AIRLINE TRANSPORT PILOTS LICENCE

(PRINCIPLES OF FLIGHT AEROPLANES)

Explanation of changes in issue **5** of the Learning Objectives for Principles of Flight, only the major changes are mentioned.

- **added note 6 to the introduction: Fly by Wire is not considered for subject 081**
- **in 081 01 01 04 introduced alternate expression for thickness to chord ratio: relative thickness.**
- **in 081 01 01 05 added the following wing shape parameters: mean geometric chord and sweep angle.**
- **in 081 01 03 01 added to the line about the C_l - α graph, that negatively cambered aerofoils should be considered as well.**
- **in 081 01 03 02 added a line to discuss the effect of the shape of a body on drag coefficient.**
- **in 081 01 08 04, 081 01 08 05, 081 04 03 10, 081 06 02 01 added a reference to the new EASA airworthiness requirements CS 23/25.**
- **expanded write-up in 081 01 08 05 on stabiliser stall, introduced: "explain and discuss cause and effects" and also added the expression "negative tail stall".**
- **in 081 03 01 04 added to: centre of pressure also: aerodynamic centre.**
- **in 081 04 03 01 rewritten and simplified the lines about phugoid and short period motion.**
- **in 081 04 05 05 added a new line: Define dihedral effect.**
- **in 081 05 02 04 replaced "in a g manoeuvre" by "a manoeuvre with a load factor higher or lower than 1".**
- **in 081 05 08 03 added to the line about the comparison between stabiliser trim and trim tab: disadvantages.**
- **also added a new line: "Discuss the effects of jammed and runaway stabiliser".**
- **in 081 06 01 00 added to the factors influencing flutter: "structural properties and IAS"**
- **in 081 07 01 01 about the geometry of a propeller changed the "representative span location" into "reference section"**
- **in 081 07 01 01 and 081 07 01 04 deleted subject: "advance ratio J", considered too theoretical for pilots**
- **in 081 07 01 01 added a note explaining the SET 081 standardised definition of geometric pitch.**

AIRLINE TRANSPORT PILOTS LICENCE

(PRINCIPLES OF FLIGHT AEROPLANES)

Introduction:

Conventions for questions in subject 081.

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 between 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 can expect questions on dedicated topics as described in detail within these Learning Objectives. It should be taken into account that knowledge of different topics within the 081 Learning Objectives can be combined in one question. An example of this can be found on the JAA website www.jaa.nl

4.
Candidates are expected in simple calculations to be able to convert knots into m/s and know the appropriate conversion factors by heart.

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.

6.
Throughout subject 081 Fly by Wire is not considered.

081

PRINCIPLES OF FLIGHT

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
080 00 00 00	**PRINCIPLES OF FLIGHT**	
081 01 00 00	**SUBSONIC AERODYNAMICS**	
081 01 01 00	**Basics, Laws and Definitions**	
081 01 01 01	**Laws and definitions**	
	- 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.	
	- Describe Newton´s Laws.	
	- Describe Newton´s first law.	
	- Describe Newton's second law.	
	- Describe Newton's third law.	
	- Explain air density.	
	- 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.	Given table of Standard Atmosphere

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe how the IAS is acquired from the pitot-static system.	
	- Describe the Ideal Gas Law.	
	- Describe the Equation of Continuity.	
	- Describe viscosity.	
	- Define the speed of sound and its symbol.	Given table of Standard Atmosphere
	- Describe how atmospheric properties affect the speed of sound.	
	- Define IAS, CAS, EAS, TAS and Mach number.	
081 01 01 02	**Basics about airflow**	
	- Describe steady and unsteady airflow.	
	- Explain the concept of a streamline.	
	- Describe and explain airflow through a streamtube.	
	- Explain the difference between two and three-dimensional airflow.	
081 01 01 03	**Aerodynamic forces and moments on the surfaces**	
	- 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 cambered aerofoil.	
	- Forces and equilibrium of forces Refer 081 08 00 00.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Define angle of attack.	
081 01 01 04	**Shape of an aerofoil**	
	- Describe the following parameters of an aerofoil:	
	- leading edge.	
	- trailing edge.	
	- chord line.	
	- thickness to chord ratio **or relative thickness.**	
	- location of maximum thickness.	
	- camber line.	
	- camber.	
	- nose radius.	
	- angle of attack.	
	- angle of incidence.	
	(note in certain textbooks angle of incidence is used as angle of attack, for JAR-FCL 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.	
	- Describe a symmetrical and an asymmetrical aerofoil.	
081 01 01 05	**The wing shape**	
	- Describe the following parameters of a wing:	
	- span.	
	- root chord.	
	- tip chord.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- taper ratio. - wing area. - wing planform - **mean geometric chord**. - mean aerodynamic chord MAC - aspect ratio. - dihedral angle. - **sweep angle**.	
081 01 02 00	**<u>The Two-dimensional Airflow about an aerofoil</u>** - Describe pressure distribution around an aerofoil and local speeds including effects of camber and angle of attack.	
081 01 02 01	**Streamline pattern** - Describe the streamline pattern over an aerofoil. - Describe converging and diverging streamlines and their effect on static pressure and velocity. - Describe upwash and downwash.	
081 01 02 02	**Stagnation point** - Describe the stagnation point. - Explain the effect on the stagnation point of angle of attack changes. - Explain local pressure changes.	
081 01 02 03	**Pressure distribution** - Describe an approximate pressure distribution over an aerofoil.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe where the minimum local static pressure is typically situated on an aerofoil.	
081 01 02 04	**Centre of pressure and aerodynamic centre**	
	- Define the centre of pressure and aerodynamic centre.	
	- Explain stable and unstable centre of pressure movement with angle of attack. (include the effect of camber)	
081 01 02 05	**Lift and downwash**	
	- Explain the association between lift and downwash.	
081 01 02 06	**Drag and wake**	
	- List two physical phenomena that cause drag.	
	- Describe skin friction drag.	
	- Describe pressure (form) drag	
	- Explain why drag and wake cause a loss of energy (momentum).	
081 01 02 07	**Influence of angle of attack**	
	- Explain the influence of angle of attack on lift.	
081 01 02 08	**Flow separation at high angles of attack**	
	- Refer to 081 01 08 01.	
081 01 02 09	**The Lift - α graph**	Given lift - α graph
	- Describe the lift and angle of attack graph.	
	- Explain the significant points on the graph.	
	- Describe lift against α graph for a symmetrical profile.	
081 01 03 00	**<u>The Coefficients</u>**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain why coefficients are used in general.	
081 01 03 01	**The lift coefficient C_l**	
	- Describe the lift formula.	
	- List factors that influence lift.	
	- Describe the factors in the lift formula and perform simple calculations	
	- Describe the C_l - α graph (symmetrical and positively **/ negatively** cambered aerofoil**s**).	
	- Describe the typical difference in C_l - α graph for fast and slow aerofoil design.	
	- Define the C_{l-max} and α_{stall} on the graph.	
	- State the approximate stall angle of attack.	
081 01 03 02	**The drag coefficient C_d**	
	- Describe the drag formula.	
	- List the factors that influence drag.	
	- Discuss effect of the shape of body on drag coefficient.	
	- Describe the factors in the drag formula and perform simple calculations	
	- State that drag increases as a function of the square of the speed.	
	- State that drag is proportional to the density of the airflow.	
	- 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.	
081 01 04 00	**<u>The Three-dimensional Airflow about an Aeroplane</u>**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain the difference between the angle of attack and the attitude of an aeroplane.	
081 01 04 01	**Streamline pattern**	
	- 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 span-wise 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 the wake turbulence.	
081 01 04 02	**The Induced Drag**	
	- 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 design means to decrease induced drag:	
	- aspect ratio	
	- winglets.	
	- tip tanks.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- wing span loading. - influence of wing twist. - influence of camber change.	

