European Aviation Safety Agency

Notice of Proposed Amendment 2016-03(B)

Technical review of the theoretical knowledge syllabi, learning objectives, and examination procedures for air transport pilot licence, multi-crew pilot licence, commercial pilot licence, and instrument ratings

Subject 020 — Aircraft general knowledge:

Subject 021 — Airframe and systems, electrics, power plant and emergency equipment;

and Subject 022 — Instrumentation

RMT.0595 — 9.6.2016

EXECUTIVE SUMMARY

This Notice of Proposed Amendment (NPA) addresses a safety and regulatory coordination issue related to flight crew licensing. It has been developed in response to the European Aviation Safety Plan (EASP) safety actions.

This NPA updates the Learning Objectives (LOs) for the theoretical knowledge (TK) syllabi and ground school examinations, and introduces the threat and error management (TEM) concept and its application. The amendments proposed in this NPA aim to ensure that the LOs correspond to today's operational environment and that commercial pilots are equipped with the knowledge and understanding relevant to modern flight deck and current industry needs. The proposed updated pilot training will contribute to the overall enhancement of the pilots' core competencies and their ability to make informed decisions.

The NPA also introduces new LOs under Area 100 'knowledge, skills and attitudes' (KSA), whose aim is to enhance the pilots' KSA contained in the core competencies. New requirements are proposed for approved training organisations (ATOs) to assess student pilots' KSA. These skills focus on the pilots' ability to apply their knowledge and understanding across subjects and to demonstrate technical and non-technical skills. These LOs will, therefore, not be the subject of examinations organised by the competent authority or its agents, but will be assessed by the ATOs to ensure that trainee pilots have an adequate level of competency before they are allowed to sit their final TK examinations.

The NPA also recommends that EASA develop a process to regularly review and update the LOs so that they are up to date with emerging safety threats as well as with developments in technology and operational practice.

Applicability	
Affected regulations and decisions:	ED Decisions 2011/016/R; 2012/006/R; 2012/007/R; 2014/020/R; 2014/022/R; 2016/008/R
Affected stakeholders:	Competent authorities; ATOs; student pilots; providers of textbooks and training materials; ECQB
Driver/origin:	Safety
Reference:	EASA 4-year Rulemaking Programme; EASA ECQB Project

Process map	
Concept paper:	No
Terms of reference:	11.3.2015
Rulemaking group:	Yes
RIA type:	Light
Technical consultation during NPA drafting:	Yes
Duration of NPA consultation:	3 months
Review group:	Yes
Focused consultation:	No
Publication date of the Opinion:	N/A
Publication date of the Decision:	2016/Q4

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Overview of the proposed amendments to Subject 020 'Aircraft general knowledge'

The revision of the 020 subject matter, aircraft general knowledge (AGK), has added more emphasis on what is relevant to a pilot rather than going in depth on the technical aspects. The pilot's perspective is the use of a system rather than the technical aspects to engineering level.

This is particularly evident in Subject 022 'Instrumentation', where a lot of the technical design of the flight instruments has been substituted by automation and the use of electronic displays and systems. The emphasis on automation is aimed at increasing the candidate's awareness of automation and on how the autoflight systems function and interact with other systems. It is becoming evident that in recent times there has been an increasing number of incidents relating to automation mismanagement, hence the need to include what is relevant rather than relying on theoretical knowledge that is based on legacy principles.

It is challenging to include automation without becoming type-specific, but these Learning Objectives (LOs) have been made using what is common terms and modes across a range of aircraft makes and models highlighting the common traits and pitfalls. It is advantageous if the candidates have the opportunity to be shown the relevant parts and scenarios using a flight simulator or systems trainer to properly reinforce the knowledge and showing the practicality of this knowledge. It must be highlighted that these devices do not need to be certified in any way and may include simpler off-the-shelf products provided the automation part for aircraft model is designed realistically.

It is also advantageous, if not essential, that the instructor has background knowledge and experience with autoflight systems to be able to relay the knowledge in a more efficient and relevant manner particularly when it comes to automation mismanagement and potential aircraft state upset.

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SUBJECT 021 — AIRFRAME AND SYSTEMS, ELECTRICS, POWER PLANT AND EMERGENCY EQUIPMENT

Syllabus reference	BK	Syllabus details and associated Learning Objectives	Aeroplane		Helicopter			IR	CBIR(A) & EIR	Comments
			ATPL	CPL	ATPL/ IR	ATPL	CPL			
020 00 00 00		**AIRCRAFT GENERAL KNOWLEDGE**								
021 00 00 00		**AIRCRAFT GENERAL KNOWLEDGE — AIRFRAME AND SYSTEMS, ELECTRICS, POWER PLANT, EMERGENCY EQUIPMENT**								
021 01 00 00		**SYSTEM DESIGN, LOADS, STRESSES, MAINTENANCE**								
021 01 01 00		**System design**								
021 01 01 01		***Design concepts***								
(01)	X	Describe the following structural design philosophy: — safe life; — fail-safe (multiple load paths); — damage-tolerant.	X	X	X	X	X			Reworded
(02)		~~Describe the following system design philosophy:~~ — R~~r~~edundancy~~.~~ Explain the purpose of redundancy in aircraft design.	X	X	X	X	X			Reworded
021 01 01 02		***Level of certification***								
~~LO (01)~~		~~Explain and state the safety objectives associated with failure conditions (AMC 25.1309, Fig. 2).~~	~~X~~							No practical use

