engine);
 - (iii) vulnerability to icing;
- (b) compressor:
 - (i) purpose/function of compressor;
 - (ii) centrifugal:
 - (A) single/multiple;
 - (iii) axial:
 - (A) single/twin;
 - (iv) inlet guide vanes;
 - (v) vulnerability to icing;
 - (vi) bleed air provisions;
 - (vii) compressor stalling:
 - (A) causes, symptoms, avoidance;

- (B) unloading compressor during start;
- (c) fan:
 - (i) purpose/function of fan;
 - (ii) relationship to compressor;
 - (iii) inlet guide vanes;
 - (iv) reverse thrust;
- (d) combustion system:
 - (i) purpose/function of combustion system;
 - (ii) combustion chamber:
 - (A) individual/annular;
 - (iii) fuel injectors;
 - (iv) igniters;
 - (v) air/fuel ratios;
- (e) turbine:
 - (i) purpose/function of turbine;
 - (ii) single/twin/triple turbines:
 - (A) for example, driving two-stage compressor with fan;
 - (iii) thermal and mechanical stress;
 - (iv) effects of damage;
 - (v) monitoring turbine temperature:
 - (A) desired to monitor inlet temperature;
 - (B) difficulties/compromise in monitoring;
 - (C) terminology – EGT, TGT, TIT;
 - (vi) reverse thrust mechanisms:
 - (A) cascade, buckets;
 - (B) safety interlocks;
- (f) exhaust:
 - (i) purpose/function of exhaust;
 - (ii) sources of noise;
 - (iii) hushkits.

4.3 Turbo-prop

- (a) drive train from engine:
 - (i) flight range; and
 - (ii) ground range;
- (b) control of propeller:
 - (i) variable speed engine;
 - (ii) constant speed engine;
- (c) reverse thrust:
 - (i) concept of zero thrust;
- (d) feathering;
- (e) propeller brake.

4.4 Auxiliary power unit (APU)

- (a) purpose/function of APU;
- (b) types commonly available;
- (c) outputs available;
- (d) availability determined by AFM:

- (i) use in flight;
- (ii) start in flight;
- (iii) outputs available in flight.

4.5 Operational considerations

- (a) use of reverse thrust:
 - (i) effectiveness with decreasing speed;
 - (ii) instability of airflow in reverse at low-ground speeds;
 - (iii) monitoring and precautions;
 - (iv) deliberate or inadvertent use in flight (where not permitted by AFM);
- (b) use of bleed air:
 - (i) effect on thrust and performance;
 - (ii) engine indications:
 - (A) EGT;
 - (B) RPM;
 - (C) EPR.

4.6 Engine starting

- (a) air-driven starters:
 - (i) characteristics;
 - (ii) sources of air;
 - (iii) failure to disconnect;
- (b) critical engine RPM:
 - (i) initiating fuel flow/ignition;
 - (ii) self-sustaining RPM;
 - (iii) stable idle;
- (c) typical engine start sequence;
- (d) typical start malfunctions:
 - (i) cause and remedy for each of the following:
 - (A) fails to light off;
 - (B) hot start;
 - (C) hung start;
 - (D) fails to stabilise at idle;
 - (E) starter fails to disengage;
 - (F) torching/tailpipe fire.

5. Engine instruments

5.1 EPR gauge

- (a) inputs;
- (b) displays:
 - (i) analogue/digital readout;
 - (ii) setting target EPR:
 - (A) manual/auto settings;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.2 Torque meter

- (a) inputs and methods of functioning;
- (b) types of indicators and units of torque;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.3 RPM indicator

- (a) types of display:
 - (i) RPM or percentage;
 - (ii) 100% not necessarily a limit and markings;
- (b) multiple RPM displays – N1, N2, N3:
 - (i) conventional order of numbering;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.4 Turbine temperature indicator

- (a) types of display:
 - (i) analogue;
 - (ii) digital;
- (b) overtemp warnings;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

5.5 Fuel consumption

- (a) flowmeters:
 - (i) analogue and digital indications;
 - (ii) importance on start-up and shutdown;
- (b) fuel-used gauges:
 - (i) may be separate or incorporated with flowmeter;
- (c) typical appearance of a set of gauges in a modern multi-engine aircraft.

6. Automatic flight control system (AFCS)**6.1 Autopilot (AP)**

- (a) purpose/function of AP;
- (b) common types (different axes);
- (c) components;
- (d) typical heavy aircraft AP controller;
- (e) command and manual modes, including typical submodes:
 - (i) ALT/HDG/IAS/MACH/VS hold;
 - (ii) VORLOC/ILS/INS tracking;
 - (iii) FMS coupling;
 - (iv) autoland and auto-go-around;
- (f) typical limitations/restrictions.

6.2 Flight Director (FD)

- (a) purpose/function of FD;
- (b) common types of presentation:
 - (i) V-bars;
 - (ii) cross-bars;
- (c) typical components;
- (d) typical heavy aircraft FD controller;
- (e) typical modes of operation:
 - (i) mode indicator.

6.3 Auto-throttle (AT)

- (a) purpose/function of AT;
- (b) typical modes of operation:
 - (i) thrust hold;

- (ii) speed hold;
- (iii) VNAV coupling;
- (c) auto-derate of take-off power;
- (d) typical engage/disengage/go-around controls;
- (e) typical limitations/restrictions.

6.4 Autoflight

- (a) relationship between AT, FD and AP;
- (b) relationship between FMS and AT/FD/AP;
- (c) redundancy requirements for autoland.

6.5 Flight envelope protection in autoflight

- (a) types for protection available:
 - (i) high speed, low speed;
 - (ii) alpha floor;
 - (iii) flap/gear speed protection;
- (b) functioning of typical system:
 - (i) inputs and outputs;
- (c) modified functioning during flare and touchdown.
- (d) alternate law, reversionary modes.

6.6 Associated autosystems

- (a) yaw damper:
 - (i) purpose/function of yaw damper:
 - (A) typical low/high speed behaviour requiring installation of yaw damper;
 - (ii) method of functioning:
 - (A) input and output;
 - (iii) series and parallel types:
 - (A) advantages/disadvantages of each type;
 - (iv) typical yaw damper controls.

7. Automatic pitch trim

- (a) purpose/function of auto-trim;
- (b) input and output;
- (c) typical auto-trim controls.

8. thrust computation

- (a) purpose/function of thrust computation system;
- (b) input and output;
- (c) relationship to FMS.

9. Warning and recording equipment

9.1 Overspeed warning system

- (a) components:
 - (i) inputs; and
 - (ii) outputs;
- (b) may be selectable according to weight/CG/fuel distribution;
- (c) typical selectors and warning indicators:
 - (i) aural warnings; and
 - (ii) visual warnings.

9.2 Stall warning

- (a) purpose/function of system;
- (b) components of a typical heavy aircraft system:
 - (i) ADC inputs, including AOA;
 - (ii) stick shaker and pusher;
 - (iii) visual and aural warnings.

9.3 Take-off warning system (TWS)

- (a) purpose/function of TWS;
- (b) typical items monitored;
- (c) aural/visual warnings.