	- 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 co-ordinated 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, show effect on graph when comparing high and low aspect ratio wings.
	  - C_L - C_D (aeroplane polar), show effect on 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	**<u>The Total Drag</u>** - Explain how lift affects drag.	
081 01 05 01	**The parasite drag** - List the types of drag that are included in the parasite drag.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe pressure (form) drag.	
	- Describe interference drag.	
	- Describe friction drag.	
081 01 05 02	**The parasite drag and speed**	
	- Describe the relationship between parasite drag and speed.	
081 01 05 03	**The induced drag and speed**	
	- Refer to 081 01 04 02.	
081 01 05 04	**The total drag**	
081 01 05 05	**The total drag and speed**	
	- Describe total drag – IAS graph and the drag components which contribute to this graph.	
081 01 05 06	**Minimum drag**	
	- Indicate the IAS for the minimum drag from the graph.	
081 01 05 07	**The drag - speed graph**	
	- 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 on the non-stable region if speed suddenly decreases.	
081 01 06 00	**<u>Ground Effect</u>**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain what happens to the tip vortices, downwash, airflow pattern and lift and drag in ground effect.	
081 01 06 01	**Effect on C_{Di}**	
	- Describe the influence of ground effect on C_{Di} and induced angle of attack.	
	- Explain the effects on entering and leaving ground effect.	
081 01 06 02	**Effect on α_{stall}**	
	- Describe the influence of ground effect on α_{stall}.	
081 01 06 03	**Effect on C_L**	
	- Describe the influence of ground effect on C_L.	
081 01 06 04	**Effect on take-off and landing characteristics of an aircraft**	
	- 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.	
081 01 07 00	**The relation between the lift coefficient and the speed for constant lift**	
	- Describe the relationship between lift coefficient and speed for constant lift as a formula.	
081 01 07 01	**As a formula**	
	- Explain the effect on C_L during speed increase/decrease in level flight and perform simple calculations.	
081 01 07 02	**In a graph**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain using a graph, the effect on speed at various angles of attack and C_L, at a given weight.	
	- Calculate the change of C_L as a function of IAS.	
081 01 08 00	**The Stall**	
081 01 08 01	**Flow separation at increasing angles of attack**	
	- Define the boundary layer.	
	- Describe the thickness of a typical boundary layer.	
	- List the factors that effect the 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 angle of attack is increased.	
	- Define the separation point.	
	- Define the critical or stall angle of attack.	
	- Describe the influence of increasing the angle of attack on:	
	- the forward stagnation point.	
	- the pressure distribution.	
	- location of the centre of pressure (straight and swept back wing).	
	- C_L and L.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- C_D and D. - the pitching moment (straight and swept back wing). - the downwash at the horizontal 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** - Solve the 1g stall speed from the lift formula. - Define the FAA stall speed. - Describe and explain the Influence of the following parameters on the stall speed: - centre of gravity. - power setting, thrust component and slipstream effect. - wing loading (W/S) or gross weight - wing contamination. - angle of sweep. - altitude (for compressibility effects see 081 02 02 03). - Define the load factor n. - Describe the general idea why the load factor increases in turns. - 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 the stall speed.	- Given the formula with V_S and C_{LMAX}.

