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

NOTE: *This syllabus is based on a multi engine turbine air transport type aeroplane.*

System and procedure items are those systems and procedures typically found in an airline-operated air-transport type aeroplane.

Assessment of this syllabus will be principally based on, but not limited to, a specific approved 'representative' aircraft and the associated performance manual data.

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 feedback to the examination candidate. These reference numbers are common across the subject levels and therefore may not be consecutive.

This syllabus presupposes a knowledge and understanding already attained at PPL and CPL levels.

Acronyms used are those in common use at the time of writing. The use of a specific acronym indicates this syllabus requires knowledge of the concept or system commonly or historically associated with that acronym.

Sub Topic	Syllabus Item
	Section 1 Aeroscience
48.2	**Transonic speed**
48.2.2	Explain the term 'speed of sound'.
48.2.4	Explain the factor determining the local speed of sound (LSS).
48.2.6	Define Mach number and associated computational formulae.
48.2.8	Calculate the speed of sound given the appropriate information.
48.2.10	Calculate 'Mach number' given the appropriate information.
48.2.12	Explain the change of IAS and TAS as a function of altitude at a given Mach number.
48.2.14	Explain the term critical Mach number (M_{crit}).
48.2.16	Explain the potential hazard of maintaining a constant Mach number in the climb and descent.
48.2.18	Explain the term 'crossover altitude' otherwise known as 'speed transition'.
48.4	**Stability and control**
48.4.2	Explain swept wing pitching moments at high subsonic speeds.
48.4.4	Explain the 'lateral stability' issues arising at high subsonic speeds.

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48.4.6 Explain how the following factors affect lateral stability at high subsonic speeds:
- (a) dihedral
- (b) anhedral
- (c) tail surface shielding
- (d) wing position
- (e) keel surface/fin area
- (f) sweepback.

48.4.8 Explain the requirement to match lateral and directional stability.

48.4.10 Explain the conditions of:
- (a) spiral instability
- (b) Dutch roll
- (c) snaking.

48.4.12 Describe the function of a yaw damper system.

48.4.14 Describe how 'active flight path stability' is managed by a fly-by-wire control system.

48.6 Transonic aerodynamics

48.6.2 Explain the meaning of the term 'shockwave'.

48.6.4 Explain the formation of shockwaves.

48.6.6 Describe the changes to the air as it passes over an aerofoil when the free airflow stream is between M_{crit} and M_{det}.

48.6.8 Describe the movement of the centre of pressure with increasing Mach number.

48.6.10 Describe the changes to the air as it passes through a shockwave.

48.6.12 Within the transonic range, describe the change in the:
- (a) lift coefficient
- (b) drag coefficient.

48.6.14 Describe the behaviour of the shockwaves as the Mach number increases.

48.6.16 Explain the meaning of the term 'bow wave'.

48.6.18 Explain the meaning of the term 'sonic buffet/Mach buffet'.

48.6.20 Explain the effect of the following on M_{crit}:
- (a) angle of sweepback
- (b) aerofoil 'thickness to chord' ratio
- (c) a 'supercritical' aerofoil section .

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48.6.22	Define Mach critical drag rise (Mcdr), otherwise known as force or drag-divergence Mach Number (Mfd or Mdd).
48.8	**Transonic aerofoils**
48.8.2	Describe the design characteristics of ‘high subsonic flight’ airfoils.
48.8.4	Explain the advantages of a ‘supercritical’ aerofoil section.
48.8.6	Explain the: (a) advantages of sweepback (b) disadvantages of sweepback.
48.8.8	Explain the phenomenon ‘aileron reversal’.
48.8.10	Explain the advantages of ‘vortex generators’ in the high subsonic speed regime.
48.8.12	Explain how an increase of the angle of attack influences the normal shockwave.
48.8.14	Explain shock stall, including its relationship with Mach buffet.
48.8.16	Describe the behaviour of an aeroplane at shock stall, including Mach tuck.
48.8.18	Describe wave drag.
48.8.20	Explain ‘area ruling’ in air-transport aeroplane design.
48.8.22	Explain the effect of a shockwave formed over a control surface on control effectiveness.
	Section 2 Aeroplane Systems
48.20	**Engine management systems**
48.20.2	Explain the function of an auto thrust system.
48.20.4	Explain the principle of operation of an auto thrust system.
48.20.6	For an auto thrust system, describe the system: (a) inputs (b) controls (c) indications (d) warnings.
48.20.8	Describe the functions of a Full Authority Digital Engine Control (FADEC).
48.22	**Flight control systems**
48.22.2	With respect to primary flight control systems:

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(a) describe the function, operation and advantages of roll control spoilers
(b) describe the function and operation of inboard and outboard aileron
(c) explain the reason for speed blending (fairing) of outboard ailerons
(d) describe the function and advantages of variable incident (all-flying) horizontal stabilisers
(e) describe the function and advantages of a rudder ratio changer system
(f) describe the function and operation of a gust suppression system.

48.22.4 With respect to secondary flight control systems:
(a) describe the function and operation of speed brakes
(b) describe the function and operation of ground spoilers (lift dumpers)
(c) describe the function, operation and advantages of trailing-edge lift augmentation devices
(d) describe the function, operation and advantages of leading-edge lift augmentation devices.

48.24 Automatic control systems

48.24.2 Describe the control surface actuation methods found on a typical air-transport aeroplane.

48.24.4 Describe the function of a 'fly-by-wire' flight control system.

48.24.6 Explain the operating principle of a 'fly-by-wire' flight control system.

48.24.8 Explain how triple-redundancy is obtained in flight control systems.

48.24.12 Describe the backup systems associated with powered flight controls.

48.24.14 Explain the purpose of 'feel or feedback systems' in powered flight controls.

48.26 Hydraulic systems

48.26.2 For an air-transport aeroplane, explain the:
(a) advantages of using hydraulics to operate services
(b) disadvantages of using hydraulics to operate services.

48.26.4 Describe the function of the following:
(a) bypass valve
(b) hydraulic fuse
(c) standpipe.

48.26.6 Explain how redundancy is obtained in the hydraulic systems of air-transport aeroplanes.

48.26.8 Explain the operating principle of a ram air turbine (RAT).

48.26.10 Describe the methods of monitoring the hydraulic system.

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48.26.12	Describe the warnings associated with a hydraulic system.
48.28	**Pneumatic systems**
48.28.2	Describe the typical sources of pneumatic bleed air.
48.28.4	Explain the principle of operation of a bleed air pneumatic system.
48.28.6	Describe the components of a pneumatic system.
48.28.8	Describe the function of a pneumatic system (including the uses of bleed air).
48.28.10	Describe the malfunctions and leak warning of pneumatic systems.
48.30	**Electrical systems - DC**
48.30.2	Describe the battery installations installed in an air-transport aeroplane.
48.30.4	For an air-transport aeroplane battery system, explain the: (a) function of the system (b) battery types (c) associated hazards (d) safety measures required.
48.32	**Electrical systems - AC**
48.32.2	For an AC electrical system, explain the terms: (a) alternating current (b) frequency (c) RMS voltage (d) RMS current (e) phase.
48.32.4	Explain the function of the following: (a) transformer rectifier (b) inverter (c) relay.
48.32.6	Explain the difference between a split system and parallel system of load distribution.
48.32.8	Explain operating principle of a constant speed generator drive (CSD).
48.32.10	Explain operating principle of an integrated drive generator (IDG).
48.32.12	Explain the consequences of an IDG mechanical disconnect during flight.
48.32.14	Explain the function and operating principle of a variable speed constant frequency (VSCF) drive.

