

Subject No 48 Advanced Aerodynamics, Performance, and Systems Knowledge (Aeroplane)

Each subject has been given a subject number and each topic within that subject a topic number. These reference numbers will be used on 'knowledge deficiency reports' and will provide valuable feed back to the examination candidate.

Sub Topic Syllabus Item

Advanced Aerodynamics

48.2 Aerodynamics at Transonic Speeds

- 48.2.2 Define 'speed of sound'.
- 48.2.4 Explain the relationship between temperature and the speed of sound.
- 48.2.6 State the formula for calculating the speed of sound.
- 48.2.8 Define 'Mach number'.
- 48.2.10 Explain the change of IAS and TAS as a function of altitude at a given Mach number.
- 48.2.12 Explain the meaning of the term 'shockwave'.
- 48.2.14 Explain the reasons for the formation of shockwaves.
- 48.2.16 Describe the changes to the air as it passes over an aerofoil when the Mach freestream is between M_{crit} and Mach 1.0.
- 48.2.18 Describe the movement of the centre of pressure with increasing Mach number.
- 48.2.20 Describe the changes to the air as it passes through a shockwave.
- 48.2.22 Describe the changes in lift and drag coefficients in transonic flow.
- 48.2.24 Describe the behaviour of the shockwaves as the Mach number increases.
- 48.2.26 Explain the meaning of the term 'bow wave'.
- 48.2.28 Describe compression and expansion waves with respect to the streamline pattern.
- 48.2.30 Describe the velocity behind a normal and an oblique shockwave.
- 48.2.32 Explain the meaning of the term 'sonic buffet'.
- 48.2.34 Define the critical Mach number (M_{crit}).
- 48.2.36 Explain the effect of the following on M_{crit} :
- (a) aerofoil thickness; and,
 - (b) angle of sweepback.
- 48.2.38 Define the Mach drag-divergence (Mach critical drag rise- M_{cdr}).
- 48.2.40 Describe the characteristics of transonic aerofoils.
- 48.2.42 Explain the advantages of a 'supercritical' aerofoil section.

Sub Topic	Syllabus Item
48.2.44	Explain the advantages and disadvantages of sweepback.
48.2.46	Explain the phenomenon 'aileron reversal'.
48.2.48	Explain the advantages of 'vortex generators' in high speed flight.
48.2.50	Explain how increase of the angle of attack influences normal shockwave.
48.2.52	Explain shock stall and describe its relationship with Mach buffet.
48.2.54	Describe the behaviour of aircraft at shock stall including Mach tuck.
48.2.56	Describe wave drag.
48.2.58	Describe effect of wave drag on control surface efficiency and hinge moment.
48.2.60	Explain area ruling in aeroplane design.
48.2.62	Explain the meaning of 'buffet margin'.
48.2.64	Define 'coffin corner'.
48.2.66	Describe the influence of the following on the buffet margin: (a) pressure altitude; (b) aircraft mass; and, (c) load factor
48.4	High Speed Stability and Control
48.4.2	Differentiate between stability and controllability.
48.4.4	Explain static stability and dynamic stability.
48.4.6	Define longitudinal stability.
48.4.8	Explain the action of the tailplane in maintaining longitudinal stability.
48.4.10	Explain wing pitching moments.
48.4.12	Explain how the following factors affect longitudinal stability: (a) tailplane design; (b) longitudinal dihedral; and, (c) the position of the Centre of Gravity.
48.4.14	Define directional stability and explain how the following factors affect it: (a) sideslip angle; (b) keel surface/fin area; and, (c) the position of the Centre of Gravity.

Sub Topic	Syllabus Item
48.4.16	Define lateral stability and explain how the following factors affect it: <ul style="list-style-type: none">(a) dihedral;(b) shielding;(c) wing position;(d) keel surface/fin area; and(e) sweepback.
48.4.18	Explain the requirement to match lateral and directional stability.
48.4.20	Explain the conditions of spiral instability, dutch roll, and snaking.
48.4.22	Explain what is meant by stick fixed and stick free stability.