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain the expression: accelerated stall.	
	- Calculate the change of stall speed as a function of the load factor.	
	- Calculate the increase of stall speed in a horizontal co-ordinated 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**	
	- Explain the initial stall sequence on the following planforms:	
	- elliptical.	
	- rectangular.	
	- moderate and high taper.	
	- sweepback or delta.	
	- Explain the influence of aerodynamic twist (wash out) and geometric twist.	
	- Explain the influence of deflected ailerons.	
	- Explain the influence of fences, vortilons, saw teeth, vortex generators.	
081 01 08 04	**Stall warning**	
	- Explain why stall warning is necessary.	
	- Explain when aerodynamic and artificial stall warnings are used.	
	- Explain why JAR**/CS 23/25** and FAR require a margin to stall speed.	
	- Describe:	
	- buffet.	
	- stall strip.	
	- flapper switch (leading edge stall warning vane).	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- angle of attack vane. - angle of attack probe. - stick shaker. - Describe warnings of: - high speed buffet. - Describe the recovery after: - stall warning. - stall. - stick pusher actuation.	
081 01 08 05	**Special phenomena of stall** - Describe the basic stall requirements for JAR **/ CS** / FAR transport category aeroplanes. - Explain the difference between the power-off and power-on stalls and recovery. - Describe the 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- 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.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain the abnormal behaviour of the stall.	
	- Describe and explain **cause and 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/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 wing 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**	
	- Describe trailing edge flaps and the reasons for their use during take-off and landing.	
	- Identify the differing types of trailing edge flaps given a relevant diagram.	
	- Split flaps.	
	- Plain flaps.	
	- Slotted flaps.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Fowler flaps.	
	- Describe their effect on wing geometry.	
	- Describe how the wing's effective camber increases.	
	- Describe how the effective chord line differs from the normal chord line.	
	- Describe their effect on the stall speed.	
	- Describe their effect on aeroplane pitching moments.	
	- 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 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 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 use in take-off and landing**	
	- Describe leading edge high lift devices.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS

	- Identify the differing types of leading edge high lift devices given a relevant diagram:
	  - Krueger flaps.
	  - variable camber flaps.
	  - slats.
	- 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.
	- Describe automatic slat operation.
	- 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**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain the purpose of vortex generators.	
	- Describe their basic operating principle.	
	- State their advantages and disadvantages.	
080 01 10 00	**Means to Decrease the C_L - C_D Ratio, increasing drag**	
081 01 10 01	**Spoilers and the reasons for use in the different phases of flight**	
	- Describe spoilers and the reasons for use in the different phases of flight.	
	- Roll spoilers.	
	- Flight spoilers (speed brakes).	
	- Ground spoilers (lift dumpers).	
	- Describe the operation of ground spoilers (lift dumpers).	
	- Describe the purpose of a spoiler-mixer unit.	
	- Describe the effect of spoilers on the C_L - α graph.	
	- Describe the influence of spoilers on the C_L – C_D graph and lift/drag ratio.	
081 01 10 02	**Speed brake as a means of increasing drag and the reasons for use in the different phases of flight**	
	- 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 of descent.	
081 01 11 00	**Boundary Layer**	
081 01 11 01	**Different types**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Refer to 081 01 08 01.	
081 01 11 02	**Advantages and disadvantages of different types of boundary layer on pressure drag and friction drag**	
081 01 12 00	**<u>Special Circumstances</u>**	
081 01 12 01	**Ice and other contamination**	
	- Explain the effect of ice, and other contamination on aeroplane performance.	
	- Describe the effects of ice accumulations at the stagnation point and discuss other locations in relation to magnitude of ice build up.	
	- Describe the effects of ice, frost, snow on the surface condition.	
	- Describe how it affects the boundary layer.	
	- Describe how rain and other liquids affect the surface condition.	
	- Describe its effect on aeroplane mass.	
	- Explain its effect on lift and drag.	
	- Describe the effect of contamination of the leading edge.	
	- Explain the effect on aeroplane controllability.	
	- List the causes of leading edge contamination.	
	- Describe the effects of contamination on the stall.	
	- Describe the effect on the boundary layer condition.	
	- Describe the effect on the stall angle of attack.	
	- Describe the effect on the stall speed.	
	- Describe how contamination leads to loss of controllability.	
	- State the effect of tail icing.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS

	- Explain the adverse effects of icing on the various phases during take-off.
	- Describe the effects on control surface moment (stick forces).
	- Describe the influence of contamination on high lift devices during take-off, landing and low speeds.
	  - Explain why contamination degrades high lift devices' efficiency.
	  - Explain why contamination increases the take-off and landing distances/speeds.
	  - Describe how contamination reduces the coefficient of lift.
	  - Explain the effect of contamination on the lift/drag ratio.	