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Syllabus reference	BK	Syllabus details and associated Learning Objectives	Aeroplane		Helicopter			IR	CBIR(A) & EIR	Comments
			ATPL	CPL	ATPL/ IR	ATPL	CPL			
~~LO (02)~~		~~Explain the relationship between the probability of a failure and the severity of the failure effects.~~	~~X~~		~~X~~	~~X~~				No practical use
(03)	X	Explain why some systems are duplicated or triplicated.	X	X	X	X				
(04) New	X	Explain that all aircraft are certified according to specifications determined by the authority, and that these certification specifications cover aspects such as design, material quality and build quality.	X	X	X	X	X			New LO
(05) New	X	State that the certification specifications for aeroplanes issued by EASA are: — CS-23 for Normal, Utility, Aerobatic and Commuter Aeroplanes; — CS-25 for Large Aeroplanes.	X	X						New LO
(06) New	X	State that the certification specifications for rotorcraft issued by EASA are: — CS-27 for Small Rotorcraft; — CS-29 for Large Rotorcraft.			X	X	X			New LO
021 01 02 00		**Loads and stresses**								
~~LO (01)~~		~~Explain the following terms:~~ — ~~stress,~~ — ~~strain,~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		~~— tension,~~ ~~— compression,~~ ~~— buckling,~~ ~~— bending,~~ ~~— torsion,~~ ~~— static loads,~~ ~~— dynamic loads,~~ ~~— cyclic loads,~~ ~~— elastic and plastic deformation.~~								
		~~*Remark: Stress is the internal force per unit area inside a structural part as a result of external loads. Strain is the deformation caused by the action of stress on a material. It is normally given as the change in dimension expressed in a percentage of the original dimensions of the object.*~~								Editorial Moved after 021 01 02 00 (03)
~~LO (02)~~		~~Describe the relationship between stress and strain for a metal.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(03)		Explain how stress and strain are always present in an aircraft structure both when parked and during manoeuvring.	X	X	X	X	X			New LO
(04)		*Remark: Stress is the internal force per unit area inside a structural part as a result of external loads. Strain is the deformation caused by the action of stress on a material.* ~~*It is normally given as the change in dimension expressed in a percentage of the original*~~								Moved from above and reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		~~*dimensions of the object.*~~								
(05) New		Describe the following types of loads that an aircraft may be subject to, when they occur, and how a pilot may affect their magnitude: — static loads; — dynamic loads; — cyclic loads.	X	X	X	X	X			New LO
(06) New		Describe the areas typically prone to stress that should be given particular attention during a pre-flight inspection, and highlight the limited visual cues that may be evident of any deformation.	X	X	X	X	X			New LO
021 01 03 00		**Fatigue and corrosion**								Combined 021 01 03 00 and 021 01 04 00
~~LO (01)~~		~~Describe the phenomenon of fatigue.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Covered in (07)
~~LO (02)~~		~~Explain the relationship between the magnitude of the alternating stress and the number of cycles (S/N diagram or Wöhler curve).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~Explain the implication of stress concentration factor.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04) New		Describe the effects of corrosion and how it can be visually identified by a pilot during the pre-flight inspection.	X	X	X	X	X			New LO
(05) New		Describe operating environments where the risk of corrosion is increased and how to minimise the effects of the environmental	X	X	X	X	X			New LO