Sub Topic	Syllabus Item
48.34	**Landing gear systems - retractable**
48.34.2	Explain the requirements placed on an air-transport aeroplane’s landing gear system.
48.34.4	Describe the layout of an air-transport aeroplane's landing gear system.
48.34.6	Describe the function of the following landing gear components: (a) bogies (b) drag-strut (c) side-strut (d) torsion links (e) air/ground sensing (f) gear pins.
48.34.8	Describe the cockpit indications associated with landing gear systems.
48.34.10	Describe gear warning systems.
48.34.12	Describe the protection systems to avoid inadvertent gear retraction on ground.
48.34.14	Explain the methods for emergency gear extension.
48.34.16	Explain the reasons for using nitrogen gas to pressurise the tyres on air-transport aeroplanes.
48.34.18	Describe the function of thermal plugs.
48.34.20	Define ‘tyre creep’.
48.34.22	Explain the requirement for speed limitations for landing gear operation.
48.36	**Aircraft wheel brake system**
48.36.2	Describe the function of an autobrake system.
48.36.4	Explain the principle of operation of an autobrake system.
48.36.6	Describe the function of an anti-skid system.
48.36.8	Describe the principle of operation of an anti-skid system.
48.36.10	Describe the RTO function of an autobrake system.
48.36.12	Explain the operation of an RTO system.
48.36.14	Explain the principle of operation of a park brake system.
48.36.16	Describe the various types of air-transport aeroplane brakes.
48.36.18	Explain the implications of excessive wheel brake temperature.

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48.36.20 Explain the requirement for brake wear indicators.

48.38 Fuel pump systems

48.38.2 Describe the function of:
- (a) low pressure engine-driven fuel pumps
- (b) high pressure engine-driven fuel pumps
- (c) submersible electric pumps
- (d) jet pumps.

48.40 Fuel tanks systems

48.40.2 Describe the function, and where appropriate, explain the operating principle of:
- (a) expansion spaces
- (b) fuel quantity detectors
- (c) fuel flow meters and totalisers
- (d) selector valves
- (e) non-return valves
- (f) vent systems
- (g) firewall shutoff valve
- (h) manual de-fuelling valve
- (i) single point pressure refueling.

48.40.4 Describe the function of fuel cross feed systems.

48.40.6 Explain the order of fuel tank use in an air-transport aeroplane.

48.40.8 Explain the meaning of ‘unusable fuel’.

48.40.10 Explain why fuel quantity is measured by weight.

48.40.12 Describe how:
- (a) fuel imbalance can occur
- (b) a fuel imbalance situation is corrected.

48.40.14 Explain the significance of fuel temperature.

48.40.16 Explain the methods of fuel temperature management.

48.40.18 Explain the requirement for a fuel jettison (dump) system.

48.40.20 Describe a fuel jettison (dump) system.

48.42 Fire warning systems

48.42.2 Describe the function of fire and smoke warning systems.

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48.42.4	Explain the operation of: (a) unit type (spot or point) fire detectors (b) continuous loop fire detectors.
48.42.6	Explain the fire warning test procedures.
48.42.8	Explain the principle of operation of the fire warning system installed in the: (a) engine area (b) APU area (c) cargo area (d) avionics area (e) wheel well (f) toilets (g) cabin.
48.44	**Fire protection and suppression systems**
48.44.2	Describe aeroplane-installed fire extinguishing systems.
48.44.4	Explain the limitations of aeroplane-installed fire extinguishing systems.
48.44.6	With reference to portable extinguishers, explain the: (a) preferred extinguishing agent for the various types of fire (b) precautions associated with the various extinguishing agents.
48.44.8	Describe aeroplane-installed electrical fire protection systems.
48.46	**Ice and rain protection systems**
48.46.2	Explain the 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	Explain the effects of ice protection system operation on engine performance.
48.46.8	Explain the correct operation of a mechanical (pneumatic boot) system.
48.46.10	Explain the correct operation of a thermal ice protection system.
48.46.12	Explain the operating principles of ice detectors.
48.46.14	Describe the effect on the performance of an air transport aeroplane of: (a) airframe icing (b) engine icing.