081 01 12 02	**Deformation and modification of airframe, ageing aircraft**	
	- 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.	
081 02 00 00	**<u>TRANSONIC AERODYNAMICS</u>**	
081 02 01 00	**<u>The Mach number definition</u>**	
081 02 01 01	**Speed of sound**	
	- Define speed of sound. - Define Mach number as a function of TAS and speed of sound.	
081 02 01 02	**Influence of temperature and altitude**	
	- Describe the influence of temperature on the speed of sound. - Explain the variation of the speed of sound with altitude. - Explain the absence of change of Mach number with varying temperature at constant flight level and Calibrated Airspeed. - Explain the change of TAS as a function of altitude at a given Mach number.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain the change of Mach number at varying altitude in the standard atmosphere (troposphere and stratosphere) with constant Calibrated Airspeed and with constant True Airspeed.	
081 02 01 03	**Compressibility**	
	- State that compressibility means that density can change along a streamline.	
	- State that Mach number is a measure of compressibility.	
081 02 02 00	**<u>Normal shock waves</u>**	Give the approximate boundaries in Mach number values
	- List the subdivision of aerodynamic flow:	
	- Subsonic flow.	
	- Low-subsonic, non-compressible flow.	
	- High subsonic, compressible flow.	
	- Transonic flow, mixture of local speeds above and below the speed of sound.	
	- Supersonic flow, all speeds higher than the speed of sound.	
	- Describe a normal shock wave in a transonic flow with respect to:	
	- static temperature, pressure, velocity, local speed of sound and density changes.	
	- location in a supersonic area of the stream pattern.	
	- length of the shock wave and orientation relative to the wing surface.	
	- Explain loss of total pressure in a shock wave.	
081 02 02 01	**M_{crit} and exceeding M_{crit}**	
	- Describe how the streamline pattern changes due to compressibility.	
	- describe M_{crit}.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- discuss effect of change of mass on Mcrit at constant IAS.	
081 02 02 02	**Influence of**	
	- Explain the influence of increasing Mach number on a normal shock wave, at positive lift, with respect to:	
	- strength.	
	- position relative to the wing.	
	- second shock wave at the lower surface.	
	- Explain the influence of control surface deflection with respect to:	
	- the effect of M_{crit}.	
	- loss of control effectiveness.	
	- location of the shock wave.	
	- Explain how increase of the angle of attack influences normal shock wave and M_{crit}.	
	- Explain the effect of aerofoil shape parameters on M_{crit}.	
	- Explain the influence of the angle of sweep with respect to:	
	- the increase of M_{crit}.	
	- effective thickness/chord change.	
	- velocity component perpendicular to the leading edge.	
	- Describe the influence of the angle of sweep at subsonic speed with respect to	
	- C_{LMAX}.	
	- efficiency of high lift devices.	
	- pitch-up stall behaviour.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain area ruling in aeroplane design.	
081 02 02 03	**Influence on**	
	- 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.	
	- Explain the behaviour of C_D versus M at constant angle of attack.	
	- Explain effect of Mach number on the C_L-C_D graph.	
081 02 02 04	**Aerodynamic heating**	
	- State that aerodynamic heating is caused by compression and friction.	
081 02 02 05	**Shock stall/Mach buffet**	
	- Explain shock induced separation, shock stall and describe its relationship with Mach buffet.	
081 02 02 06	**Influence on**	
	- Describe the influence on:	
	- wave drag.	
	- Explain the influence of shock stall on the location of the centre of pressure with respect to:	
	- loss of lift at the wing root.	
	- reduction of downwash at the wing root.	
	- List the aerodynamic and mechanical counter measures for the Mach tuck-under effect.	
081 02 02 07	**Buffet margin, aerodynamic ceiling**	
	- Describe the influence on the buffet margin of:	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- angle of attack. - Mach number. - pressure altitude. - mass. - load factor.	
	- Describe the 1.3 g altitude with respect to the buffet margin.	
	- Describe what can be obtained from the buffet boundary chart.	
	- Find: - buffet restricted speed limits at a given pressure altitude. - aerodynamic ceiling at a given mass. - load factor and bank angle at which buffet occurs at a given mass, Mach number and pressure altitude.	Given a Buffet Onset Boundary Chart of the Airbus A310
	- Illustrate the behaviour of the buffet margin when an aeroplane is descending or ascending at a given indicated airspeed, or Mach number.	
	- Describe the effect of exceeding the speed for buffet onset.	
081 02 02 08	**Meaning of the expression 'coffin corner'**	Given a flight envelope diagram of the Airbus A310
	- Identify the V_{MO} and M_{MO} values.	
	- Identify the stall speed.	
	- Identify the “coffin corner”.	
	- Describe: - the allowable speed range in the coffin corner. - the influence of mass on the coffin corner boundaries.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- the consequences of exceeding V_{MO}.	
	- the consequences of exceeding M_{MO}.	
	- Describe the influence of:	
	- buffet on the flight envelope.	
	- mass on the values of V_{MO} and M_{MO}.	
	- temperature on the pressure altitude at which the V_{MO} limit intersects the M_{MO} limit.	
081 02 03 00	**Means to avoid the effects of exceeding M_{crit}**	
081 02 03 01	**Vortex generators**	
	- Explain the use of vortex generators as a means to avoid or restrict flow separation.	
081 02 03 02	**Supercritical profile**	
	- Identify the following shape characteristics of a supercritical aerofoil shape:	
	- blunt nose.	
	- large thickness.	
	- s-shaped camber line.	
	- flat upper surface.	
	- thick trailing edge.	
	- Explain with respect to a supercritical aerofoil:	
	- the increased number of smaller and weakened shock waves compared those of a classic profile.	
	- the absence of a strong influence on M_{crit}.	
	- aft loading.	
	- Explain the following advantages of a supercritical aerofoil:	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- allows use of less sweep angle.	
	- may be built lighter, due to greater thickness.	
	- allows storage of more fuel.	
	- allows use of a higher aspect ratio.	
	- Explain the following disadvantages of a supercritical aerofoil:	
	- negative camber at the aerofoil front side.	
	- buffet may cause severe oscillations.	
081 03 00 00	**SUPERSONIC AERODYNAMICS**	
081 03 01 00	**Oblique Shock waves**	
	- Compare characteristics of normal and oblique shock waves.	
081 03 01 01	**Mach cone**	
	- Define Mach angle μ.	
	- Explain how the Mach angle changes with varying Mach number.	
	- Define the bow wave.	
	- Identify the Mach cone zone of influence of a pressure disturbance due to the presence of the aeroplane.	
	- Explain "sonic boom"	
081 03 01 02	**Influence of aircraft mass**	
	- Describe influence of mass (wing loading).	
081 03 01 03	**Expansion waves**	
	- Describe shock waves and expansion waves with respect to the streamline pattern and variation of	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	pressure, static temperature, density and velocity along a streamline.	
	- Describe the velocity behind a normal and an oblique shock wave.	
081 03 01 04	**Centre of pressure**	
	- Describe the movement of the centre of pressure **and aerodynamic centre** with increasing Mach number.	
	- Describe the pressure distribution in chord direction in supersonic flight.	
081 03 01 05	**Wave drag**	
	- Describe wave drag.	
	- Describe effect on control surface hinge moment.	
	- Describe effect on control surface efficiency.	
	- Explain that an oblique shock wave moves with aeroplane ground speed over the earth surface.	
081 04 00 00	**<u>STABILITY</u>**	
081 04 01 00	**<u>Condition of equilibrium in steady horizontal flight</u>**	
081 04 01 01	**Precondition for static stability**	
	- Explain an equilibrium of forces and moments as the condition for the concept of static stability.	
	- Identify:	
	- static longitudinal stability.	
	- static directional stability.	
	- static lateral stability.	
081 04 01 02	**Sum of moments**	
	- Identify the moments considered in the equilibrium of moments: moments about all three axes.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
081 04 01 03	**Sum of forces**	
	- Identify the forces considered in the equilibrium of forces.	
081 04 02 00	**Methods of achieving balance**	
081 04 02 01	**Wing and empennage (tail and canard)**	
	- 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 canard.	
	- Explain the influence of the balancing force on the magnitude of the wing/fuselage lift.	
081 04 02 02	**Control surfaces**	
	- 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 02 03	**Ballast or weight trim**	
	- Explain the most advantageous location of the centre of gravity.	
	- Explain the control of the location of the centre of gravity by means of fuel distribution and loading.	
081 04 03 00	**Longitudinal Stability**	
081 04 03 01	**Basics and definitions**	
	- Define static stability.	
	- Identify a statically stable, neutral and unstable equilibrium.	
	- Define dynamic stability.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Identify a dynamically stable, neutral and unstable motion. - Explain what combinations of static and dynamic stability will return an aeroplane to the equilibrium state after a disturbance. - 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.	
081 04 03 02	**Static stability** - Explain static stability. - Explain manoeuvrability. - Discuss effect of cg location on manoeuvrability. - Explain the changes in aerodynamic forces when varying angle of attack for a static longitudinally stable aeroplane.	
081 04 03 03	**Neutral point/location of neutral point** - Neutral point / location of neutral point. - Define neutral point. - Explain why the location of the neutral point is only dependent on the aerodynamic design of the aeroplane.	
081 04 03 04	**Contribution of** - Indicate the location of the neutral point relative to the locations of the aerodynamic centre of the wing and tail/canard.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- 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.	
081 04 03 05	**Location of centre of gravity** - Explain the influence of the location of the centre of gravity on static and dynamic stability of the aeroplane. - Explain the approved forward and aft limits of the centre of gravity with respect to the criteria of control forces, elevator effectiveness and stability. - Define the minimum stability margin.	