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		factors.								
(06) New		Explain that aircraft have highly corrosive fluids on board as part of their systems and equipment.	X	X	X	X	X			New LO
(07) New		Explain fatigue, how it affects the useful life of an aircraft, and the effect of the following factors on the development of fatigue: — corrosion; — number of cycles; — type of flight manoeuvres; — stress level; — level and quality of maintenance.								New LO
021 01 04 00		~~**Corrosion**~~ **Intentionally left blank**								Combined with 021 01 03 00
~~LO (01)~~		~~Describe the following types of corrosion:~~ ~~— oxidation,~~ ~~— electrolytic.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (02)~~		~~Describe the interaction between fatigue and corrosion (stress corrosion).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Combined with 021 01 03 00 (07)
021 01 05 00		**Maintenance**								
021 01 05 01		***Maintenance methods: hard time and on condition***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		Explain the following terms: — hard-time or fixed-time maintenance; — on-condition maintenance~~.~~; — condition monitored.	X	X	X	X	X			Reworded and updated
021 02 00 00		**AIRFRAME**								
021 02 01 00		**~~Construction and a~~ Attachment methods**								Reworded
~~LO (01)~~		~~Describe the principles of the following construction methods:~~ — M~~m~~onocoque; — semi-monocoque; — cantilever; — sandwich, including honey comb; — truss.	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(02)		Describe the following attachment methods used for aircraft parts and components: — riveting, — welding, — bolting, — pinning, — adhesives (bonding).	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
~~LO (03)~~		~~State that sandwich structural parts need additional provisions to carry concentrated loads.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04) New		Explain how the development of a faulty attachment between aircraft parts or components can be detected by a pilot during the pre-flight inspection.	X	X	X	X	X			New LO
021 02 02 00		**Materials**								
~~LO (01)~~		~~Explain the following material properties:~~ — ~~elasticity,~~ — ~~plasticity,~~ — ~~stiffness,~~ — ~~strength,~~ — ~~strength-to-density ratio.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (02)~~		~~Compare the above properties as they apply to aluminium alloys, magnesium alloys, titanium alloys, steel and composites.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~Explain the need to use alloys rather than pure metals.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)	X	Explain the principle of a composite material, and give examples of typical composite materials used on aircraft: — carbon, — glass, — Kevlar.	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
~~LO (05)~~		~~Describe the function of the following components:~~ — M~~m~~atrix, resin or filler; — fibres.	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(06)	X	State the advantages and disadvantages of composite materials compared with metal alloys by considering the following: — strength-to-weight ratio; — capability to tailor the strength to the direction of the load; — stiffness; — electrical conductivity (lightning); — resistance to fatigue; — resistance to corrosion and cost~~.~~; — discovering damage during a pre-flight inspection.	X	X	X	X	X			Reworded
~~LO (07)~~		~~State that the following are composite fibre materials:~~ — C~~c~~arbon, — glass, — aramid (Kevlar).	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(08) New		Describe that several types of materials are used on aircraft and that they are chosen based on type of structure or component and the required/desired material properties.	X	X	X	X	X			New LO
021 02 03 00		**Aeroplane: wings, tail surfaces and control surfaces**								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 02 03 01		***Design ~~and construction~~***								
~~LO (01)~~		~~Describe the following types of construction:~~ — Ceantilever, — non-cantilever (braced).	~~X~~	~~X~~						No practical use
(02) New		Describe the following types of design and explain their advantages and disadvantages: — high-mounted wing; — low-mounted wing; — low- or mid-set tailplane; — T-tail.	X	X						New LO
021 02 03 02		***Structural components***								
(01)		Describe the function of the following structural components: — spar and its components (web and girder or cap); — rib; — stringer; — skin; — torsion box.	X	X						Reworded
021 02 03 03		***Loads, stresses and aeroelastic vibrations (‘flutter’)***								
(01)		Describe the vertical and horizontal loads on the ground and	X	X						Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		during normal flight.								
(02)		~~Describe the loads in flight for symmetrical and asymmetrical conditions, considering both vertical and horizontal loads and loads due to engine failure.~~ Describe the vertical and horizontal loads during asymmetric flight following an engine failure for a multi-engine aeroplane, and how a pilot may potentially overstress the structure during the failure scenario.	X	X						Reworded
(03)		~~Describe~~ Explain the principle of flutter, flutter damping and resonance for the wing and control surfaces, and describe possible countermeasures.	X	X						Reworded
(04)		Explain the significance on stress relief and flutter of the following: — chord-wise and span-wise position of masses (e.g. engines, fuel and balance masses, control balance masses); — torsional stiffness; — bending flexibility~~.~~; — fuel-balancing procedures by the pilot during flight.	X	X						Reworded
~~LO (05)~~		~~Describe the following design configurations:~~ — C~~c~~onventional (low- or mid-set) tailplane; — T-tail.	~~X~~	~~X~~						Covered in 021 02 03 01 (02)
021 02 04 00		**Fuselage, landing gear, doors, floor, windscreen and windows**								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)	X	Describe the following types of fuselage construction: — monocoque, — semi-monocoque.	X	X	X	X	X			
(02)		Describe the construction and the function of the following structural components of a fuselage: — frames; — bulkhead; — pressure bulkhead; — stiffeners, stringers, longerons; — skin, doublers; — floor suspension (crossbeams); — floor panels; — firewall.	X	X	X	X	X			Reworded
(03)		Describe the loads on the fuselage due to pressurisation.	X	X						
(04)		Describe the following loads on a main landing gear: — touch-down loads (vertical and horizontal); — taxi loads on bogie gear (turns).	X	X						
(05)		Describe the structural danger of a nose-wheel landing with respect to: — fuselage loads;	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— nose-wheel strut loads.								
(06)		Describe the structural danger of a tail strike with respect to: — fuselage and aft bulkhead damage (pressurisation).	X	X						
(07)		Describe the door and hatch construction for pressurised and unpressurised aeroplanes including: — door and frame (plug type); — hinge location; — locking mechanism.	X	X						
(08)	X	Explain the advantages and disadvantages of the following fuselage cross sections: — circular; — double bubble (two types); — oval; — rectangular.	X	X						
(09)		~~State that~~ Explain why flight-deck windows are constructed with different layers.	X	X						Reworded
(10)		Explain the function of window heating for structural purposes.	X	X						
(11)		Explain the implication of a direct-vision window (see CS 25.773(b)(3)).	X	X						
(12)		State the need for an eye-reference position.	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(13)		Explain the function of floor venting (blow-out panels).	X	X						
(14)		Describe the construction and fitting of sliding doors.			X	X	X			
021 02 05 00		**Helicopter: flight controls structural aspects**								
021 02 05 01		***Design and construction***								
(01)		List the functions of flight controls.			X	X	X			
~~LO (02)~~		~~Describe and explain the different flight control design concepts for conventional, tandem, coaxial, side by side, NOTAR and Fenestron-equipped helicopters.~~			~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~Explain the advantages, disadvantages and limitations of the respective designs above.~~			~~X~~	~~X~~	~~X~~			No practical use
~~LO (04)~~		~~Explain the function of the synchronised elevator.~~			~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~Describe the construction methods and alignment of vertical and horizontal stabilisers.~~ Explain why vertical and horizontal stabilisers may have different shapes and alignments.			X	X	X			Reworded
021 02 05 02		***Structural components and materials***								
(01)		Name the main components of flight and control surfaces.			X	X	X			
(02)		Describe the fatigue life and methods of checking for serviceability of flight and control surface components and materials.			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 02 05 03		***Loads, stresses and aeroelastic vibrations***								
~~LO (01)~~		~~Describe and explain where the main stresses are applied to components.~~			~~X~~	~~X~~	~~X~~			No practical use
(02)		Describe the dangers and stresses regarding safety and serviceability in flight when the manufacturer's design envelope is exceeded.			X	X	X			
~~LO (03)~~		~~Explain the procedure for:~~ — S~~s~~tatic chord-wise balancing; — static span-wise balancing; — blade alignment; — dynamic chord-wise balancing; — dynamic span-wise balancing.			~~X~~	~~X~~	~~X~~			No practical use
(04)		~~Explain the process of blade tracking including:~~ — T~~t~~he pre-track method of blade tracking; — the use of delta incidence numbers; — aircraft configuration whilst carrying out tracking; — factors affecting blade flying profile; — ground tracking and in-flight trend analysis; — use of pitch-link and blade trim tab adjustments; — tracking techniques, including stroboscopic and electronic.			X	X	X			Reworded

