M. SUBJECT 081 — PRINCIPLES OF FLIGHT (AEROPLANE)

(1) The following standard conventions are used for certain mathematical symbols:

*	multiplication
≥	greater than or equal to
≤	less than or equal to
SQRT( )	square root of the function, symbol or number in round brackets

(2) Normally, it should be assumed that the effect of a variable under review is the only variation that needs to be addressed, unless specifically stated otherwise.

(3) Candidates are expected in simple calculations to be able to convert knots (kt) into metres/second (m/s), and know the appropriate conversion factors by heart.

(4) In the subsonic range, as covered under subject 081 01, compressibility effects normally are not considered, unless specifically mentioned.

(5) For those questions related to propellers (subject 081 07), as a simplification of the physical reality, the inflow speed into the propeller plane is taken as the aeroplane's TAS. In addition, when discussing propeller rotational direction, it will always be specified as seen from behind the propeller plane.

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
080 00 00 00	**PRINCIPLES OF FLIGHT**						
081 00 00 00	**PRINCIPLES OF FLIGHT — AEROPLANE**						
081 01 00 00	**SUBSONIC AERODYNAMICS**						
081 01 01 00	**Basics, laws and definitions**						
081 01 01 01	**Laws and definitions**						
LO	— List the SI units of measurement for mass, acceleration, weight, velocity, density, temperature, pressure, force, wing loading and power. — Define 'mass', 'force', 'acceleration' and 'weight'. — State and interpret Newton's laws. — State and interpret Newton's first law. — State and interpret Newton's second law. — State and interpret Newton's third law. — Explain air density.	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	— List the atmospheric properties that effect air density. — Explain how temperature and pressure changes affect density. — Define 'static pressure'. — Define 'dynamic pressure'. — Define the 'formula for dynamic pressure'. — Apply the formula for a given altitude and speed. — State Bernoulli's equation. — Define 'total pressure'. — Apply the equation to a Venturi. — Describe how the IAS is acquired from the pitot-static system. — Describe the relationship between density, temperature and pressure for air. — Describe the Equation of Continuity. — Define 'IAS', 'CAS', 'EAS', 'TAS'.						
081 01 01 02	**Basics about airflow**						
LO	— Describe steady and unsteady airflow. — Explain the concept of a streamline. — Describe and explain airflow through a stream tube. — Explain the difference between two and three-dimensional airflow.	x	x				
081 01 01 03	**Aerodynamic forces and moments on aerofoils**						
LO	— Describe the force resulting from the pressure distribution around an aerofoil. — Resolve the resultant force into the components 'lift' and 'drag'. — Describe the direction of lift and drag. — Define the 'aerodynamic moment'. — List the factors that affect the aerodynamic moment. — Describe the aerodynamic moment for a symmetrical aerofoil. — Describe the aerodynamic moment for a positively and negatively cambered aerofoil. — Forces and equilibrium of forces	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	(refer to 081 08 00 00). — Define 'angle of attack'.						
081 01 01 04	**Shape of an aerofoil section**						
LO	Describe the following parameters of an aerofoil section: — leading edge; — trailing edge; — chord line; — thickness to chord ratio or relative thickness; — location of maximum thickness; — camber line; — camber; — nose radius. Describe a symmetrical and an asymmetrical aerofoil section.	x	x				
081 01 01 05	**Wing shape**						
LO	Describe the following parameters of a wing: — span; — tip and root chord; — taper ratio; — wing area; — wing planform; — mean geometric chord; — mean aerodynamic chord (MAC); — aspect ratio; — dihedral angle; — sweep angle; — wing twist; — geometric; — aerodynamic; — angle of incidence. *Remark: In certain textbooks, angle of incidence is used as angle of attack. For Part-FCL theoretical knowledge examination purposes this use is discontinued and the angle of incidence is defined as the angle between the aeroplane longitudinal axis and the wing-root chord line.*	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
081 01 02 00	**Two-dimensional airflow around an aerofoil**						
081 01 02 01	**Streamline pattern**						
LO	— Describe the streamline pattern around an aerofoil. — Describe converging and diverging streamlines and their effect on static pressure and velocity. — Describe upwash and downwash.	x	x				
081 01 02 02	**Stagnation point**						
LO	— Describe the stagnation point. — Explain the effect on the stagnation point of angle-of-attack changes. — Explain local-pressure changes.	x	x				
081 01 02 03	**Pressure distribution**						
LO	— Describe pressure distribution and local speeds around an aerofoil including effects of camber and angle of attack. — Describe where the minimum local static pressure is typically situated on an aerofoil.	x	x				
081 01 02 04	**Centre of pressure and aerodynamic centre**						
LO	Explain centre of pressure and aerodynamic centre.	x	x				
081 01 02 05	**Lift and downwash**						
LO	Explain the association between lift and downwash.	x	x				
081 01 02 06	**Drag and wake**						
LO	— List two physical phenomena that cause drag. — Describe skin friction drag. — Describe pressure (form) drag. — Explain why drag and wake cause loss of energy (momentum).	x	x				
081 01 02 07	**Influence of angle of attack**						
LO	Explain the influence of angle of attack on lift.	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
081 01 02 08	**Flow separation at high angles of attack**						
LO	Refer to 081 01 08 01.	x	x				
081 01 02 09	**The lift — α graph**						
LO	— Describe the lift and angle-of-attack graph. — Explain the significant points on the graph. — Describe lift against α graph for a symmetrical aerofoil.	x	x				
081 01 03 00	**Coefficients**						
LO	Explain why coefficients are used in general.	x	x				
081 01 03 01	**The lift coefficient C_l**						
LO	— Describe the lift formula and perform simple calculations. — Describe the **C_l – α** graph (symmetrical and positively/ negatively cambered aerofoils). — Describe the typical difference in **C_l – α** graph for fast and slow aerofoil design. — Define 'C_{lMAX}' and 'α_{stall}' on the graph.	x	x				
081 01 03 02	**The drag coefficient C_d**						
LO	— Describe the drag formula and perform simple calculations. — Discuss the effect of the shape of a body on the drag coefficient. — Describe the **C_l – C_d** graph (aerofoil polar). — Indicate minimum drag on the graph. — Explain why the **C_l–C_d** ratio is important as a measure of performance. — State the normal values of **C_l–C_d**.	x	x				
081 01 04 00	**Three-dimensional airflow about an aeroplane**						
LO	— Define 'angle of attack.' *Remark: For theoretical knowledge examination purposes, the angle-of-attack definition requires a reference line. This*	x	x				