Performance

48.6 Aerodrome Geometry and Definitions

48.6.2	Explain the meaning of the following: <ul style="list-style-type: none">(a) runway;(b) the 'slope' of a runway;(c) stopway;(d) clearway;(e) takeoff run (TOR);(f) takeoff run available (TORA);(g) takeoff run required (TORR);(h) takeoff distance (TOD);(i) takeoff distance available (TODA);(j) takeoff distance required (TODR);(k) accelerate stop distance (ASD);(l) accelerate stop distance available (ASDA);(m) accelerate stop distance required (ASDR);(n) the 'screen height' on takeoff;(o) a balanced field length (BFL); and(p) a balanced takeoff.
48.6.4	State the lateral dimensions of a clearway for international aerodromes.

Sub Topic	Syllabus Item
48.8	Takeoff Speeds
48.8.2	Explain the meaning of the following: <ul style="list-style-type: none">(a) Airspeed Indicator Reading (ASIR);(b) IAS;(c) CAS;(d) RAS;(e) EAS;(f) TAS;(g) VS;(h) VSO;(i) VEF;(j) V1;(k) VMCG;(l) V1(MCG);(m) VMCA;(n) VR;(o) VMU;(p) VLOF;(q) VMBE;(r) V2 min;(s) VREF;(t) VFC.
48.8.4	Explain the factors affecting V1.
48.8.6	Explain the derivation of V2.
48.8.8	State the relationship between: <ul style="list-style-type: none">(a) VEF and V1;(b) V1 and VR;(c) V1 and VMCA;(d) V1 and VMCG;

Sub Topic Syllabus Item

- (e) V1 and VMBE;
- (f) VR and VMCA;
- (g) VR and V2;
- (h) V2 and VS;
- (i) VS and VMCA;
- (j) V2 and VMCA;
- (k) V2 and V2 min.

48.10 Rejected Take-off Considerations

- 48.10.2 Define a Rejected Takeoff (RTO-aborted takeoff).
- 48.10.4 Describe the standard procedures applied following an aircraft malfunction on the takeoff roll, prior to V1.
- 48.10.6 Describe the standard procedures applied following an engine failure or fire at or above V1.
- 48.10.8 Describe the likely outcome of continuing a takeoff following an engine failure at more than 2 seconds before V1.
- 48.10.10 Describe the likely outcome of aborting a takeoff following an engine failure at more than 2 seconds after V1.

48.12 Take-off Climb

- 48.12.2 Explain the meaning of the following:
 - (a) takeoff path;
 - (b) takeoff flight path;
 - (c) gross performance;
 - (d) net performance;
 - (e) gross height;
 - (f) net height;
 - (g) climb gradient;
 - (h) gross climb gradient;
 - (i) net climb gradient;
 - (j) reference zero;
 - (k) net takeoff flight path (NTOFP).

Sub Topic	Syllabus Item
48.12.4	State the minimum heights and speeds which must be attained by the end of the TODA, in the following situations: <ul style="list-style-type: none">(a) all engines operating takeoff;(b) one engine inoperative, straight flight path, from a dry runway;(c) one engine inoperative, straight flight path, from a wet runway;(d) one engine inoperative, turning flight path, from a dry runway;(e) one engine inoperative, turning flight path, from a wet runway.
48.12.6	Define: <ul style="list-style-type: none">(a) 1st climb segment;(b) 2nd climb segment;(c) 3rd climb segment;(d) 4th climb segment.
48.12.8	State the aircraft configuration, power/thrust setting, speed, obstacle clearance heights and minimum climb gradients (net and gross), required in each of the initial climb segments.
48.12.10	Describe the lateral dimensions of the net takeoff flight path (NTOFP).
48.12.12	State the effect of near-in obstacles in the NTOFP on TODA.
48.14	Takeoff and Initial Climb - Operational Considerations
48.14.2	Explain how various takeoff configurations, procedures and techniques can affect an aircraft's takeoff and initial climb performance.
48.14.4	Describe the circumstances under which reduced power may be used for takeoff.
48.14.6	Explain how reduced thrust/power is determined for takeoff.
48.14.8	Define a wet runway.
48.14.10	Define a contaminated runway.
48.14.12	Describe the effect of wet or contaminated runways on takeoff performance.
48.16	Factors determining Maximum Take-off Weight
48.16.2	Explain the factors which affect an aircraft's takeoff performance.
48.16.4	Explain the factors which affect an aircraft's initial climb performance.
48.16.6	Explain the effect of runway dimensions on an aircraft's takeoff performance.
48.16.8	Explain the effect of tyre and brake energy limitations on an aircraft's takeoff performance.