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48.46.16	Describe: (a) windscreen heating systems (b) rain clearance systems.
48.50	**Oxygen systems**
48.50.2	Explain the purpose of a flight deck oxygen system.
48.50.4	Explain the principle of operation of a flight deck oxygen system.
48.50.6	Explain the purpose of passenger cabin oxygen systems.
48.50.8	Explain the principle of operation of a passenger cabin overhead oxygen system.
48.50.10	Describe the actuation methods for passenger cabin oxygen.
48.50.12	Explain the advantages and disadvantages of a: (a) chemical oxygen system. (b) gaseous oxygen system.
48.52	**Environmental control systems**
48.52.2	Describe the function of an air-conditioning system.
48.52.4	Explain the principle of operation of an air-conditioning system.
48.52.6	For an air-conditioning system, describe the associated: (a) controls (b) indications (c) warnings.
48.52.8	Describe the function of a pressurisation system.
48.52.10	Explain the principle of operation of a pressurisation system.
48.52.12	For a pressurisation system, describe the associated: (a) controls (b) indications (c) warnings.
48.52.14	Explain the following terms: (a) pressure hull (b) cabin altitude (c) cabin vertical speed (d) differential pressure (e) pressurisation profile (f) ‘catching the cabin’.

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48.52.16 Describe the function of the following:

(a) pressure controller
(b) pressure rate selector
(c) cabin landing altitude selector
(d) barometric pressure selector.

48.52.18 Explain the operating principle of the following:

(a) pressure controller
(b) pressure relief valve
(c) negative pressure relief valve
(d) outflow valve.

48.52.20 Describe the emergency operation of a pressurisation system.

Section 3 Performance

48.60 Performance factors – takeoff

48.60.2 Explain the meaning of the following:

(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) reduced thrust
(p) balanced field length (BFL)
(q) balanced takeoff.

48.60.4 Explain the meaning of the following:

(a) V_{EF}
(b) V_1
(c) V_{MCG}
(d) V_{MCA}
(e) V_R
(f) V_{MU}
(g) V_{LOF}

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(h) V_{MBE}
(i) $V_{2.}$

48.60.6 Explain the factors affecting V_1.

48.60.8 Explain the factors affecting $V_{2.}$

48.60.10 State the relationship between:
(a) V_{EF} and V_1
(b) V_1 and V_R
(c) V_1 and V_{MCG}
(d) V_1 and V_{MBE}
(e) V_R and V_{MCA}
(f) V_2 and V_S
(g) V_S and V_{MCA}
(h) V_2 and $V_{MCA.}$

48.60.12 Describe a rejected takeoff (RTO).

48.60.14 Describe the procedures applied following an aeroplane malfunction on the takeoff roll, prior to V_1.

48.60.16 Describe the procedures applied following an engine failure or fire at or above V_1.

48.60.18 Describe the likely outcome of continuing a takeoff following an engine failure earlier than 2 seconds prior to V_1.

48.60.20 Describe the likely outcome of aborting a takeoff following an engine failure after V_1 on a runway length limited takeoff.

48.60.22 Explain the meaning of the following:
(a) takeoff path
(b) takeoff flight path
(c) gross climb gradient
(d) net climb gradient
(e) reference zero
(f) net takeoff flight path (NTOFP).

48.60.24 State the minimum heights between the NTOFP and obstacles which must be maintained in the following situations:
(a) straight flight path from a dry runway
(b) straight flight path from a wet runway
(c) turning flight path from a dry runway
(d) turning flight path from a wet runway.

48.60.26 Define:
(a) 1st climb segment

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(b) 2nd climb segment
(c) 3rd climb segment
(d) 4th climb segment.

48.60.28 In each of the initial climb segments, describe the:
(a) aeroplane configuration
(b) required power/thrust setting
(c) speed
(d) obstacle clearance heights
(e) minimum climb gradients (net and gross).