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	reference line for 3-D has been chosen to be the longitudinal axis and for 2-D the chord line. — Explain the difference between the angle of attack and the attitude of an aeroplane.						
081 01 04 01	**Streamline pattern**						
LO	— Describe the general streamline pattern around the wing, tail section and fuselage. — Explain and describe the causes of spanwise flow over top and bottom surfaces. — Describe tip vortices and local α. — Explain how tip vortices vary with angle of attack. — Explain upwash and downwash due to tip vortices. — Describe spanwise lift distribution including the effect of wing planform. — Describe the causes, distribution and duration of the wake turbulence behind an aeroplane. — Describe the influence of flap deflection on the tip vortex. — List the parameters that influence wake turbulence.	x	x				
081 01 04 02	**Induced drag**						
LO	— Explain what causes the induced drag. — Describe the approximate formula for the induced drag coefficient. — State the factors that affect induced drag. — Describe the relationship between induced drag and total drag in the cruise. — Describe the effect of mass on induced drag at a given IAS. — Describe the means to reduce induced drag: • aspect ratio; • winglets;	x	x				

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	• tip tanks; • wing twist; • camber change. — Describe the influence of lift distribution on induced drag. — Describe the influence of tip vortices on the angle of attack. — Explain induced and effective local angle of attack. — Explain the influence of the induced angle of attack on the direction of the lift vector. — Explain the relationship between induced drag and: • speed; • aspect ratio; • wing planform; • bank angle in a horizontal coordinated turn. — Explain the induced drag coefficient. — Explain the relationship between the induced drag coefficient and the angle-of-attack or lift coefficient. — Explain the influence of induced drag on: • C_L–angle-of-attack graph, how the effect on the graph when comparing high and low aspect ratio wings; • C_L–C_D (aeroplane polar), show the effect on the graph when comparing high and low aspect ratio wings; • parabolic aeroplane polar in a graph and as a formula ($C_D = C_{Dp} + kC_L^2$).						
081 01 05 00	**Total drag**						
LO	State that total drag consists of parasite drag and induced drag.	x	x				
081 01 05 01	**Parasite drag**						
LO	— List the types of drag that are included in parasite drag. — Describe form (pressure) drag. — Describe interference drag. — Describe friction drag.	x	x				

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081 01 05 02	**Parasite drag and speed**						
LO	Describe the relationship between parasite drag and speed.	x	x				
081 01 05 03	**Induced drag and speed**						
LO	Refer to 081 01 04 02.	x	x				
081 01 05 04	***Intentionally left blank***						
081 01 05 05	**Total drag and speed**						
LO	— Explain the total drag–speed graph and the constituent drag components. — Indicate the speed for minimum drag.	x	x				
081 01 05 06	***Intentionally left blank***						
081 01 05 07	**The total drag–speed graph**						
LO	— Describe the effect of aeroplane gross mass on the graph. — Describe the effect of pressure altitude on: • drag–IAS graph; • drag–TAS graph. — Describe speed stability from the graph. — Describe non-stable, neutral and stable IAS regions. — Explain what happens to the IAS and drag in the non-stable region if speed suddenly decreases.	x	x				
081 01 06 00	**Ground effect**						
LO	Explain what happens to the tip vortices, downwash, airflow pattern, lift and drag in ground effect.	x	x				
081 01 06 01	**Effect on C_{Di}**						
LO	— Describe the influence of ground effect on C_{Di} and induced angle of attack. — Explain the effects on entering and leaving ground effect.	x	x				
081 01 06 02	**Effect on α_{stall}**						

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe the influence of ground effect on α_{stall}.	x	x				
081 01 06 03	**Effect on C_L**						
LO	Describe the influence of ground effect on C_L.	x	x				
081 01 06 04	**Effect on take-off and landing characteristics of an aeroplane**						
LO	— Describe the influence of ground effect on take-off and landing characteristics and performance of an aeroplane. — Describe the difference between: • high and low wing characteristics; • high and low tail characteristics. — Explain the effects on static pressure measurements at the static ports when entering and leaving ground effect.	x	x				
081 01 07 00	**The relationship between lift coefficient and speed in steady, straight and level flight**						
081 01 07 01	**Represented by an equation**						
LO	Explain the effect on C_L during speed increase/decrease in steady, straight and level flight, and perform simple calculations.	x	x				
081 01 07 02	**Represented by a graph**						
LO	Explain, by using a graph, the effect on speed of C_L changes at a given weight.	x	x				
081 01 08 00	**The stall**						
081 01 08 01	**Flow separation at increasing angles of attack**						
LO	— Define the 'boundary layer'. — Describe the thickness of a typical boundary layer.	x	x				

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	— List the factors that affect thickness. — Describe the laminar layer. — Describe the turbulent layer. — Define the 'transition point'. — List the differences between laminar and turbulent boundary layers. — Explain why the laminar boundary layer separates easier than the turbulent one. — List the factors that slow down the airflow over the aft part of an aerofoil, as the angle of attack increases. — Define the 'separation point' and describe its location as a function of angle of attack. — Define the 'critical stall angle of attack'. — Describe the influence of increasing the angle of attack on: • the forward stagnation point; • the pressure distribution; • the location of the centre of pressure (straight and swept back wing); • C_L and L; • C_D and D; • the pitching moment (straight and swept back wing); • the downwash at the horizon stabiliser. — Explain what causes the possible natural buffet on the controls in a pre-stall condition. — Describe the effectiveness of the flight controls in a pre-stall condition. — Describe and explain the normal post-stall behaviour of a wing/ aeroplane; — Describe the dangers of using the controls close to the stall.						
081 01 08 02	**The stall speed**						
LO	— Explain V_{S0}, V_{S1}, V_{SR}, V_{S1g}. — Solve the 1G stall speed from the lift formula. — Describe and explain the influence of the following parameters on stall	x	x				