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		Explain that blade tracking is important both to minimise vibration and to help ensure uniformity of flow through the disc.								
(05)		Describe the early indications and vibrations which are likely to be experienced when the main-rotor blades and tail rotor are out of balance and/or tracking, including the possible early indications due to possible fatigue and overload.			X	X	X			
(06)		Explain how a vibration harmonic can be set up in other components which can lead to their early failure.			X	X	X			
(07)		Describe the three planes of vibration measurement, i.e. vertical, lateral, fore and aft.			X	X	X			
021 02 06 00		**Structural limitations**								
(01)		Define and explain the following maximum structural masses: — maximum ramp mass; — maximum take-off mass; — maximum zero-fuel mass; — maximum landing mass. *Remark: These limitations may also be found in the relevant part of Ssubjects 031, 032 and 034.*	X	X						
(02)		Explain that airframe life is limited by fatigue, created by alternating stress and the number of load cycles.	X	X						

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(03)		Explain the maximum structural masses: — maximum take-off mass.			X	X	X			
(04)		Explain that airframe life is limited by fatigue, created by load cycles.			X	X	X			
021 03 00 00		**HYDRAULICS**								
021 03 01 00		**Hydromechanics: basic principles**								
(01)	X	Explain the concept and basic principles of hydromechanics including: — hydrostatic pressure; — Pascal's law; — the relationship between pressure, force and area; — transmission of power: multiplication of force, decrease of displacement.	X	X	X	X	X			
021 03 02 00		**Hydraulic systems**								
021 03 02 01		***Hydraulic fluids: types, characteristics, limitations***								
(01)	X	List and explain the desirable properties of a hydraulic fluid: — thermal stability; — corrosiveness; — flashpoint and flammability;	X	X	X	X	X			

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		— volatility; — viscosity.								
(02)	X	State that hydraulic fluids are irritating for skin and eyes.	X	X	X	X	X			
~~LO (03)~~		~~List the two different types of hydraulic fluids:~~ — S~~s~~ynthetic, — mineral.	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (04)~~		~~State that different types of hydraulic fluids cannot be mixed.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~State that at the pressures being considered, hydraulic fluid is considered incompressible.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
021 03 02 02		***System components: design, operation, degraded modes of operation, indications and warnings***								
(01)		Explain the working principle of a hydraulic system.	X	X	X	X	X			
(02)		Describe the difference in principle of operation between a constant pressure system and a system pressurised only on specific demand ~~(open-centre)~~.	X	X	X	X	X			Reworded
(03)		State the differences in principle of operation between a passive hydraulic system (without a pressure pump) and an active hydraulic system (with a pressure pump).	X	X	X	X	X			
(04)	X	List the main advantages and disadvantages of system actuation by hydraulic or purely mechanical means with respect to:	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— weight, — size, — force.								
(05)		List the main ~~users~~ uses of hydraulic systems.	X	X	X	X	X			Reworded
(06)		State that hydraulic systems can be classified as either high pressure (typically 3 000 psi or higher) and low pressure (typically up to 2 000 psi).	X	X	X	X	X			
(07)		~~State that the normal hydraulic pressure of most large transport aircraft is 3 000 psi.~~ State that a high-pressure hydraulic system is normally operating at 3 000 psi.	X	X	X	X	X			Reworded
(08)		~~Explain the working principle of a low-pressure (0–2000 psi) open centred system using an off loading valve and an RPM dependent pump.~~ Explain the working principle of a low-pressure (0–2 000 psi) system.	X	X	X	X	X			Reworded
(09)		Explain the advantages and disadvantages of a high-pressure system over a low-pressure system.	X	X	X	X	X			
~~LO (10)~~		~~Describe the working principle and functions of pressure pumps including:~~ — constant pressure pump (swash plate or cam plate);	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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		— pressure pump whose output is dependent on pump revolutions per minute (RPM) (gear type).								
(11)		~~State that for an aeroplane, the power sources of a hydraulic pressure pump can be:~~ Explain the following different sources of hydraulic pressure, their typical application and potential operational limitations: — manual; — engine gearbox; — electrical; — air (pneumatic and ram-air turbine); — hydraulic (power transfer unit) or reversible motor pumps.	X	X						Reworded
(12)		~~State that for a helicopter, the power sources of a hydraulic pressure pump can be:~~ Explain the following different sources of hydraulic pressure, their typical application and potential operational limitations: — manual, — engine, — gearbox, — electrical.			X	X	X			Reworded
(13)		Describe the working principle and functions of the following hydraulic system components:	X	X	X	X	X			Reworded

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		— reservoir (pressurised and unpressurised); — accumulators; — case drain lines and fluid cooler return lines; — piston actuators (single and double acting); — hydraulic motors; — filters; — non-return (check) valves; — relief valves; — restrictor valves; — elector valves (linear and basic rotary selectors, two and four ports); — bypass valves; — shuttle valves; — fire shut-off valves; — priority valves; — fuse valves; — pressure and return pipes.								
(14)		Explain why many transport aeroplanes have ‘demand’ hydraulic pumps.	X	X						
(15)		Explain how redundancy is obtained by giving examples.	X	X	X	X	X			

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(16)		~~Interpret the hydraulic system schematic appended to these LOs (to be introduced at a later date).~~ Interpret a typical hydraulic system schematic to the level of detail as found in an aircraft flight crew operating manual (FCOM).	X	X	X	X	X			Reworded
(17)		Explain the implication of a high system demand.	X	X	X	X	X			
~~LO (18)~~		~~Explain the implication of a system internal leakage including hydraulic lock of piston actuators.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(19)		List and describe the instruments and alerts for monitoring a hydraulic system.	X	X	X	X	X			
(20)		State the indications and explain the implications of the following malfunctions: — system leak or low level; — low pressure; — high temperature.	X	X	X	X	X			
021 04 00 00		**LANDING GEAR, WHEELS, TYRES, BRAKES**								
021 04 01 00		**Landing gear**								
021 04 01 01		***Types***								
(01)	X	Name, for an aeroplane, the following different landing-gear configurations: — nose wheel,	X	X						