081 04 03 06	**The C_m-α graph**
	- 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 of slope and static stability.	

081 04 03 07	**Contribution of**
	- Explain:
	  - the effect on the C_m-α graph with 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 wing contribution and the effect of the location of the cg with respect to the aerodynamic centre	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	on the wing contribution. - the contribution of the fuselage and the effect of the location of the centre of gravity on the fuselage contribution. - the contribution of the tail. - the contribution of the configuration (gear and flaps). - the contribution of aerofoil camber.	
081 04 03 08	**The elevator position - speed graph (IAS)** - Describe the elevator position speed graph. - Explain: - the gradient of the elevator position speed graph. - the influence of the airspeed on the stick position stability.	
081 04 03 09	**Contribution of** - Explain the contribution on the elevator position - speed graph of: - location of centre of gravity. - trim (trim tab and stabiliser trim). - high lift devices.	
081 04 03 10	**The stick force - speed graph (IAS)** - Define the stick force speed graph. - Describe the minimum gradient for stick force versus speed that is required for certification according JAR **/ CS** 23 and JAR **/ 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.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain how a pilot perceives stable static longitudinal stick force stability.	
081 04 03 11	**Contribution of**	
	- Explain the contribution of:	
	- location of the centre of gravity.	
	- trim (trim tab and stabiliser trim).	
	- Mach number and the effect of Mach tuck-under and the Mach trim system.	
	- downspring.	
	- bob weight.	
	- friction.	
	- State that:	
	- in transonic flow due to the Mach tuck under effect the stick force gradient may be too small or unstable.	
	- the Mach trim system restores stick force gradient.	
	- Explain corrective measures when the Mach trim fails.	
081 04 03 12	**The manoeuvring/stick force per g**	
	- Define the stick force per g.	
	- 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 airspeeds.	
081 04 03 13	**not used**	
081 04 03 14	**Contribution of**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS

	- Explain that the stick force per g is:
	  - dependent on location of centre of gravity
	  - independent of the trim setting.
	  - independent of a down spring in the control system.
	  - greater with the application of a bob weight in the control system.	