48.60.30 Describe the lateral dimensions of the net takeoff flight path (NTOFP).

48.60.32 Explain the effect of near-in obstacles in the NTOFP on TODA.

48.60.34 Explain how initial climb performance is affected by various takeoff:
(a) configurations
(b) procedures.

48.60.36 Describe the circumstances under which reduced thrust/power may be used for takeoff.

48.60.38 Explain how the reduced thrust/power is determined for takeoff.

48.60.40 Define a:
(a) wet runway
(b) contaminated runway.

48.60.42 Describe the effect of wet or contaminated runways on takeoff performance.

48.60.44 Explain the environmental factors which affect an aeroplane's takeoff performance.

48.60.46 Explain the environmental factors which affect an aeroplane's initial climb performance.

48.60.48 Explain the effect of runway dimensions on an aeroplane’s takeoff performance.

48.60.50 Explain the effect of tyre and brake energy limitations on an aeroplane's takeoff performance.

48.60.52 Explain how flight manual data is used to construct specimen runway performance information.

48.60.54 Explain the application of a balanced field length including the:
(a) relationship between takeoff distance, accelerate stop distance and V_1
(b) effect of a stopway on the allowed takeoff weight and appropriate V_1
(c) effect of a clearway on the allowed takeoff weight and appropriate V_1.

48.60.56 Explain the factors which affect an aeroplane's enroute climb performance.

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48.62	**Performance factors - cruise**
48.62.2	Define design manoeuvring speed (V_A).
48.62.4	Explain the derivation of V_A.
48.62.6	Explain the effect of weight on V_A.
48.62.8	Define turbulence penetration speed (V_B).
48.62.10	Explain the derivation of V_B.
48.62.12	Explain the meaning of ‘low speed buffet’.
48.62.14	Explain the meaning of ‘high speed buffet’.
48.62.16	Explain the meaning of ‘buffet margin’.
48.62.18	Define the term ‘coffin corner’.
48.62.20	Explain the ‘coffin corner’ recovery considerations.
48.62.22	Describe the influence of the following on the buffet margin: (a) pressure altitude (b) aeroplane weight (c) load factor.
48.62.24	Explain the purpose of step climbs used on long distance flights.
48.62.26	Explain the factors which affect the choice of optimum altitude.
48.62.28	Explain the factors which may limit the maximum operating altitude.
48.62.30	Explain the factors which affect an aeroplane's cruise performance.
48.62.32	Explain the use of ‘cost index’ to determine the appropriate speeds for climb and cruise.
48.62.34	Differentiate between max range cruise (MRC) speed and long range cruise (LRC).
48.62.36	Explain the effect of wind on cruise range (distance and speed).
48.62.38	Explain the effect of weight on cruise range (distance and speed).
48.62.40	Describe the flight profile which provides greatest fuel efficiency.
48.62.42	Describe the flight profile which allows the longest time airborne before reaching minimum reserves.
48.62.44	Describe the flight profile which best utilises fuel before it is lost out of a leaking tank.

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48.62.46 Explain the meaning of ‘drift down’.

48.62.48 Identify factors which affect the enroute drift down flight path.

48.62.50 Describe the minimum obstacle clearance enroute net flight path.

48.62.52 State the thrust to be set on the operating engine(s) during drift down.

48.62.54 State the thrust to be set in the case of critical terrain clearance during drift down.

48.64 Performance factors - approach and landing

48.64.2 Explain the meaning of the following:

(a) V_{MO}/M_{MO}
(b) V_{LE}
(c) V_{LO}
(d) V_{FE}
(e) V_{REF}
(f) V_{APP} (Velocity Approach)
(g) V_{TT}/T_{TS} (otherwise known as V_{AT} and V_T).

48.64.4 State the relationship between:

(a) configuration and manoeuvring speed
(b) V_{REF} and V_S.

48.64.6 Explain the factors which affect an aeroplane's descent performance.

48.64.8 Explain the effect of weight on descent planning.

48.64.10 Calculate the top of descent point to make good a specified height and distance, given a descent profile in nautical miles per 1000 feet.

48.64.12 Explain the factors which affect an aeroplane's approach and landing performance.

48.64.14 Explain the meaning of 'screen height' on landing.

48.64.16 Explain the meaning of:

(a) demonstrated landing distance (DLD)
(b) landing distance required (LDR).