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		— tail wheel.								
(02)	X	Name, for a helicopter, the following different landing-gear configurations: — nose wheel, — tail wheel, — skids.			X	X	X			Reworded
021 04 01 02		***System components, design, operation, indications and warnings, on-ground/in-flight protections, emergency extension systems***								
(01)		Explain the function of the following components of a landing gear: — oleo leg/shock strut; — axles; — bogies and bogie beam; — drag struts; — side stays/struts; — torsion links; — locks (over centre); — gear doors and retraction mechanisms (normal and emergency operation).	X	X						
(02)		Explain the function of the following components of a landing gear: — oleo leg/shock strut;			X	X	X			

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		— axles; — drag struts; — side stays/struts; — torsion links; — locks (over centre); — gear doors and retraction mechanisms (normal and emergency operation).								
(03)		Name the different components of a landing gear, using the diagram appended to these LOs.	X	X						
(04)		~~Describe the sequence of events of the landing gear during normal operation.~~ Describe the sequence of events during normal operation of the landing gear.	X	X	X	X	X			Reworded
(05)		State how landing-gear position indication and alerting is implemented.	X	X	X	X	X			
(06)		Describe the various protection devices to avoid inadvertent gear retraction on the ground and explain the implications of taking off with one or more protection devices in place: — ground lock (pins); — protection devices in the gear-retraction mechanism.	X	X	X	X	X			Reworded

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(07)		Explain the speed limitations for gear operation (VLO (maximum landing gear operating speed) and VLE (max landing gear extended speed)).	X	X						
(08)		Describe the sequence for emergency gear extension: — unlocking; — operating; — down-locking.	X	X	X	X	X			
(09)		Describe some methods for emergency gear extension including: — gravity/free fall; — air or nitrogen pressure; — manually/mechanically.	X	X	X	X	X			
021 04 02 00		**Nose-wheel steering: design, operation**								
(01)		Explain the operating principle of nose-wheel steering.	X	X	X	X	X			
(02)		Explain, for a helicopter, the functioning of differential braking with free-castoring nose wheel.			X	X	X			
(03)		Describe, for an aeroplane, the functioning of the following systems: — differential braking with free-castoring nose wheel; — tiller or hand wheel steering; — rudder pedal nose-wheel steering.	X	X						

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(04)		Explain the centring mechanism of the nose wheel.	X	X						
(05)		Define the term 'shimmy' and the possible consequences for the nose- and the main-wheel system.	X	X	X	X	X			
(06)		Explain the purpose of main-wheel (body) steering.	X	X						
021 04 03 00		**Brakes**								
021 04 03 01		***Types and materials***								
(01)		Describe the basic operating principle of a disk brake.	X	X	X	X	X			
(02)		State the different materials used in a disc brake (steel, carbon).	X	X	X	X	X			
(03)		~~Describe their characteristics, advantages and disadvantages such as:~~ Describe the characteristics, advantages and disadvantages of steel or carbon brake disks referring to: — weight; — temperature limits; — internal-friction coefficient; — wear.	X	X	X	X	X			Reworded
021 04 03 02		***System components, design, operation, indications and warnings***								
(01)		~~State~~ Explain the limitation of brake energy and describe the operational consequences.	X	X						Reworded

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(02)		Explain how brakes are actuated: — hydraulically, — electrically.	X	X	X	X	X			Reworded
~~LO (03)~~ (04)		~~Identify the task of an auto-retract or in-flight brake system.~~ Explain the purpose of an in-flight wheel brake system.	X	X						Reworded
~~LO (05)~~		~~State that brakes can be torque-limited.~~	~~X~~	~~X~~						No practical use
(06)		Describe the function of a brake accumulator.	X	X	X	X	X			
(07)		Describe the function of the parking brake.	X	X	X	X	X			
(08)		Explain the function of brake-wear indicators.	X	X						Reworded
(09)		Explain the reason for the brake-temperature indicator.	X	X						
~~LO (10)~~		~~State that the main power source for brakes in normal operation and for alternate operation for large transport aeroplanes is hydraulic.~~	~~X~~	~~X~~						Covered in (02)
021 04 03 03		***Anti-skid***								
(01)		Describe the operating principle of an anti-skid system where the brake performance is based on maintaining the optimum wheel-slip value.	X	X						
(02)		~~Explain the purpose of the wheel-speed signal (tachometer) and of the aeroplane reference speed signal to the anti-skid computer,~~	X	X						Reworded

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		~~considering:~~ Explain that the anti-skid computer compares wheel speed to aeroplane reference speed to provide the following: — slip ratio for maximum braking performance; — locked-wheel prevention (protection against deep skid on one wheel); — touchdown protection (protection against brake-pressure application during touchdown); — hydroplane protection.								
(03)		Give examples of the impact of an anti-skid system on performance, and explain the implications of anti-skid system failure.	X	X						Reworded
021 04 03 04		***Autobrake***								
(01)		Describe the operating principle of an autobrake system.	X	X						
(02)		~~State that~~ Explain why the anti-skid system must be available when using autobrakes.	X	X						Reworded
(03)		Explain the difference between the three ~~possible levels~~ modes of operation of an autobrake system: — OFF (system off or reset); — Armed~~/Disarm~~ (~~arm:~~ the system is ready to operate under certain conditions);	X	X						Reworded