Sub Topic	Syllabus Item
48.16.10	Explain how flight manual data is used to construct specimen runway performance charts.
48.16.12	Explain the significance and applicability of a balanced field length including: (a) the effect of a stopway on the allowed take off mass and appropriate V1; (b) the effect of a clearway on the allowed take off mass and appropriate V1; (c) the relationship between take off distance, accelerate stop distance and V1.
48.18	Enroute Climb and Cruise
48.18.2	Define Rate of Climb (VY).
48.18.4	Define Angle of Climb (VX).
48.18.6	Explain the factors which affect an aircraft's enroute climb performance.
48.18.8	Define VA.
48.18.10	Explain the derivation of VA.
48.18.12	State the effect of weight on VA.
48.18.14	Define turbulence penetration speed.
48.18.16	Explain the derivation of turbulence penetration speed.
48.18.18	Explain the meaning of 'low speed buffet'.
48.18.20	Explain the meaning of 'high speed buffet'.
48.18.22	Explain the meaning of 'buffet manoeuvre capability'.
48.18.24	Explain the purpose of step climbs used on long distance flights.
48.18.26	Explain the factors which affect the choice of optimum altitude.
48.18.28	Explain the factors which might affect or limit the maximum operating altitude.
48.18.30	Explain the factors which affect an aircraft's cruise performance.
48.18.32	Explain the use of 'cost index' to determine the appropriate speeds for climb and cruise.
48.18.34	Differentiate between max range cruise (MRC) speed and long range cruise (LRC).
48.18.36	Explain range and endurance configurations, speeds and power settings.
48.18.38	Explain the effect of wind on cruise range (distance and speed).
48.18.40	Explain the effect of weight on cruise range (distance and speed).
48.20	One Engine Inoperative Drift Down
48.20.2	Explain the meaning of 'drift down'.

Sub Topic	Syllabus Item
48.20.4	Identify factors which affect the enroute drift down flight path.
48.20.6	Describe the minimum obstacle clearance enroute flight path (net and gross).
48.20.8	State the thrust to be set on the operating engine(s) during drift down.
48.20.10	State the thrust to be set in the case of critical terrain clearance during drift down.
48.22	Descent, Approach and Landing
48.22.2	Explain the meaning of the following: <ul style="list-style-type: none">(a) VMO/MMO;(b) VLE;(c) VLO;(d) VFE;(e) manoeuvring speed;(f) VREF;(g) VAT;(h) VT;(i) VTI/TTS.
48.22.4	State the relationship between: <ul style="list-style-type: none">(a) configuration and manoeuvring speed;(b) VREF and VS.
48.22.6	Explain the factors which affect an aircraft's descent performance.
48.22.8	Explain the effect of weight on descent planning.
48.22.10	Explain the factors which affect an aircraft's approach and landing performance.
48.22.12	Explain the meaning of 'demonstrated landing distance'.
48.22.14	Explain how 'demonstrated landing distance' is determined.
48.22.16	Explain the meaning of 'screen height' on landing.
48.22.18	Explain the meaning of 'landing distance available '.
48.22.20	State the relationship between demonstrated landing distance and landing distance available.
48.22.22	Explain the meaning of 'approach climb'.
48.22.24	State the configuration and minimum climb gradient used to determine the approach climb limited landing weight.