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	speed: • centre of gravity; • thrust component; • slipstream; • wing loading; • mass; • wing contamination; • angle of sweep; • altitude (for compressibility effects, see 081 02 03 02). — Define the 'load factor n'. — Explain why the load factor increases in a turn. — Explain why the load factor increases in a pull-up and decreases in a push-over manoeuvre. — Describe and explain the influence of the 'load factor n' on stall speed. — Explain the expression 'accelerated stall'. *Remark: Sometimes accelerated stall is also erroneously referred to as high-speed stall. This latter expression will not be used for subject 081.* — Calculate the change of stall speed as a function of the load factor. — Calculate the increase of stall speed in a horizontal coordinated turn as a function of bank angle. — Calculate the change of stall speed as a function of the gross mass.						
081 01 08 03	**The initial stall in span-wise direction**						
LO	— Explain the initial stall sequence on the following platforms: • elliptical; • rectangular; • moderate and high taper; • sweepback or delta. — Explain the influence of geometric twist (wash out) and aerodynamic twist. — Explain the influence of deflected ailerons. — Explain the influence of fences, vortilons, saw teeth, vortex	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	generators.						
081 01 08 04	**Stall warning**						
LO	— Explain why stall warning is necessary. — Explain when aerodynamic and artificial stall warnings are used. — Explain why CS-23 and CS-25 require a margin to stall speed. — Describe: • buffet; • stall strip; • flapper switch (leading-edge stall-warning vane); • angle-of-attack vane; • angle-of-attack probe; • stick shaker. — Describe the recovery after: • stall warning; • stall; • stick-pusher actuation.	x	x				
081 01 08 05	**Special phenomena of stall**						
LO	— Describe the basic stall requirements for transport category aeroplanes. — Explain the difference between power-off and power-on stalls and recovery. — Describe stall and recovery in a climbing and descending turn. — Describe the effect on stall and recovery characteristics of: • wing sweep (consider both forward and backward sweep); • T-tailed aeroplane; • canards. — Describe super-stall or deep-stall. — Describe the philosophy behind the stick-pusher system. — Explain the effect of ice, frost or snow on the stagnation point. — Explain the absence of stall warning. — Explain the abnormal behaviour of the stall. — Describe and explain cause and	x	x				

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	effects of the stabiliser stall (negative tail stall). — Describe when to expect in-flight icing. — Explain how the effect is changed when retracting/ extending lift augmentation devices. — Describe how to recover from a stall after a configuration change caused by in-flight icing. — Explain the effect of a contaminated wing. — Explain what 'on-ground' icing is. — Describe the aerodynamic effects of de-icing/anti-ice fluid after the holdover time has been reached. — Describe the aerodynamic effects of heavy tropical rain on stall speed and drag. — Explain how to avoid spins. — List the factors that cause a spin to develop. — Describe spin development, recognition and recovery. — Describe the differences in recovery techniques for aeroplanes that have different mass distributions between the wings and the fuselage.						
081 01 09 00	**C_{LMAX} augmentation**						
081 01 09 01	**Trailing-edge flaps and the reasons for use in take-off and landing**						
LO	— Describe trailing-edge flaps and the reasons for their use during take-off and landing. — Identify the different types of trailing-edge flaps given a relevant diagram: • split flaps; • plain flaps; • slotted flaps; • fowler flaps. — Describe their effect on wing geometry. — Describe how the wing's effective camber increases.	x	x				

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	— Describe how the effective chord line differs from the normal chord line. — Describe their effect on: • the location of centre of pressure; • pitching moments; • stall speed. — Compare their influence on the C_L–α graph: • indicate the variation in C_L at any given angle of attack; • indicate the variation in C_D at any given angle of attack; • indicate their effect on C_{LMAX}; • indicate their effect on the stall or critical angle of attack; • indicate their effect on the angle of attack at a given C_L. — Compare their influence on the C_L–C_D graph: • indicate how the $(C_L/C_D)_{MAX}$ differs from that of a clean wing. — Explain the influence of trailing-edge flap deflection on the glide angle. — Describe flap asymmetry: • explain the effect on aeroplane controllability. — Describe trailing-edge flap effect on take-off and landing: • explain the advantages of lower-nose attitudes; • explain why take-off and landing speeds/distances are reduced.						
081 01 09 02	**Leading-edge devices and the reasons for their use in take-off and landing**						
LO	— Describe leading-edge high-lift devices. — Identify the different types of leading-edge high-lift devices given a relevant diagram: • Krueger flaps; • variable camber flaps; • slats.	x	x				

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	— State their effect on wing geometry. — Describe the function of the slot. — Describe how the wing's effective camber increases. — Describe how the effective chord line differs from the normal chord line. — State their effect on the stall speed, also in comparison with trailing edge flaps. — Compare their influence on the C_L–α graph, compared with trailing-edge flaps and a clean wing: • indicate the effect of leading-edge devices on C_{LMAX}; • explain how the C_L curve differs from that of a clean wing; • indicate the effect of leading-edge devices on the stall or critical angle of attack. — Compare their influence on the C_L–C_D graph; — Describe slat asymmetry: • describe the effect on aeroplane controllability. — Explain the reasons for using leading-edge high-lift devices on take-off and landing: • explain the disadvantage of increased nose-up attitudes; • explain why take-off and landing speeds/distances are reduced.						
081 01 09 03	**Vortex generators**						
LO	— Explain the purpose of vortex generators. — Describe their basic operating principle. — State their advantages and disadvantages.	x	x				
081 01 10 00	**Means to reduce the C_L–C_D ratio**						
081 01 10 01	**Spoilers and the reasons for use in the different phases of flight**						
LO	— Describe the aerodynamic functioning of spoilers: • roll spoilers;	x	x				

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	• flight spoilers (speed brakes); • ground spoilers (lift dumpers). — Describe the effect of spoilers on the C_L–α graph and stall speed. — Describe the influence of spoilers on the C_L–C_D graph and lift–drag ratio.						
081 01 10 02	**Speed brakes and the reasons for use in the different phases of flight**						
LO	— Describe speed brakes and the reasons for use in the different phases of flight. — State their influence on the C_L–C_D graph and lift–drag ratio. — Explain how speed brakes increase parasite drag. — Describe how speed brakes affect the minimum drag speed. — Describe their effect on rate and angle of descent.	x	x				
081 01 11 00	**The boundary layer**						
081 01 11 01	**Different types**						
LO	Refer to 081 01 08 01.	x	x				
081 01 11 02	**Their advantages and disadvantages on pressure drag and friction drag**						
081 01 12 00	**Aerodynamic degradation**						
081 01 12 01	**Ice and other contaminants**						
LO	— Describe the locations on an aeroplane where ice build-up will occur during flight. — Explain the aerodynamic effects of ice and other contaminants on: • lift (maximum lift coefficient); • drag; • stall speed; • stalling angle of attack; • stability and controllability. — Explain the aerodynamic effects of icing on the various phases during take-off.	x	x				
081 01 12 02	**Deformation and modification of**						