081 04 03 15	**Stick force per g and the limit load factor**	
	- 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.	
081 04 03 16	**Refer to 081 05 02 03**	
081 04 04 00	**<u>Static directional stability</u>**	
	- Define static directional stability.	
081 04 04 01	**Sideslip angle β**	
	- Define sideslip angle. - Identify β as the symbol used for the sideslip angle.	
081 04 04 02	**Yaw moment coefficient C_n**	
	- Define the yawing moment coefficient C_n. - Define the relationship between C_n and β for an aeroplane with static directional stability.	
081 04 04 03	**C_n - β graph**	
	- Explain why: - C_n depends on the angle of sideslip.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- 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.	
081 04 04 04	**Contribution of**	
	- Describe how the following aeroplane components contribute to static directional stability:	
	- wing.	
	- fin.	
	- dorsal fin.	
	- ventral fin.	
	- angle of sweep of the wing.	
	- angle of sweep of the fin.	
	- location of centre of gravity.	
	- fuselage at high angles of attack.	
	- strakes.	
	- Explain why both the fuselage and the fin contribution reduce static directional stability after an aft shift of the centre of gravity.	
081 04 05 00	**Static lateral stability**	
	- Define static lateral stability	
	- Explain the effects of static lateral stability being too small or too large.	
081 04 05 01	**Bank angle Ø**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Define bank angle Ø.	
081 04 05 02	**The roll moment coefficient C_l**	
	- Define the roll moment coefficient C_l.	
081 04 05 03	**Contribution of sideslip angle β**	
	- Explain how without co-ordination, the bank angle creates sideslip angle.	
081 04 05 04	**The C_l - β graph**	
	- Describe C_l - β graph.	
	- Identify the slope of the C_l - β graph as a measure for static lateral stability.	
081 04 05 05	**Contribution of**	
	- Explain the contribution to the static lateral stability of:	
	- dihedral, anhedral.	
	- high wing, low wing.	
	- sweep angle of the wing.	
	- ventral fin.	
	- vertical tail.	
	- Mach number.	
	- **Define dihedral effect**	
081 04 05 06	**Effective lateral stability**	
	- Define effective dihedral.	
	- Explain the negative effects of high static lateral stability in:	
	- strong crosswind landings.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- asymmetric thrust situations at high power setting and low speed (go-around, take off).	
081 04 06 00	**<u>Dynamic lateral/directional stability</u>**	
081 04 06 01	**Effects of asymmetric propeller slipstream**	
081 04 06 02	**Tendency to spiral dive**	
	- Explain how lateral and directional stability are coupled.	
	- Explain how high static 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, roll attitude, nose low pitch attitude and decreasing altitude.	
081 04 06 03	**Dutch roll**	
	- Describe Dutch roll.	
	- Explain:	
	- why Dutch roll occurs when the dihedral effect is large compared to static directional stability.	
	- the condition for a stable Dutch roll motion and those for marginally stable, neutral or unstable Dutch roll motion.	
	- the function of the yaw damper.	
	- actions to be taken in case of non-availability of the yaw damper.	
081 04 06 04	**Effects of altitude on dynamic stability**	
	- Explain that increased pressure altitude reduces dynamic lateral/directional stability.	
081 05 00 00	**<u>CONTROL</u>**	
081 05 01 00	**<u>General</u>**	
081 05 01 01	**Basics, the Three Planes and Three Axis**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Define: - lateral axis. - longitudinal axis. - normal axis. - Define: - pitch angle. - roll angle. - yaw angle. - Describe the motion about the three axes. - Name and describe the devices that control these motions.	
081 05 01 02	**Camber change**	
	- Explain how camber is changed by movement of a control surface.	
081 05 01 03	**Angle of Attack change**	
	- Explain the influence of local angle of attack change by movement of a control surface.	
081 05 02 00	**<u>Pitch Control</u>**	
081 05 02 01	**Elevator/all flying tail**	
	- Explain the working principle of the horizontal tailplane (stabiliser) - Discuss advantages and disadvantages of T-tails. - Explain the working principle of the elevator and describe its function. - State graphically the effect of elevator deflection on the moment curve. - Explain why the moment curve is independent of angle of attack.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe the loads on the tailplane in normal flight, lower than normal flight speeds, and higher than normal speed.	
081 05 02 02	**Downwash effects**	
	- Explain the effect of downwash on the tailplane angle of attack.	
	- Explain in this context the use of a T-tail or stabiliser trim.	
081 05 02 03	**Ice on tail**	
	- Explain how ice can change the aerodynamic characteristics of the tailplane.	
	- Explain how this can affect the tail's proper function.	
081 05 02 04	**Location of centre of gravity**	
	- Explain the relationship between pitching moment coefficient and lift coefficient.	
	- Explain the relationship between elevator deflection and location of cg in straight flight, and in a **manoeuvre with a load factor higher or lower than 1.**	
	- Explain effect of forward cg limit on pitch control.	
081 05 03 00	<u>**Yaw control**</u>	
	- 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.	
081 05 03 01	**Pedal/Rudder ratio changer**	
	- Describe the purpose of the rudder ratio changer.	
081 05 03 02	**Moments due to engine thrust**	
	- Describe the effect of engine thrust on pitching moments	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Explain fin stall due to rudder displacement.	
081 05 03 03	**Engine failure (n - 1)**	
	- Refer to 081 08 02 00.	
081 05 04 00	**<u>Roll control</u>**	
081 05 04 01	**Ailerons**	
	- Explain the functioning of ailerons.	
	- Describe the adverse effects of ailerons.	
	- Explain in this context the use of inboard and outboard ailerons.	
	- Explain outboard aileron lockout and conditions under which this feature is used.	
	- Describe the use of aileron deflection in normal flight, flight with sideslip, cross wind landings, horizontal turns, flight with one engine out.	
	- Define roll rate.	
	- List the factors that effect roll rate.	
	- Flaperons, aileron droop.	
081 05 04 02	**Not used**	
081 05 04 03	**Spoilers**	
	- Explain how spoilers affect lift.	
	- Explain how spoilers can be used to control the rolling movement in combination with or instead of the ailerons.	
081 05 04 04	**Adverse yaw**	
	- Explain how the use of ailerons induces adverse yaw.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
081 05 04 05	**Means to avoid adverse yaw**	
	- Explain how the following reduce adverse yaw:	
	- frise ailerons.	
	- differential ailerons deflection.	
	- coupling aileron deflection.	
	- roll spoilers.	
	- effects of asymmetric propeller slipstream.	
081 05 05 00	**Interaction in different planes (yaw/roll)**	
	- Describe the coupling effect of roll and yaw.	
	- Explain the secondary effect of ailerons.	
	- Explain the secondary effect of rudder.	
081 05 05 01	**Limitations of asymmetric power**	
	- Refer to 081 08 02 06.	
081 05 06 00	**<u>Means to reduce control forces</u>**	
081 05 06 01	**Aerodynamic balance**	
	- Describe the working principle of the nose and horn balancing (positioning of the hinge line in elevator, aileron and rudder).	
	- Describe the working principle of internal balance.	
	- Describe the working principle of:	
	- balance tab.	
	- anti-balance tab.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- spring tab.	
	- servo tab.	
081 05 06 02	**Artificial means**	
	- List examples of artificial means of reducing/increasing aerodynamic force.	
	- Describe fully powered controls.	
	- Describe power assisted controls.	
	- Explain why artificial feel is required.	
	- Explain how artificial feel is produced (inputs).	
	- Dynamic pressure.	
	- Stabiliser setting.	
081 05 07 00	**<u>Mass Balance</u>**	
	- Refer 081 06 01 00.	
081 05 07 01	**Reasons to balance**	
	- Reasons to use mass balance.	
081 05 08 00	**<u>Trimming</u>**	
081 05 08 01	**Reasons for trimming**	
	- State the reasons for trimming devices.	
	- Explain the difference between a trim tab and the various balance tabs.	
081 05 08 02	**Trim tabs**	
	- Describe the working principle of a trim tab including cockpit indications.	
081 05 08 03	**Stabiliser trim/Trim rate versus IAS**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe stabiliser trim/trim rate versus IAS.	
	- Explain the advantages **and disadvantages** of a stabiliser trim **compared with** a trim tab.	
	- **Discuss the effects of jammed and runaway stabiliser.**	
	- Explain elevator deflection when aeroplane is trimmed for fully powered and power assisted pitch controls.	
	- Explain the factors influencing stabiliser setting:	
	- in-flight.	
	- before take-off.	
	- Explain the influence of take-off stabiliser trim setting on stick force during rotation at varying cg positions within the allowable cg range.	
	- Explain the landing technique with a jammed stabiliser.	
081 06 00 00	**<u>Limitations</u>**	
081 06 01 00	**<u>Operating Limitations</u>**	
	- Describe the phenomenon of flutter, and list the factors:	
	- elasticity.	
	- backlash.	
	- aero-elastic coupling.	
	- mass distribution.	
	- **structural properties**.	
	- **IAS**.	
	- List the flutter modes of an aeroplane:	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- 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.	