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		— ~~Operative/Inoperative or~~ Activated/Deactivated (application of pressure on brakes).								
(04) New		Describe how an autobrake system setting will result in a given rate of deceleration, and how the amount of braking applied may be affected by: — the use of reverse thrust; — slippery runway.	X	X						New LO
021 04 04 00		**Wheels, rims and tyres**								
021 04 04 01		***Types, structural components and materials, operational limitations, thermal plugs***								
(01)	X	Describe the different types of tyres such as: — tubeless; — diagonal (cross ply); — radial (circumferential bias).	X	X	X	X	X			
(02)	X	Define the following terms: — ply rating; — tyre tread; — tyre creep; — retread (cover).	X	X	X	X	X			
(03)		Explain the function of thermal/fusible plugs.	X	X						

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(04)		Explain the implications of tread separation and tyre burst.	X	X						
(05)		~~State that~~ Explain why the ground speed of tyres is limited.	X	X						Reworded
~~LO (06)~~		~~Describe material and basic construction of the rim of an aeroplane wheel.~~	~~X~~	~~X~~						No practical use
021 04 05 00		**Helicopter equipment**								
(01)		Explain flotation devices and how they are operated.			X	X	X			
(02)		Explain why ~~the~~ indicated airspeed (IAS) limitations before, during and after flotation-device deployment must be observed.			X	X	X			
021 05 00 00		**FLIGHT CONTROLS**								
021 05 01 00		**Aeroplane: primary flight controls**								
		~~*Remark: The manual, irreversible and reversible flight control systems as discussed in 021 05 01 01, 05 01 02 and 05 01 03 are all considered to be mechanical flight control systems. Fly by wire flight control systems are discussed in 021 05 04 00.*~~								No practical use
(01)		Define a 'primary flight control'.	X	X						
(02)		List the following primary flight control surfaces: — elevator; — aileron, roll spoilers, flaperon; — rudder.	X	X						Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(03)		List the various means of control surface actuation including: — manual; — fully powered (irreversible); — partially powered (reversible).	X	X						
021 05 01 01		***Manual controls***								
(01)		Explain the basic principle of a fully manual control system.	X	X						
021 05 01 02		***Fully powered controls (irreversible)***								
(01)		Explain the basic principle of a fully powered control system.	X	X						
(02)		Explain the concept of irreversibility in a flight control system.	X	X						
(03)		Explain the need for a 'feel system' in a fully powered control system.	X	X						
(04)		Explain the operating principle of a stabiliser trim system in a fully powered control system.	X	X						
(05)		Explain the operating principle of rudder and aileron trim in a fully powered control system.	X	X						
021 05 01 03		***Partially powered controls (reversible)***								
(01)		Explain the basic principle of a partially powered control system.	X	X						
(02)		Explain why a 'feel system' is not necessary in a partially powered control system.	X	X						

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021 05 01 04		***System components, design, operation, indications and warnings, degraded modes of operation, jamming***								
(01)		List and describe the function of the following components of a flight control system: — actuators; — control valves; — cables or electrical wiring; — electrical wiring; — control surface position sensors.	X	X						Reworded
(02)		Explain how redundancy is obtained in primary flight control systems of large transport aeroplanes.	X	X						
(03)		Explain the danger of control jamming and the means of retaining sufficient control capability.	X	X						
(04)		Explain the methods of locking the controls on the ground and describe ‘gust or control lock’ warnings.	X	X						
(05)		Explain the concept of a rudder-deflection limitation (rudder limiter) system and the various means of implementation (rudder ratio changer, variable stops, blow-back).	X	X						
021 05 02 00		**Aeroplane: secondary flight controls**								
021 05 02 01		***System components, design, operation, degraded modes of***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		operation, indications and warnings								
(01)		Define a 'secondary flight control'.	X	X						
(02)		List the following secondary flight control surfaces: — lift-augmentation devices (flaps and slats); — speed brakes; — flight and ground spoilers; — trimming devices such as trim tabs, trimmable horizontal stabiliser.	X	X						Editorial
(03)		Describe secondary flight control actuation methods and sources of actuating power.	X	X						
(04)		Explain the function of a mechanical lock when using hydraulic motors driving a screw jack.	X	X						
(05)		Describe the requirement for limiting speeds for the various secondary flight control surfaces.	X	X						
(06)		For lift-augmentation devices, explain the load-limiting (relief) protection devices and the functioning of an auto-retraction system.	X	X						Editorial
(07)		Explain how a flap/slat asymmetry protection device functions, and describe the implications of a flap/slat asymmetry situation.	X	X						Reworded
(08)		Describe the function of an auto-slat system.	X	X						Editorial

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(09)		Explain the concept of control surface blow-back (aerodynamic forces overruling hydraulic forces).	X	X						
021 05 03 00		**Helicopter: flight controls**								
(01)		Explain the methods of locking the controls on the ground.			X	X	X			
(02)		Describe main-rotor droop stops and how ~~static~~ rotor flapping is restricted.			X	X	X			Reworded
~~LO (03)~~		~~Describe the need for linear and rotary control input/output.~~			~~X~~	~~X~~	~~X~~			No practical use
(04)		Explain the principle of phase lag and advance angle.			X	X	X			
(05)		Describe the following four axes of control operation, their operating principle and their associated cockpit controls: — collective control; — cyclic fore and aft (pitch axis); — cyclic lateral (roll axis); — yaw.			X	X	X			
(06)		Describe the swash plate or azimuth star control system including the following: — swash plate inputs; — the function of the non-rotating swash plate; — the function of the rotating swash plate;			X	X	X			