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	airframe, ageing aeroplanes						
LO	— Describe the effect of airframe deformation and modification of an ageing aeroplane on aeroplane performance. — Explain the effect on boundary layer condition of an ageing aeroplane.	x	x				
081 02 00 00	**HIGH-SPEED AERODYNAMICS**						
081 02 01 00	**Speeds**						
081 02 01 01	**Speed of sound**						
LO	— Define 'speed of sound'. — Explain the variation of the speed of sound with altitude. — Describe the influence of temperature on the speed of sound.	x					
081 02 01 02	**Mach number**						
LO	Define 'Mach number as a function of TAS and speed of sound'.	x					
081 02 01 03	**Influence of temperature and altitude on Mach number**						
LO	— Explain the absence of change of Mach number with varying temperature at constant flight level and calibrated airspeed. — Referring to 081 08 01 02 and 081 08 01 03, explain the relationship of Mach number, TAS and IAS during climb and descent at constant Mach number and IAS, and explain variation of lift coefficient, angle of attack, pitch and flight-path angle. — Referring to 081 06 01 04 and 081 06 01 05, explain that VMO can be exceeded during a descent at constant Mach number and that MMO can be exceeded during a climb at constant IAS.	x					
081 02 01 04	**Compressibility**						
LO	— State that compressibility means that density can change along a streamline.	x					

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	— Describe how the streamline pattern changes due to compressibility. — State that Mach number is a measure of compressibility.						
081 02 01 05	**Subdivision of aerodynamic flow**						
LO	— List the subdivision of aerodynamic flow: • subsonic flow; • transonic flow; • supersonic flow. — Describe the characteristics of the flow regimes listed above. — State that transport aeroplanes normally cruise at Mach numbers above M_{crit}.	x					
081 02 02 00	**Shock waves**						
LO	Define a 'shock wave'.	x					
081 02 02 01	**Normal shock waves**						
LO	Describe a normal shock wave with respect to changes in: — static temperature; — static and total pressure; — velocity; — local speed of sound; — Mach number; — density. Describe a normal shock wave with respect to orientation relative to the wing surface. Explain the influence of increasing Mach number on a normal shock wave, at positive lift, with respect to: — strength; — length; — position relative to the wing; — second shock wave at the lower surface. Explain the influence of angle of attack on shock-wave intensity at constant Mach number.	x					

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	Discuss the bow wave.						
081 02 02 02	**Oblique shock waves**						
LO	Describe an oblique shock wave with respect to changes in: — static temperature; — static and total pressure; — velocity; — local speed of sound; — Mach number; — density. Compare the characteristics of normal and oblique shock waves.	x					
081 02 02 03	**Mach cone**						
LO	Define ‘Mach angle μ’ with a formula and perform simple calculations. Identify the Mach-cone zone of influence of a pressure disturbance due to the presence of the aeroplane. Explain ‘sonic boom’.	x					
081 02 03 00	**Effects of exceeding M_{crit}**						
081 02 03 01	**M_{crit}**						
LO	Define ‘M_{crit}’. Explain how a change in angle of attack influences M_{crit}.	x					
081 02 03 02	**Effect on lift**						
LO	Describe the behaviour of lift coefficient CL versus Mach number at constant angle of attack. Explain shock-induced separation, shock stall, and describe its relationship with Mach buffet. Define ‘shock stall’. *Remark: For theoretical knowledge examination purposes, the following*	x					

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	description is used for shock stall: Shock stall occurs when the lift coefficient, as a function of Mach number, reaches its maximum value (for a given angle of attack). Describe the consequences of exceeding M_{crit} with respect to: — gradient of the C_L–α graph; — C_{LMAX} (stall speed). Explain the change in stall speed (IAS) with altitude. Discuss the effect on critical or stalling angle of attack.						
081 02 03 03	**Effect on drag**						
LO	Describe wave drag. Describe the behaviour of drag coefficient C_D versus Mach number at constant angle of attack. Explain the effect of Mach number on the C_L–C_D graph. Define 'drag divergence Mach number' and explain the relation with M_{crit}.	x					
081 02 03 04	**Effect on pitching moment**						
LO	Discuss the effect of Mach number on the location of centre of pressure and aerodynamic centre. Explain 'tuck under' effect. List the methods of compensating for tuck under effect. Discuss the aerodynamic functioning of the Mach trim system. Discuss the corrective measures if the Mach trim fails.	x					
081 02 03 05	**Effect on control effectiveness**						

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LO	Discuss the effects on the functioning of control surfaces.	x					
081 02 04 00	**Buffet onset**						
LO	Explain the concept of buffet margin and describe the influence of the following parameters: — angle of attack; — Mach number; — pressure altitude; — mass; — load factor; — angle of bank; — CG location. Explain how the buffet onset boundary chart can be used to determine manoeuvre capability. Describe the effect of exceeding the speed for buffet onset. Explain aerodynamic ceiling and ‘coffin corner’. Explain the concept of the ‘1.3G’ altitude. Find (using an example graph): — buffet free range; — aerodynamic ceiling at a given mass; — load factor and bank angle at which buffet occurs at a given mass, Mach number and pressure altitude.	x					
081 02 05 00	**Means to influence M_{crit}**						
081 02 05 01	**Wing sweep**						
LO	Explain the influence of the angle of sweep on: — M_{crit}; — effective thickness/chord change or velocity component perpendicular to the quarter chord line. Describe the influence of the angle of sweep at subsonic speed on:	x					