	- Describe the phenomenon of aileron reversal:
	  - at low speeds - aileron deflection/stall angle relationship.
	  - at high speeds - aileron deflection causing the wing to twist.	

	- Describe the aileron reversal speed in relationship to V_{NE} and V_{NO}.	

	- 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.	
080 06 01 01	**V_{MO}, V_{NO}, V_{NE}**	
	- Define V_{MO} and V_{NE}. - Describe the difference between V_{MO} and V_{NE}.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe the relationship between V_{MO} and V_C.	
	- Define V_{NO}.	
	- Explain that V_{MO} can be exceeded during a descent at constant Mach number.	
	- Explain the dangers of flying at speeds close to V_{NE} .	
081 06 01 02	**M_{MO}**	
	- Define M_{MO} and state its limiting factors.	
	- Explain that M_{MO} can be exceeded during a climb at constant IAS.	
081 06 02 00	**<u>Manoeuvring Envelope</u>**	Given an example diagram
081 06 02 01	**Manoeuvring load diagram**	
	- Describe the manoeuvring load diagram.	
	- Define limit and ultimate load factor and explain what can happen if these values are exceeded.	
	- Identify the varying features on the diagram:	
	- load factor 'n'.	
	- speed scale, equivalent airspeed, EAS.	
	- C_{LMAX} boundary.	
	- V_A design manoeuvring speed.	
	- V_C design cruising speed.	
	- V_D design dive speed, a speed set sufficient above V_C to allow for the effects of a defined 'upset'.	
	- State the load factor limits for JAR **/ CS** 23 and 25 aeroplanes in a typical cruise condition and with flaps extended.	
	- Explain the relationship between V_A and V_S in a formula.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
081 06 02 02	**Contribution of mass, altitude and Mach number**	
	- State the relationship of mass to:	
	- load factor limits.	
	- accelerated stall speed limit.	
	- V_A, V_B and V_C.	
	- Explain the relationship between V_A , aeroplane mass and altitude.	
	- Calculate the change of V_A with changing mass.	
	- 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.	
081 06 03 00	**<u>Gust Envelope</u>**	Given example diagram
081 06 03 01	**Gust Load Diagram**	
	- Recognise a typical gust load diagram.	
	- Identify the various features shown on the diagram:	
	- gust load factor 'n'.	
	- calculate gust load factor 'n' as a result of increasing angle of attack.	
	- speed scale, equivalent airspeed, EAS.	
	- C_{L-MAX} boundary.	
	- vertical gust velocities.	
	- relationship of V_B to V_C and V_D.	
	- gust limit load factor.	
	- Define $V_{RA.}$	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Discuss considerations for the selection of this speed.	
	- Explain adverse effects on the aeroplane when flying in turbulence.	
081 06 03 02	**Contribution of mass, altitude, speed, Mach number, aspect ratio and wing sweep**	
	- 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.	
081 07 00 00	**<u>Propellers</u>**	
081 07 01 00	**<u>Conversion of engine torque to thrust</u>**	Given diagram
	- Describe thrust and torque load.	
	- Explain resolution of aerodynamic force on a propeller blade element into lift and drag or into thrust and torque.	
081 07 01 01	**Meaning of pitch**	
	- 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.	Given diagram
	- define geometric pitch, effective pitch and propeller slip.	
	- **note: since there are several definitions for geometric pitch throughout Europe, for standardisation purposes the SET 081 uses the following definition for geometric pitch: the theoretical distance a propeller would advance in one revolution at zero blade angle of attack.**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- define fine and coarse pitch.	
081 07 01 02	**Blade twist**	
	- Define blade twist.	
	- Explain why blade twist is necessary.	
081 07 01 03	**Fixed pitch and variable pitch/constant speed**	
	- List the different types of propeller:	
	- fixed pitch.	
	- adjustable pitch or variable pitch (non-governing).	
	- variable pitch (governing)/constant speed.	
	- 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.	
081 07 01 04	**Propeller efficiency versus speed**	
	- Define propeller efficiency.	
	- Explain the relationship between propeller efficiency and speed (TAS).	
	- Plot propeller efficiency against speed for the types of propellers listed in 081 07 01 03 above.	Given diagram
	- Explain the relationship between blade angle and thrust.	
	- Calculate propeller efficiency during straight and level flight for an aeroplane with given aerodynamic characteristics, power and mass.	
081 07 01 05	**Effects of ice on a propeller**	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	- Describe the effects of ice on a propeller.	
081 07 02 00	**<u>Engine Failure or Engine Stop</u>**	
	- Engine Failure or Engine Stop (shut-down).	
081 07 02 01	**Windmilling drag**	
	- 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.	
081 07 02 02	**Feathering**	
	- Explain the reasons for feathering and the effect on performance and controllability.	
	- Influence on yaw moment during asymmetric power.	
081 07 03 00	**<u>Design features for power absorption</u>**	
	- Describe the factors concerning propeller design which increase power absorption.	
081 07 03 01	**Aspect ratio of blade**	
	- Define blade aspect ratio.	
081 07 03 02	**Diameter of Propeller**	
	- Explain the reasons for restricting propeller diameter.	
081 07 03 03	**Number of blades**	
	- Define “solidity”.	
	- Describe the advantages and disadvantages of increasing the number of blades.	
081 07 03 04	**Propeller noise**	
	- Explain how propeller noise can be minimised.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
081 07 04 00	**<u>Moments and couples due to propeller operation</u>**	
081 07 04 01	**Torque reaction**	
	- Describe the effects of engine/propeller torque.	
	- Describe the following methods for counteracting engine/propeller torque:	
	- counter-rotating propellers.	
	- contra-rotating propellers.	
081 07 04 02	**Gyroscopic precession**	
	- Describe what causes gyroscopic precession.	
	- Describe the effect on the aeroplane due to the gyroscopic effect.	
081 07 04 03	**Asymmetric slipstream effect**	
	- Describe the possible asymmetric effects of the rotating propeller slipstream.	
081 07 04 04	**Asymmetric blade effect**	
	- Explain the asymmetric blade effect.	
	- Explain influence of direction of rotation on critical engine on twin engine aeroplanes.	
081 08 00 00	**<u>FLIGHT MECHANICS</u>**	
081 08 01 00	**<u>Forces Acting on an Aeroplane</u>**	
081 08 01 01	**Straight horizontal steady flight**	
	- Describe the forces acting on an aeroplane in straight horizontal steady flight.	
	- List the four forces and state where they act.	
	- Explain how the four forces are balanced.	
	- Describe the function of the tailplane.	