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		— how swash plate tilt is achieved; — swash plate pitch axis; — swash plate roll axis; — balancing of pitch/roll/collective inputs to the swash plate to equalise torsional loads on the blades.								
~~LO (07)~~ (08)		~~Describe the main-rotor spider control system including the following:~~ — T~~t~~he collective beam; — pitch/roll/collective inputs to the collective beam; — spider drive. Describe the operation of the spider control system.			X	X	X			Reworded
~~LO (09)~~		~~Describe the need for control system interlinks, in particular:~~ — C~~c~~ollective/yaw; — collective/throttle; — cyclic/stabilator; — interaction between cyclic controls and horizontal/stabilator.			~~X~~	~~X~~	~~X~~			No practical use
(10)		~~State the need for 'feel systems' in the hydraulic actuated flight control system.~~ State the need for artificial feel in a hydraulically actuated flight control system.			X	X	X			Reworded

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(11)		Describe and explain the purpose of a trim system.			X	X	X			Reworded
~~LO (12)~~		~~Describe the purpose of a cyclic beep-trim system that utilises parallel trim actuators to enable the pilot to control the aircraft.~~			~~X~~	~~X~~	~~X~~			Covered in (11)
~~LO (13)~~		~~List and describe the different types of trim systems.~~			~~X~~	~~X~~	~~X~~			Covered in (11)
~~LO (14)~~		~~Explain the basic components of a trim system, in particular:~~ — ~~force trim switch;~~ — ~~force gradient;~~ — ~~parallel trim actuator;~~ — ~~cyclic 4-way trim switch;~~ — ~~interaction of trim system with an SAS/SCAS/ASS stability system;~~ — ~~trim motor indicators.~~			~~X~~	~~X~~	~~X~~			Covered in (11)
(15)		Describe the different types of control runs.			X	X	X			
(16)		Explain the use of control stops.			X	X	X			
021 05 04 00		**Aeroplane: f~~F~~ly-by-w~~W~~ire (FBW) control systems**								
(01)		Explain that an FBW flight control system is composed of the following: — pilot's input command (control stick/column); — electrical signalling, including:	X	X						

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		• pilot input to computer; • computer to flight control surfaces; • feedback from aircraft response to computer; — flight control computers; — actuators; — control surfaces.								
(02)		State the advantages and disadvantages of an FBW system in comparison with a conventional flight control system including: — weight; — pilot workload; — flight-envelope protection.	X	X						
(03)		Explain why an FBW system is always irreversible.	X	X						
(04)		~~State the existence of degraded modes of operation.~~ Explain the different modes of operation: — normal law; — alternate law; — direct law.	X	X						Reworded
(05) New		Describe the implications of mode degradation in relation to pilot workload and flight-envelope protection.	X	X						New LO

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(06) New		Describe the implications for pilot workload during flight in normal law during the following scenarios: — an undetected system error activates the envelope protection; — aircraft departs from intended flight path; — aircraft does not respond as expected to control inputs.	X	X						New LO
(07)		Describe the implications of: — dual control input made by the pilots; — the control takeover facility available to the pilots.	X	X						New LO
021 05 05 00		**Helicopter: f~~F~~ly-by-w~~W~~ire (FBW) control systems**								
(01)		To be introduced at a later date.			X	X	X			
021 06 00 00		**PNEUMATICS — PRESSURISATION AND AIR-CONDITIONING SYSTEMS**								
021 06 01 00		**Pneumatic/bleed air supply**								
021 06 01 01		***Piston-engine air supply***								
(01)		~~State the method~~ Describe the means of supplying air for the pneumatic systems for piston-engine aircraft.	X	X	X	X	X			Reworded
(02)		State that an air supply is required for the following systems: — instrumentation,	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— heating, — de-icing.								
021 06 01 02		***Gas turbine engine: bleed air supply***								
(01)		State that the possible bleed air sources for gas turbine engine aircraft are the following: — engine, — auxiliary power unit (APU), — ground supply.	X	X	X	X	X			
(02)		State that for an aeroplane a bleed air supply can be used for the following systems or components: — anti-icing;~~,~~ — engine air starter;~~,~~ — pressurisation of a hydraulic reservoir;~~,~~ — air-driven hydraulic pumps;~~,~~ — pressurisation and air conditioning.	X	X						
(03)		State that for a helicopter a bleed air supply can be used for the following systems or components: — anti-icing;~~,~~ — engine air starter;~~,~~ — pressurisation of a hydraulic reservoir.			X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(04)		State that the bleed air supply system can comprise the following: — pneumatic ducts~~;~~, — isolation valve~~;~~, — pressure-regulating valve~~;~~, — engine bleed valve (HP/IP valves)~~;~~, — fan-air pre-cooler~~;~~, — temperature and pressure sensors.	X	X	~~X~~	~~X~~	~~X~~			No practical use for helicopter
(05)		~~Interpret the pneumatic system schematic appended to these LOs (to be introduced at a later date).~~ Interpret a basic pneumatic system schematic to the level of detail as found in an FCOM.	X	X	X	X	X			Reworded
(06)		Describe the cockpit indications for bleed air systems.	X	X	X	X	X			
(07)		~~State~~ Explain how the bleed air supply system is controlled and monitored.	X	X	X	X	X			
(08)		~~List~~ State the following ~~air~~ bleed air malfunctions: — over-temperature, — over-pressure, — low pressure, — overheat/duct leak.	X	X	X	X	X			Reworded
021 06 02 00		**Helicopter: air-conditioning systems**								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 06 02 01		***Types, system components, design, operation, degraded modes of operation, indications and warnings***								
(01)		Describe the purpose of an air-conditioning system.			X	X	X			
(02)		Explain how an air-conditioning system is controlled.			X	X	X			
(03)		Describe the vapour cycle air-conditioning system including system components, design, operation, degraded modes of operation and system malfunction indications.			X	X	X			
(04)		Identify the following components from a diagram of an air-conditioning system and describe the operating principle and function: — air-cycle machine (pack, bootstrap system); — pack-cooling fan; — water separator; — mixing valves; — flow-control valves; — isolation valves; — recirculation fans; — filters for recirculation; — temperature sensors.			X	X	X			
(05)		List and describe the controls, indications and warnings related to			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		an air-conditioning system.								
021 06 03 00		**Aeroplane: pressurisation and air-conditioning system**								
021 06 03 01		***System components, design, operation, degraded modes of operation, indications and warnings***								
(01)		~~State~~ Explain that a pressurisation and an air-conditioning system of an aeroplane controls: — ventilation, — temperature, — pressure.	X	X						Reworded
(02)		~~State~~ Explain how ~~that in general~~ humidity is ~~not~~ controlled.	X	X						Reworded
(03)		Explain that the following components constitute a pressurisation system: — pneumatic system as the power source; — outflow valve; — outflow valve actuator; — pressure controller; — excessive differential pressure-relief valve; — negative differential pressure-relief valve.	X	X						
(04)		Explain that the following components constitute an air-conditioning system and describe their operating principles and	X	X						Editorial