48.64.18 Describe the determination of:

(a) demonstrated landing distance
(b) landing distance required.

48.64.20 Explain the meaning of landing distance available (LDA).

48.64.22 Describe the determination of landing distance available.

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48.64.24 State the relationship between demonstrated landing distance and landing distance available.

48.64.26 Explain the meaning of ‘approach climb’.

48.64.28 Explain the configuration and minimum climb gradient used to determine the approach climb limited landing weight.

48.64.30 Explain the meaning of ‘landing climb’.

48.64.32 Explain the configuration and minimum climb gradient used to determine the landing climb limited landing weight.

48.64.34 Describe the one engine inoperative landing committal/decision height.

48.64.36 Describe the effect of the following system malfunctions on an aeroplane's landing performance:

(a) flap restrictions
(b) anti-skid failure
(c) reduced brake availability.

48.64.38 Describe the effect of wet or contaminated runways on landing performance.

48.64.40 Define ‘hydroplaning’ (aquaplaning).

48.64.42 Calculate the speed at which hydroplaning may occur for a given tyre pressure.

48.64.44 Explain the technical factors determining minimum ‘turnaround time'.

48.90 Performance - calculations and data extraction

48.90.2 Using appropriate weather, load, airfield and aeroplane performance data, extract/calculate:

(a) takeoff distance available
(b) accelerate stop distance available
(c) maximum takeoff weight
(d) takeoff thrust (including reduced thrust)
(e) maximum continuous thrust
(f) takeoff speeds
(g) flap retraction configuration
(h) air conditioning pack configuration for takeoff
(i) stabiliser trim setting
(j) climb thrust (including reduced thrust)
(k) climb speed schedules
(l) cruise thrust
(m) cruise speed schedules
(n) maximum and optimum cruise levels
(o) optimum aircraft weight for a step climb

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(p) high and low speed buffet margins
(q) turbulence penetration speeds
(r) one engine inoperative (OEI) drift down thrust, speeds, flight paths and level-off altitude
(s) time and distance to touchdown
(t) landing distances available
(u) landing speeds
(v) landing distance required
(w) maximum landing weight
(x) go-around thrust.

48.92 Weight and balance - general

48.92.2 Explain the meaning of the following:

(a) % MAC
(b) empty weight (empty aeroplane weight)
(c) basic operating weight (aeroplane prepared for service weight)
(d) maximum zero fuel weight (MZFW)
(e) maximum ramp weight
(f) takeoff/brakes release weight (TOW/BRW)
(g) maximum takeoff weight (MTOW)
(h) regulated takeoff weight (RTOW)
(i) landing weight
(j) maximum landing weight.

48.92.4 Explain why the centre of gravity (CofG) must be within the certified limits.

48.92.6 Describe the influence of fuel loading on the centre of gravity.

48.92.8 Explain the effect of centre of gravity on fuel consumption.

48.94 Weight and balance - calculations and data extraction

48.94.2 Using representative air-transport aeroplane loading and performance data, extract/calculate:

(a) ramp weight
(b) takeoff/brakes release weight (TOW/BRW)
(c) regulated takeoff weight (RTOW)
(d) zero fuel weight (ZFW)
(e) landing weight
(f) available payload
(g) the aeroplane’s CofG at any given time.

48.94.4 Solve the following loading problems to determine the:

(a) revised CofG position when loading or offloading weight
(b) revised CofG position when relocating load components

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(c) load change required to place the CofG within limits
(d) load position change to place the CofG within limits.

48.96 Aeroplane and pavement classification systems

48.96.2 Given representative air-transport aeroplane and runway data, determine the:
(a) runway Pavement Classification Number (PCN)
(b) aeroplane Aircraft Classification Number (ACN).

48.96.4 Given representative air-transport aeroplane and runway data, use the ACN-PCN method to determine if the runway and associated taxiways will support the weight of the aeroplane.