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081 08 01 02	**Straight steady climb**
	- 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** (note also applicable for horizontal flight and descent)
	- 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.	

081 08 01 03	**Straight steady descent**
	- Describe the forces acting on an aeroplane in a straight steady descent.
	- Name the forces parallel and 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.
	- Explain relationship of Mach number, TAS and IAS during descent at constant Mach number and IAS	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	and explain variation of lift coefficient.	
081 08 01 04	**Straight steady glide**	
	- 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.	
081 08 01 05	**Steady co-ordinated turn**	
	- Describe the forces acting on an aeroplane in a steady co-ordinated turn.	
	- Resolve the forces acting horizontally and vertically during a co-ordinated turn ($\tan \phi = \frac{V^2}{gR}$).	
	- Describe the difference between a co-ordinated and an unco-ordinated turn and explain how to correct an unco-ordinated 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	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
	airspeed ($\tan\phi = \frac{V^2}{gR}$).	
	- Calculate the turn radius and the time for a complete turn at a given angle of bank and TAS.	
	- Discuss 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**	
	Describe the effects on the aeroplane during flight with asymmetric thrust.	
	- Define critical engine, include effect of crosswind when on the ground.	
	- Explain effect of steady asymmetric flight on a conventional (needle, ball) turn and slip indicator.	
081 08 02 01	**Moments about the vertical**	
	- 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.	

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081 08 02 02	**Forces on vertical fin**	
	- Describe the forces acting on the fin.	
	- Describe the side force on the fin which counteracts the aeroplane yawing moment about the cg.	
	- Resolve the aeroplane yawing moment and fin side force by simple calculation.	
081 08 02 03	**Influence of bank angle**	
	- Describe the influence of bank angle on yawing moment.	
	- Explain the effect on fin side force when the aeroplane is banked towards the live engine.	
	- Explain why the bank angle must be limited.	
	- Explain the effect on fin angle of attack due to sideslip.	
081 08 02 04	**Influence of aircraft mass**	
	- Describe the effect of mass increase.	
	- Describe how mass increase will increase the yawing moment.	
	- Describe the effect on sideslip with mass increase.	
	- Describe the effect on rudder effectiveness.	
081 08 02 05	**Influence of use of ailerons**	
	- Describe the influence of ailerons.	
	- Explain why aileron effectiveness is reduced.	
081 08 02 06	**Influence of special propeller effects on roll moments**	
	- Describe the effect on roll moment created by propeller effect.	
	- Explain the influence of torque reaction.	
	- Explain the influence of flaps on roll moment.	

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081 08 02 07	**Influence of sideslip angle on roll moments** - Describe the influence of sideslip angle on roll moments. - Explain how sidelip angle changes the C_L of the left and right wings.	
081 08 02 08	**V_{MCA}** - Define V_{MCA}. - Describe how V_{MCA} is obtained. - Explain influence of cg location.	
081 08 02 09	**V_{MCL}** - Define V_{MCL}. - Describe how V_{MCL} is obtained. - Explain influence of cg location.	
081 08 02 10	**V_{MCG}** - Define V_{MCG}. - Describe how V_{MCG} is obtained. - Explain influence of cg location.	
081 08 02 11	**Influence of altitude** - Describe the influence of altitude and temperature. - Explain why V_{MCA} and V_{MCG} reduces with an increase in altitude and temperature.	
081 08 03 00	**Emergency descent** - Describe low and high speed emergency descent. - Explain the advantages and disadvantages of low and high speed emergency descent.	

JAR-FCL REF NO	LEARNING OBJECTIVES	REMARKS
081 08 03 01	**Influence of configuration**	
	- Describe the influence of configuration on emergency descent.	
	- Describe the methods to increase drag.	
081 08 03 02	**Influence of chosen Mach number and IAS**	
	- Explain why M_{MO} is the limiting speed at altitude.	
	- Explain why indicated airspeed is the limiting speed at low level.	
	- Describe the dangers when recovering from emergency descent.	
081 08 03 03	**Typical points on polar curve**	
	- Identify the typical points on a polar curve.	
081 08 03 04	**Windshear**	
	- Effect on take-off and landing.	
	- Describe the influence of increasing and decreasing windspeed.	
	- Describe a typical recovery from windshear.	