Sub Topic	Syllabus Item
48.22.26	Explain the meaning of 'landing climb'.
48.22.28	State the configuration and minimum climb gradient used to determine the landing climb limited landing weight.
48.22.30	Describe the one engine inoperative landing committal/decision height.
48.22.32	Describe the effect of the following system malfunctions on an aircraft's landing performance: <ul style="list-style-type: none">(a) flap restrictions;(b) anti-skid failure;(c) reduced brake availability.
48.22.34	Describe the effect of wet or contaminated runways on landing performance.
48.22.36	Define 'hydroplaning' (aquaplaning) and calculate the speed at which it may occur.
48.22.38	Explain 'turn around time' and describe the factors which may affect it.
48.24	Using Specimen Performance Data
48.24.2	Using specimen aircraft performance data, extract/calculate: <ul style="list-style-type: none">(a) takeoff distances available;(b) maximum takeoff weight;(c) takeoff thrust (including reduced thrust);(d) maximum continuous thrust;(e) takeoff speeds;(f) flap retraction schedule;(g) air conditioning pack configuration for takeoff;(h) stab trim setting;(i) climb thrust;(j) climb speed schedules;(k) time and distance to altitude;(l) cruise thrust;(m) cruise speed schedules;(n) optimum and maximum altitudes;(o) high and low speed buffet margins;(p) turbulence penetration speeds;

Sub Topic Syllabus Item

- (q) driftdown thrust, speeds, flight paths and level-off altitude and weight;
- (r) time and distance to touchdown;
- (s) landing distances available;
- (t) landing speeds;
- (u) landing distance required;
- (v) maximum landing weight;
- (w) go-around thrust;
- (x) turn around time.

48.26 Aircraft and Pavement Classification Systems

- 48.26.2 Given information relating to a runway's pavement strength, and/or a specific aircraft, determine:
- (a) a runway's PCN;
 - (b) an aircraft's ACN;
 - (c) a runway's LCN/LCG;
 - (d) an aircraft's LCN/LCG;
 - (e) the maximum aircraft weight for landing;
 - (f) whether a particular runway and associated taxiways will support the weight of a specified aircraft.

48.28 Loading

- 48.28.2 Explain the meaning of the following:
- (a) arm;
 - (b) datum;
 - (c) moment (including the units used);
 - (d) centre of gravity (C of G);
 - (e) C of G range;
 - (f) station;
 - (g) index units;
 - (h) % MAC;
 - (i) aircraft prepared for service weight (APS);
 - (j) empty weight (empty aircraft weight);

Sub Topic	Syllabus Item
	(k) basic operating weight (aircraft prepared for service weight);
	(l) gross weight;
	(m) payload;
	(n) zero fuel weight (ZFW);
	(o) maximum zero fuel weight (MZFW);
	(p) ramp weight;
	(q) maximum ramp weight;
	(r) takeoff weight (TOW);
	(s) maximum takeoff weight (MTOW);
	(t) regulated takeoff weight (RTOW);
	(u) landing weight;
	(v) maximum landing weight.
48.28.4	Explain why the C of G must be within the certified limits.
48.28.6	Describe the influence of fuel loading or usage on the centre of gravity.
48.28.8	Explain the effect of centre of gravity on fuel consumption.
48.28.10	Using specimen aircraft loading and performance data, calculate: (a) ramp weight; (b) takeoff weight (TOW); (c) regulated takeoff weight (RTOW); (d) zero fuel weight (ZFW); (e) landing weight; (f) compartment weights; (g) available payload; (h) maximum floor/running loading when loading small heavy items; (i) the aircraft's C of G at any given time.
48.28.12	Solve the following loading problems: (a) loading or offloading weight and find new C of G position; (b) loading or offloading weight to place the C of G at a given station; (c) loading or offloading weight at a given station without exceeding C of G limits; (d) adding, reducing and shifting loads and finding new C of G position.