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	— C_{LMAX}; — efficiency of high-lift devices. — pitch-up stall behaviour. Discuss the effect of wing sweep on drag.						
081 02 05 02	**Aerofoil shape**						
LO	Explain the use of thin aerofoils with reduced camber. Explain the main purpose of supercritical aerofoils. Identify the shape characteristics of a supercritical aerofoil shape. Explain the advantages and disadvantages of supercritical aerofoils for wing design.	x					
081 02 05 03	**Vortex generators**						
LO	Explain the use of vortex generators as a means to avoid or restrict flow separation.	x					
081 02 05 04	**Area ruling**						
LO	Explain area ruling in aeroplane design.	x					
081 03 00 00	***Intentionally left blank***						
081 04 00 00	**STABILITY**						
081 04 01 00	**Static and dynamic stability**						
081 04 01 01	**Basics and definitions**						
LO	Define 'static stability': — identify a statically stable, neutral and unstable condition (positive, neutral and negative static stability). Explain manoeuvrability. Explain why static stability is the opposite of manoeuvrability. Define 'dynamic stability': — identify a dynamically stable, neutral and unstable motion (positive, neutral and negative	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
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	dynamic stability); — identify periodic and aperiodic motion. Explain what combinations of static and dynamic stability will return an aeroplane to the equilibrium state after a disturbance.						
081 04 01 02	**Precondition for static stability**						
LO	Explain an equilibrium of forces and moments as the condition for the concept of static stability.	x	x				
081 04 01 03	**Sum of forces**						
LO	Identify the forces considered in the equilibrium of forces.	x	x				
081 04 01 04	**Sum of moments**						
LO	Identify the moments about all three axes considered in the equilibrium of moments. Discuss the effect of sum of moments not being zero.	x	x				
081 04 02 00	***Intentionally left blank***						
081 04 03 00	**Static and dynamic longitudinal stability**						
081 04 03 01	**Methods for achieving balance**						
LO	Explain the stabiliser and the canard as the means to satisfy the condition of nullifying the total sum of the moments about the lateral axis. Explain the influence of the location of the wing centre of pressure relative to the centre of gravity on the magnitude and direction of the balancing force on stabiliser and canard. Explain the influence of the indicated airspeed on the magnitude and direction of the balancing force on stabiliser and	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	canard. Explain the influence of the balancing force on the magnitude of the wing/fuselage lift. Explain the use of the elevator deflection or stabiliser angle for the generation of the balancing force. Explain the elevator deflection required to balance thrust changes.						
081 04 03 02	**Static longitudinal stability**						
LO	Explain the changes in aerodynamic forces when varying angle of attack for a static longitudinally stable aeroplane. Discuss the effect of CG location on pitch manoeuvrability.	x	x				
081 04 03 03	**Neutral point**						
LO	Define 'neutral point'. Explain why the location of the neutral point is only dependent on the aerodynamic design of the aeroplane.	x	x				
081 04 03 04	**Factors affecting neutral point**						
LO	Indicate the location of the neutral point relative to the locations of the aerodynamic centre of the wing and tail/canard. Explain the influence of the downwash variations with angle-of-attack variation on the location of the neutral point. Explain the contribution of engine nacelles.	x	x				
081 04 03 05	**Location of centre of gravity**						
LO	Explain the influence of the CG location on static longitudinal stability of the aeroplane.	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	Explain the CG forward and aft limits with respect to: — longitudinal control forces; — elevator effectiveness; — stability. Define 'static margin'.						
081 04 03 06	**The C_m–α graph**						
LO	Define the 'aerodynamic pitching moment coefficient (C_m)'. Describe the C_m–α graph with respect to: — positive and negative sign; — linear relationship; — angle of attack for equilibrium state; — relationship between the slope of the graph and static stability.	x	x				
081 04 03 07	**Factors affecting the C_m–α graph**						
LO	Explain: — the effect on the C_m–α graph of a shift of CG in the forward and aft direction; — the effect on the C_m–α graph when the elevator is moved up or down; — the effect on the C_m–α graph when the trim is moved; — the effect of the wing contribution and how it is affected by CG location; — the effect of the fuselage contribution and how it is affected by CG location; — the tail contribution; — the effect of aerofoil camber change.	x	x				
081 04 03 08	**The elevator position versus speed graph (IAS)**						
LO	Describe the elevator position speed graph. Explain: — the gradient of the elevator position	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	speed graph; — the influence of the airspeed on the stick position stability.						
081 04 03 09	**Factors affecting the elevator position–speed graph**						
LO	Explain the contribution on the elevator position–speed graph of: — the location of centre of gravity; — the trim (trim tab and stabiliser trim); — high-lift devices.	x	x				
081 04 03 10	**The stick force versus speed graph (IAS)**						
LO	Define the ‘stick force speed graph’. Describe the minimum gradient for stick force versus speed that is required for certification according to CS-23 and CS-25. Explain the importance of the stick force gradient for good flying qualities of an aeroplane. Identify the trim speed in the stick force speed graph. Explain how a pilot perceives stable static longitudinal stick force stability.	x	x				
081 04 03 11	**Factors affecting the stick force versus speed graph**						
LO	Explain the contribution of: — the location of the centre of gravity; — the trim (trim tab and stabiliser trim); — down spring; — bob weight; — friction.	x	x				
LO	Explain the contribution of Mach number — Ref. 081 02 03 04.	x					
081 04 03 12	**The manoeuvring stability/stick force per G**						
LO	Define the ‘stick force per G’.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
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	Explain why: — the stick force per G has a prescribed minimum and maximum value; — the stick force per G decreases with pressure altitude at the same indicated airspeed.						
081 04 03 13	***Intentionally left blank***						
081 04 03 14	**Factors affecting the manoeuvring stability/stick force per G**						
LO	Explain the influence on stick force per G of: — CG location; — trim setting; — a down spring in the control system; — a bob weight in the control system.	x	x				
081 04 03 15	**Stick force per G and the limit-load factor**						
LO	Explain why the prescribed minimum and maximum values of the stick force per G are dependent on the limit-load factor. Calculate the stick force to achieve a certain load factor at a given manoeuvre stability.	x	x				
081 04 03 16	**Dynamic longitudinal stability**						
LO	Describe the phugoid and short-period motion in terms of period, damping, variations (if applicable) in speed, altitude and angle of attack. Explain why short-period motion is more important for flying qualities than the phugoid. Define and describe ‘pilot-induced oscillations’. Explain the effect of high altitude on dynamic stability. Describe the influence of the CG location on the dynamic longitudinal stability of the	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	aeroplane.						
081 04 04 00	**Static directional stability**						
LO	Define 'static directional stability'. Explain the effects of static directional stability being too weak or too strong.	x	x				
081 04 04 01	**Sideslip angle β**						
LO	Define 'sideslip angle'. Identify β as the symbol used for the sideslip angle.	x	x				
081 04 04 02	**Yaw-moment coefficient C_n**						
LO	Define the 'yawing-moment coefficient C_n'. Define the relationship between C_n and β for an aeroplane with static directional stability.	x	x				
081 04 04 03	**C_n–β graph**						
LO	Explain why: — C_n depends on the angle of sideslip; — C_n equals zero for that angle of sideslip that provides static equilibrium about the aeroplane's normal axis; — if no asymmetric engine thrust, flight control or loading condition prevails, the equilibrium angle of sideslip equals zero. Identify how the slope of the C_n–β graph is a measure for static directional stability.	x	x				
081 04 04 04	**Factors affecting static directional stability**						
LO	Describe how the following aeroplane components contribute to static directional stability: — wing; — fin;	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
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	— dorsal fin; — ventral fin; — angle of sweep of the wing; — angle of sweep of the fin; — fuselage at high angles of attack; — strakes. Explain why both the fuselage and the fin contribution reduce static directional stability when the CG moves aft.						
081 04 05 00	**Static lateral stability**						
LO	Define 'static lateral stability'. Explain the effects of static lateral stability being too weak or too strong.	x	x				
081 04 05 01	**Bank angle Ø**						
LO	Define 'bank angle Ø'.	x	x				
081 04 05 02	**The roll-moment coefficient C_l**						
LO	Define the 'roll-moment coefficient C_l'.	x	x				
081 04 05 03	**Contribution of sideslip angle β**						
LO	Explain how without coordination the bank angle creates sideslip angle.	x	x				
081 04 05 04	**The C_l–β graph**						
LO	Describe C_l–β graph. Identify the slope of the C_l–β graph as a measure for static lateral stability.	x	x				
081 04 05 05	**Factors affecting static lateral stability**						
LO	Explain the contribution to the static lateral stability of: — dihedral, anhedral; — high wing, low wing; — sweep angle of the wing; — ventral fin; — vertical tail. Define 'dihedral effect'.	x	x				
081 04 05 06	***Intentionally left blank***						