Sub Topic	Syllabus Item
	Systems Knowledge (Aeroplane)
48.30	Autopilot and Flight Control Systems
48.30.2	Explain the function and operating principle of the primary and secondary flight controls.
48.30.4	Describe the flight control selectors and indicators.
48.30.6	Explain the control surface actuation methods.
48.30.8	Explain the function and operating principles of achieving control balance.
48.30.10	Explain the function and operating principles of the lift augmentation devices.
48.30.12	Explain the function and operating principle of a 'fly-by-wire' flight control system.
48.30.14	Explain how redundancy is obtained in flight control systems.
48.30.16	Explain the meaning of 'triple-redundancy'.
48.30.18	Explain the effect of a complete hydraulic system failure on flight control.
48.30.20	Explain the purpose of 'feel systems' in flight controls.
48.30.22	Explain the function and operating principle of an automatic flight control system (AFCS).
48.30.24	Describe the use of the automatic flight control system control panel and the operational modes available.
48.30.26	Describe the inputs, controls, indications and warnings of an automatic flight control system.
48.30.28	Explain the function and operating principle of an autoland system.
48.30.30	Explain the system redundancy in an autoland system.
48.30.32	Explain the function and operating principle of flight envelope protection.
48.30.34	Describe the inputs, indications and warnings of flight envelope protection.
48.30.36	Explain the function and operating principle of the yaw damper system.
48.30.38	Describe the inputs, indications and warnings of the yaw damper system.
48.30.40	Explain the function and operating principle of the automatic trim system.
48.30.42	Describe the component units, indications and warnings of the automatic trim system.
48.30.44	Explain the function and operating principle of an auto thrust system.
48.30.46	Describe the inputs, controls, indications and warnings of an auto thrust system.
48.30.48	Describe the functions of the Full Authority Digital Engine Control (FADEC).

Sub Topic	Syllabus Item
48.32	Electrical Systems
48.32.2	Explain the function and operating principle of the following: <ul style="list-style-type: none">(a) battery;(b) ground power source;(c) alternator;(d) AC generator;(e) DC generator;(f) bus bar;(g) relay;(h) voltage regulator;(i) overvoltage protection;(j) circuit breaker;(k) electrical bonding;(l) static discharge leads.
48.32.4	Explain the meaning of the various measures of electrical power.
48.32.6	Calculate battery life given rating and voltage, and system load.
48.32.8	Explain the method of calculating power consumption in an electrical circuit.
48.32.10	Explain the function and operating principle of: <ul style="list-style-type: none">(a) a transformer-rectifier;(b) an inverter;(c) a rectifier;(d) an inductor;(e) a commutator
48.32.12	Explain the difference between a split system and parallel system of load distribution.
48.32.14	Explain the relative advantages and disadvantages of AC and DC systems.
48.32.16	Explain the function and operating principle of a constant speed generator drive (CSGD).
48.32.18	Explain the function and operating principle of an integrated drive generator (IDG).
48.32.20	Explain the consequences of an IDG mechanical disconnect during flight.
48.32.22	Explain the function and operating principle of a variable speed constant frequency

Sub Topic Syllabus Item

(VSCF) drive.

48.34 Fuel Systems

48.34.2 Explain the function and operating principle of the following:

- (a) fuel tanks;
- (b) tank vents;
- (c) water drains;
- (d) expansion spaces;
- (e) baffles;
- (f) fuel quantity detectors and gauges;
- (g) fuel flow meter;
- (h) fuel strainers and filters;
- (i) tank selector valves;
- (j) non return valve;
- (k) shutoff valve;
- (l) manual defuelling valve;
- (m) engine-driven fuel pump;
- (n) fuel booster pump.