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
081 04 06 00	**Dynamic lateral/directional stability**						
081 04 06 01	**Effects of asymmetric propeller slipstream**						
081 04 06 02	**Tendency to spiral dive**						
LO	Explain how lateral and directional stability are coupled. Explain how high-static directional stability and a low-static lateral stability may cause spiral divergence (unstable spiral dive), and under which conditions the spiral dive mode is neutral or stable. Describe an unstable spiral dive mode with respect to deviations in speed, bank angle, nose low-pitch attitude and decreasing altitude.	x	x				
081 04 06 03	**Dutch roll**						
LO	Describe Dutch roll. Explain: — why Dutch roll occurs when the static lateral stability is large compared with static directional stability; — the condition for a stable, neutral or unstable Dutch roll motion; — the function of the yaw damper; — the actions to be taken in case of non-availability of the yaw damper.	x	x				
LO	State the effect of Mach number on Dutch roll.	x					
081 04 06 04	**Effects of altitude on dynamic stability**						
LO	Explain that increased pressure altitude reduces dynamic lateral/directional stability.	x	x				
081 05 00 00	**CONTROL**						
081 05 01 00	**General**						

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
081 05 01 01	**Basics, the three planes and three axes**						
LO	Define: — lateral axis; — longitudinal axis; — normal axis. Define: — pitch angle; — bank angle; — yaw angle. Describe the motion about the three axes. Name and describe the devices that control these motions.	x	x				
081 05 01 02	**Camber change**						
LO	Explain how camber is changed by movement of a control surface.	x	x				
081 05 01 03	**Angle-of-attack change**						
LO	Explain the influence of local angle-of-attack change by movement of a control surface.	x	x				
081 05 02 00	**Pitch (longitudinal) control**						
081 05 02 01	**Elevator/all-flying tails**						
LO	Explain the working principle of the elevator/all-flying tail and describe its function. Describe the loads on the tailplane over the whole speed range.	x	x				
081 05 02 02	**Downwash effects**						
LO	Explain the effect of downwash on the tailplane angle of attack. Explain in this context the use of a T-tail or stabiliser trim.	x	x				
081 05 02 03	**Ice on tail**						
LO	Explain how ice can change the	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	aerodynamic characteristics of the tailplane. Explain how this can affect the tail's proper function.						
081 05 02 04	**Location of centre of gravity**						
LO	Explain the relationship between elevator deflection and CG location to produce a given aeroplane response. Explain the effect of forward CG limit on pitch control.	x	x				
081 05 02 05	**Moments due to engine thrust**						
LO	Describe the effect of engine thrust on pitching moments for different engine locations.	x	x				
081 05 03 00	**Yaw (directional) control**						
LO	Explain the working principle of the rudder and describe its function. — State the relationship between rudder deflection and the moment about the normal axis; — Describe the effect of sideslip on the moment about the normal axis.	x	x				
081 05 03 01	**Rudder limiting**						
LO	Explain why and how rudder deflection is limited on transport aeroplanes.	x					
081 05 04 00	**Roll (lateral) control**						
081 05 04 01	**Ailerons**						
LO	Explain the functioning of ailerons. Describe the adverse effects of ailerons. (Refer to 081 05 04 04 and 081 06 01 02) Explain in this context the use of inboard and outboard ailerons. Explain outboard-aileron lockout and conditions under which this feature is	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	used. Describe the use of aileron deflection in normal flight, flight with sideslip, crosswind landings, horizontal turns, flight with one engine out. Define 'roll rate'. List the factors that affect roll rate. Flaperons, aileron droop.						
081 05 04 02	***Intentionally left blank***						
081 05 04 03	**Spoilers**						
LO	Explain how spoilers can be used to control the rolling movement in combination with or instead of the ailerons.	x	x				
081 05 04 04	**Adverse yaw**						
LO	Explain how the use of ailerons induces adverse yaw.	x	x				
081 05 04 05	**Means to avoid adverse yaw**						
LO	Explain how the following reduce adverse yaw: — Frise ailerons; — differential aileron deflection; — rudder aileron cross-coupling; — roll spoilers.	x	x				
081 05 05 00	**Roll/yaw interaction**						
LO	Explain the secondary effect of roll. Explain the secondary effect of yaw.	x	x				
081 05 06 00	**Means to reduce control forces**						
081 05 06 01	**Aerodynamic balance**						
LO	Describe the purpose of aerodynamic balance. Describe the working principle of the nose and horn balance. Describe the working principle of internal	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	balance. Describe the working principle and the application of: — balance tab; — anti-balance tab; — spring tab; — servo tab.						
081 05 06 02	**Artificial means**						
LO	Describe fully powered controls. Describe power-assisted controls. Explain why artificial feel is required. Explain the inputs to an artificial feel system.	x	x				
081 05 07 00	**Mass balance**						
LO	Refer to 081 06 01 01 for mass balance. Refer to 081 04 03 11 and 081 04 03 14 for bob weight.	x	x				
081 05 08 00	**Trimming**						
081 05 08 01	**Reasons to trim**						
LO	State the reasons for trimming devices. Explain the difference between a trim tab and the various balance tabs.	x	x				
081 05 08 02	**Trim tabs**						
LO	Describe the working principle of a trim tab including cockpit indications.	x	x				
081 05 08 03	**Stabiliser trim**						
LO	Explain the advantages and disadvantages of a stabiliser trim compared with a trim tab. Explain elevator deflection when the aeroplane is trimmed in the case of fully powered and power-assisted pitch controls.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	Explain the factors influencing stabiliser setting. Explain the influence of take-off stabiliser trim setting on rotation characteristics and stick force during take-off rotation at extremes of CG position. Discuss the effects of jammed and runaway stabiliser. Explain the landing considerations with a jammed stabiliser.						
081 06 00 00	**LIMITATIONS**						
081 06 01 00	**Operating limitations**						
081 06 01 01	**Flutter**						
LO	Describe the phenomenon of flutter and list the factors: — elasticity; — backlash; — aeroelastic coupling; — mass distribution; — structural properties — IAS. List the flutter modes of an aeroplane: — wing, — tailplane, — fin, — control surfaces including tabs. Describe the use of mass balance to alleviate the flutter problem by adjusting the mass distribution: — wing-mounted pylons; — control surface mass balance. List the possible actions in the case of flutter in flight.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
081 06 01 02	**Aileron reversal**						
LO	Describe the phenomenon of aileron reversal: — at low speeds; — at high speeds. Describe the aileron reversal speed in relationship to V_{NE} and V_{NO}.	x	x				
081 06 01 03	**Landing gear/flap operating**						
LO	Describe the reason for flap/landing gear limitations. — define 'V_{LO}'; — define 'V_{LE}'. Explain why there is a difference between V_{LO} and V_{LE} in the case of some aeroplane types. Define 'V_{FE}'. Describe flap design features to prevent overload.	x	x				
081 06 01 04	**V_{MO}, V_{NO}, V_{NE}**						
LO	Define 'V_{MO}', 'V_{NO}', 'V_{NE}'. Describe the differences between V_{MO}, V_{NO} and V_{NE}. Explain the dangers of flying at speeds close to V_{NE}.	x	x				
081 06 01 05	**M_{MO}**						
LO	Define 'M_{MO}' and state its limiting factors.	x					
081 06 02 00	**Manoeuvring envelope**						
081 06 02 01	**Manoeuvring-load diagram**						
LO	Describe the manoeuvring-load diagram. Define limit and ultimate load factor and explain what can happen if these values are exceeded. Define 'V_A', 'V_C', 'V_D'.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	Identify the varying features on the diagram: — load factor 'n'; — speed scale, equivalent airspeed, EAS; — C_{LMAX} boundary; — accelerated stall speed (refer to 081 01 08 02). Describe the relationship between V_{MO} and V_C. State all the manoeuvring limit load factors applicable to CS-23 and CS-25 aeroplanes. Explain the relationship between V_A and V_S in a formula. Explain the adverse consequences of exceeding V_A.						
081 06 02 02	**Factors affecting the manoeuvring-load diagram**						
LO	State the relationship of mass to: — load factor limits; — accelerated stall speed limit; — V_A and V_C. Explain the relationship between V_A, aeroplane mass and altitude. Calculate the change of V_A with changing mass.	x	x				
LO	Describe the effect of altitude on Mach number, with respect to limitations. Explain why V_A loses significance at higher altitude where compressibility effects occur. Define 'M_C' and 'M_D' and their relation with V_C and V_D.	x					
081 06 03 00	**Gust envelope**						
081 06 03 01	**Gust-load diagram**						
LO	Recognise a typical gust-load diagram.	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	Identify the various features shown on the diagram: — gust-load factor ‘n’; — speed scale, equivalent airspeed and EAS; — C_{LMAX} boundary; — vertical gust velocities; — relationship of V_B to V_C and V_D. — gust limit load factor. Define ‘V_{RA}’, ‘V_B’. Discuss considerations for the selection of this speed. Explain the adverse effects on the aeroplane when flying in turbulence.						
081 06 03 02	**Factors affecting the gust-load diagram.**						
LO	Explain the relationship between the gust-load factor, lift-curve slope, density ratio, wing loading, EAS and equivalent vertical sharp-edged gust velocity and perform relevant calculations.	x	x				
081 07 00 00	**PROPELLERS**						
081 07 01 00	**Conversion of engine torque to thrust**						
LO	Explain the resolution of aerodynamic force on a propeller blade element into lift and drag or into thrust and torque. Describe propeller thrust and torque and their variation with IAS.	x	x				
081 07 01 01	**Relevant propeller parameters**						
LO	Describe the geometry of a typical propeller blade element at the reference section: — blade chord line; — propeller rotational velocity vector; — true-airspeed vector; — blade angle of attack; — pitch or blade angle; — advance or helix angle;	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	— define 'geometric pitch', 'effective pitch' and 'propeller slip'. *Remark: For theoretical knowledge examination purposes, the following definition is used for geometric pitch: the theoretical distance a propeller would advance in one revolution at zero blade angle of attack.* Define 'fine and coarse pitch'.						
081 07 01 02	**Blade twist**						
LO	Define 'blade twist'. Explain why blade twist is necessary.	x	x				
081 07 01 03	**Fixed pitch and variable pitch/constant speed**						
LO	List the different types of propellers: — fixed pitch; — adjustable pitch or variable pitch (non-governing); — variable pitch (governing)/ constant speed. Discuss the advantages and disadvantages of fixed-pitch and constant-speed propellers. Discuss climb and cruise propellers. Explain the relationship between blade angle, blade angle of attack and airspeed for fixed and variable pitch propellers. Given a diagram, explain the forces acting on a rotating blade element in normal, feathered, windmilling and reverse operation. Explain the effects of changing propeller pitch at constant IAS.	x	x				
081 07 01 04	**Propeller efficiency versus speed**						
LO	Define 'propeller efficiency'. Explain the relationship between propeller	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
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	efficiency and speed (TAS). Plot propeller efficiency against speed for the types of propellers listed in 081 07 01 03 above. Explain the relationship between blade angle and thrust.						
081 07 01 05	**Effects of ice on propeller**						
LO	Describe the effects of ice on a propeller.	x	x				
081 07 02 00	**Engine failure**						
081 07 02 01	**Windmilling drag**						
LO	List the effects of an inoperative engine on the performance and controllability of an aeroplane: — thrust loss/drag increase; — influence on yaw moment during asymmetric power.	x	x				
081 07 02 02	**Feathering**						
LO	Explain the reasons for feathering and the effect on performance and controllability. Influence on yaw moment during asymmetric power.	x	x				
081 07 03 00	**Design features for power absorption**						
LO	Describe the factors of propeller design that increase power absorption.	x	x				
081 07 03 01	**Aspect ratio of blade**						
LO	Define ‘blade-aspect ratio’.	x	x				
081 07 03 02	**Diameter of propeller**						
LO	Explain the reasons for restricting propeller diameter.	x	x				
081 07 03 03	**Number of blades**						
LO	Define ‘solidity’. Describe the advantages and	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
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	disadvantages of increasing the number of blades.						
081 07 03 04	**Propeller noise**						
LO	Explain how propeller noise can be minimised.	x	x				
081 07 04 00	**Secondary effects of propellers**						
081 07 04 01	**Torque reaction**						
LO	Describe the effects of engine/propeller torque. Describe the following methods for counteracting engine/propeller torque: — counter-rotating propellers; — contra-rotating propellers.	x	x				