48.34.4 Explain the safety consideration when refuelling aircraft.

48.34.6 State the purpose of the fuel crossfeed system.

48.34.8 Explain the normal order of fuel tank use in large air-transport aircraft.

48.34.10 Describe the centre of gravity movement with fuel burn.

48.34.12 State the meaning of 'unusable fuel'.

48.34.14 Describe how fuel imbalance can occur and how this situation is corrected.

48.34.16 Explain the purpose and method of fuel temperature measurement and control.

48.34.18 Describe the function and operating principle of a fuel jettison (dump) system.

48.36 Hydraulic Systems

48.36.2 State Pascal's principle.

48.36.4 Explain mechanical advantage and show how it can be gained hydraulically in the operation of aircraft services.

48.36.6 Calculate the force generated, given hydraulic piston sizes and system pressure.

Sub Topic	Syllabus Item
48.36.8	Explain the advantages and disadvantages of using hydraulics to operate aircraft services.
48.36.10	Describe the properties of hydraulic oils.
48.36.12	Describe the function and operating principle of the following: <ul style="list-style-type: none">(a) reservoir;(b) pump;(c) pressure regulator;(d) accumulator;(e) check valve;(f) relief valve;(g) bypass valve;(h) selector valve;(i) fuse;(j) actuator;(k) standpipe;(l) filter.
48.36.14	Describe the effect of flow rate and component resistance on hydraulic system pressure.
48.36.16	Explain how redundancy is obtained in the hydraulic systems of heavy air-transport aircraft.
48.36.18	Explain the operating principle of a ram air turbine (RAT).
48.36.20	Describe the instruments for monitoring the hydraulic system
48.36.22	Describe the warnings associated with the hydraulic system.
48.36.24	Describe the trends in hydraulic system design.
48.38	Pneumatic Systems
48.38.2	Describe the function and principle of operation of pneumatic systems.
48.38.4	Describe the controls, indications and warnings of pneumatic systems.
48.38.6	List typical aircraft systems for which a pneumatic system is a power source.
48.40	Oxygen Systems
48.40.2	Describe the function and principle of operation of a cockpit oxygen system.
48.40.4	Describe the function and operation of cockpit oxygen masks.

Sub Topic	Syllabus Item
48.40.6	Describe the function and principle of operation of passenger oxygen systems.
48.40.8	Describe the actuation methods for passenger oxygen.
48.40.10	Explain the relative advantages and disadvantages of chemical and gaseous oxygen systems.
48.42	Environmental Control Systems
48.42.2	Describe the function and principle of operation of a cabin air-conditioning system.
48.42.4	Describe the controls, indications and warnings of a cabin air-conditioning system.
48.42.6	Describe the function and principle of operation of a cabin pressurisation system.
48.42.8	Describe the controls, indications and warnings of a cabin pressurisation system.
48.42.10	Define the following terms: <ul style="list-style-type: none">(a) pressure hull;(b) cabin altitude;(c) cabin vertical speed;(d) differential pressure.
48.42.12	Describe the function and operating principle of the following: <ul style="list-style-type: none">(a) cabin pressure controller;(b) cabin pressure rate selector;(c) landing altitude selector;(d) barometric pressure selector;(e) cabin pressure relief valve;(f) negative pressure relief valve.
48.42.14	Describe the emergency operation of a pressurisation system.
48.44	Landing Gear
48.44.2	Describe the requirements placed on an aircraft landing gear system.
48.44.4	List the main components of the landing gear and describe their function and principle of operation.
48.44.6	Describe the indications of typical landing gear systems.
48.44.8	Describe typical gear warning systems and explain their operating principles.
48.44.10	Describe the protection device to avoid gear retraction on ground.
48.44.12	Describe various methods for emergency gear extension.

Sub Topic	Syllabus Item
48.44.14	Name the gas used to pressurise the tyres on large air-transport aircraft.
48.44.16	Explain the function of thermal plugs.
48.44.18	Define the term 'tyre creep'.
48.44.20	Describe basic principle of operation of wheel brake units.
48.44.22	Describe the function and principle of operation of an auto brake system.
48.44.24	Describe the operation and operating principle of the anti-skid system.
48.44.26	Describe the operating principle of the park brake system.
48.44.28	Describe the function of wheel brake temperature indication.
48.44.30	Explain the function of brake wear indicators.
48.46	Ice and Rain Protection Systems
48.46.2	Describe the function and operating principles of the following types of ice protection systems: (a) bleed air thermal; (b) pneumatic boots; (c) electrical.
48.46.4	Explain the difference between anti-icing systems and de-icing systems.
48.46.6	Describe the effects of ice protection system operation on engine performance.
48.46.8	Explain the proper handling of mechanical (pneumatic boot) and thermal ice protection systems.
48.46.10	Describe the operating principles of ice detectors.
48.46.12	Describe the effect of airframe and engine icing on the performance of and aircraft on the ground and in flight.
48.46.14	Describe windscreen heating and rain clearance systems.
48.48	Fire Warning and Protection Systems
48.48.2	Describe the indications of typical fire warning systems.
48.48.4	Describe the principles, features and parameters of typical fire protection systems.
48.48.6	Describe the operation of unit-type and continuous loop fire detectors.
48.48.8	Describe common fire extinguishing systems and the limitations with their use.
48.48.10	List the common extinguishing agents and state any precautions with their use.
48.48.12	Describe typical fire fighting methods on aircraft.
48.48.14	Describe the various types of fire likely to occur on aircraft and the preferred extinguishing agents for each.