081 07 04 02	**Gyroscopic precession**						
LO	Describe what causes gyroscopic precession. Describe the effect on the aeroplane due to the gyroscopic effect.	x	x				
081 07 04 03	**Asymmetric slipstream effect**						
LO	Describe the possible asymmetric effects of the rotating propeller slipstream.	x	x				
081 07 04 04	**Asymmetric blade effect**						
LO	Explain the asymmetric blade effect (also called P factor). Explain influence of direction of rotation on critical engine on twin engine aeroplanes.	x	x				
081 08 00 00	**FLIGHT MECHANICS**						
081 08 01 00	**Forces acting on an aeroplane**						
081 08 01 01	**Straight horizontal steady flight**						
LO	Describe the forces acting on an aeroplane in straight horizontal steady flight.	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	List the four forces and state where they act. Explain how the four forces are balanced. Describe the function of the tailplane.						
081 08 01 02	**Straight steady climb**						
LO	Define ‘γ flight-path angle’. Describe the relationship between pitch attitude, flight-path angle and angle of attack for the zero-wind, zero-bank and sideslip conditions. Describe the forces acting on an aeroplane in a straight steady climb. Name the forces parallel and perpendicular to the direction of flight. — Apply the formula relating to the parallel forces ($T = D + W \sin \gamma$). — Apply the formula relating to the perpendicular forces ($L = W \cos \gamma$). Explain why thrust is greater than drag. Explain why lift is less than weight. Explain the formula (for small angles) giving the relationship between flight-path angle, thrust, weight and lift–drag ratio, and use this formula for simple calculations. Explain how IAS, angle of attack and flight-path angle change in a climb performed with constant pitch attitude and normal thrust decay with altitude.	x	x				
081 08 01 03	**Straight steady descent**						
LO	Describe the forces acting on an aeroplane in a straight steady descent. Name the forces parallel and	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
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	perpendicular to the direction of flight. — Apply the formula parallel to the direction of flight ($T = D – W \sin \gamma$). — Apply the formula relating to the perpendicular forces ($L = W \cos \gamma$). Explain why lift is less than weight. Explain why thrust is less than drag.						
081 08 01 04	**Straight steady glide**						
LO	Describe the forces acting on an aeroplane in a straight steady glide. Name the forces parallel and perpendicular to the direction of flight. — Apply the formula for forces parallel to the direction of flight ($D = W \sin \gamma$); — Apply the formula for forces perpendicular to the direction of flight ($L = W \cos \gamma$). Describe the relationship between the glide angle and the lift–drag ratio. Describe the relationship between angle of attack and the best lift–drag ratio. Explain the effect of wind component on glide angle, duration and distance. Explain the effect of mass change on glide angle, duration and distance. Explain the effect of configuration change on glide angle, duration and distance. Describe the relation between TAS and sink rate including minimum glide angle and minimum sink rate.	x	x				
081 08 01 05	**Steady coordinated turn**						
LO	Describe the forces acting on an aeroplane in a steady coordinated turn. Resolve the forces acting horizontally and	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	vertically during a coordinated turn (tan $\phi = \frac{V^2}{gR}$). Describe the difference between a coordinated and an uncoordinated turn and explain how to correct an uncoordinated turn using turn and slip indicator. Explain why the angle of bank is independent of mass and only depends on TAS and radius of turn. Resolve the forces to show that for a given angle of bank the radius of turn is determined solely by airspeed (tan $\phi = \frac{V^2}{gR}$). Calculate the turn radius, load factor and the time for a complete turn for relevant parameters given for a steady turn. Discuss the effects of bank angle on: — load factor; — angle of attack; — thrust; — drag. Define ‘angular velocity’. Define ‘rate of turn’ and ‘rate-one turn’. Explain the influence of TAS on rate of turn at a given bank angle.						
081 08 02 00	**Asymmetric thrust**						
LO	Describe the effects on the aeroplane during flight with asymmetric thrust including both jet engine and propeller-driven aeroplanes. Discuss critical engine, include effect of crosswind when on the ground. Explain effect of steady asymmetric flight	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	on a conventional (ball) slip indicator.						
081 08 02 01	**Moments about the normal axis**						
LO	Describe the moments about the normal axis. Explain the yawing moments about the CG. Describe the change to yawing moment caused by power changes. Describe the changes to yawing moment caused by engine distance from CG. Describe the methods to achieve balance.	x	x				
081 08 02 02	***Intentionally left blank***						
081 08 02 03	**Forces parallel to the lateral axis**						
LO	Explain: — the force on the vertical fin; — the fuselage side force due to sideslip; — the use of bank angle to tilt the lift vector. Explain how bank angle and sideslip are related in a steady asymmetric flight. Explain why the bank angle must be limited. Explain the effect on fin angle of attack due to sideslip.	x	x				
081 08 02 04	**Influence of aeroplane mass**						
LO	Explain why controllability with one engine inoperative is a typical problem encountered at low aeroplane mass.	x	x				
081 08 02 05	***Intentionally left blank***						
081 08 02 06	**Secondary propeller effects**						
LO	Describe propeller effects: — slip stream; — torque reaction;	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
	— asymmetric blade effect.						
081 08 02 07	***Intentionally left blank***						
081 08 02 08	**V_{MCA}**						
LO	Define 'V_{MCA}'. Describe how V_{MCA} is determined. Explain the influence of the CG location.	x	x				
081 08 02 09	**V_{MCL}**						
LO	Define 'V_{MCL}'. Describe how V_{MCL} is determined. Explain the influence of the CG location.	x	x				
081 08 02 10	**V_{MCG}**						
LO	Define 'V_{MCG}'. Describe how V_{MCG} is determined. Explain the influence of the CG location.	x	x				
081 08 02 11	**Influence of density**						
LO	Describe the influence of density. Explain why V_{MCA}, V_{MCL} and V_{MCG} reduce with an increase in altitude and temperature.	x	x				
081 08 03 00	**Particular points on a polar curve**						
LO	Identify the particular points on a polar curve and explain their significance, assuming a parabolic approximation.	x	x				