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		function: — air-cycle machine (pack, bootstrap system); — pack-cooling fan; — water separator; — mixing valves; — flow-control valves (outflow valve); — isolation valves; — ram-air valve; — recirculation fans; — filters for recirculated air; — temperature sensors. *Remark: The bootstrap system is the only air-conditioning system considered for Part-FCL aeroplane examinations.*								
(05)		Describe the use of hot trim air.	X	X						
(06)		Define the following terms: — cabin altitude; — cabin vertical speed; — differential pressure; — ground pressurisation.	X	X						
(07)		Describe the operating principle of a pressurisation system.	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(08)		Describe the emergency operation by manual setting of the outflow valve position.	X	X						
(09)		Describe the working principle of an electronic cabin-pressure controller.	X	X						
(10)		State how the maximum operating altitude is determined.	X	X						
(11)		~~State~~ Explain: — why the maximum allowed value of cabin altitude is limited; — a typical value of maximum differential pressure for large transport aeroplanes ~~(8 to 9 psi)~~; — the relation between cabin altitude, the maximum differential pressure and maximum aeroplane operating altitude.	X	X						Reworded
(12)		~~Identify the aural warning when cabin altitude exceeds 10 000 ft.~~ Explain the typical warning on a transport category aircraft when cabin altitude exceeds 10 000 ft.	X	X						Reworded
(13)		List and interpret typical ~~the~~ indications of the pressurisation system.	X	X						Reworded
(14) New		Describe the main operational differences between a bleed-air-driven air-conditioning system and an electrically driven air-conditioning system as found on aircraft without engine bleed air system.	X	X						New LO

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 07 00 00		**ANTI-ICING AND DE-ICING SYSTEMS**								
021 07 01 00		**Types, design, operation, indications and warnings, operational limitations**								
(01)		Explain the concepts of de-icing and anti-icing.	X	X	X	X	X			
(02)		Name the components of an aircraft which can be protected from ice accretion.	X	X	X	X	X			
(03)		State that on some aeroplanes the tail does not have an ice-protection system.	X	X						
(04)		State the different types of anti-icing/de-icing systems and describe their operating principle: ~~(hot air, electrical, fluid)~~ — hot air, — electrical, — fluid.	X	X	X	X	X			Reworded
~~LO (05)~~		~~Describe the operating principle of these systems.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Combined with (04)
(06)		Describe the operating principle of the inflatable boot de-icing system.	X	X						
021 07 02 00		**Ice warning systems: types, operation, and indications**								
(01)		Describe the different operating principles of the following ice detectors:	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— mechanical systems using air pressure; — electromechanical systems using resonance frequencies.								
(02)		Describe the principle of operation of ice warning systems.	X	X						
021 07 03 00		**Helicopter blade heating systems**								
(01)		Explain the limitations on blade heating and the fact that on some helicopters the heating does not heat all the main-rotor blades at the same time.			X	X	X			
021 08 00 00		**FUEL SYSTEM**								
021 08 01 00		**Piston engine**								
021 08 01 01		***Fuel: types, characteristics, limitations***								
(01)		State the types of fuel used by piston engine ~~(diesel, AVGAS, MOGAS)~~ and their associated limitations: — diesel, — JET-A1 (for high-compression engines), — AVGAS, — MOGAS.	X	X	X	X	X			Reworded. Editorial
(02)		State the main characteristics of these fuels and give typical values regarding their flash points, freezing points and density.	X	X	X	X	X			
021 08 01 02		***Design, operation, system components, indications***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		State the tasks of the fuel system.	X	X	X	X	X			
(02)		Name the following main components of a fuel system, and state their location and their function. — lines; — boost pump; — pressure valves; — filter, strainer; — tanks (wing, tip, fuselage); — vent system; — sump; — drain; — fuel-quantity sensor; — temperature sensor.	X	X	X	X	X			
(03)		Describe a gravity fuel feed system and a pressure feed fuel system.	X	X	X	X	X			
(04)		Describe the construction of the different types of fuel tanks and state their advantages and disadvantages: — drum tank, — bladder tank, — integral tank.	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(05)		Explain the function of cross-feed.	X	X	X	X	X			
(06)		Define the term 'unusable fuel'.	X	X	X	X	X			
(07)		List the following parameters that are monitored for the fuel system: — fuel quantity (low-level warning); — fuel temperature.	X	X	X	X	X			
021 08 02 00		**Turbine engine**								
021 08 02 01		***Fuel: types, characteristics, limitations***								
(01)		State the types of fuel used by gas turbine engine: ~~(JET-A, JET-A1, JET-B)~~ — JET-A, — JET-A1, — JET-B.	X	X	X	X	X			Editorial
(02)		State the main characteristics of these fuels and give typical values regarding their flash points, freezing points and density.	X	X	X	X	X			
(03)		State the existence of additives for freezing.	X	X	X	X	X			
021 08 02 02		***Design, operation, system components, indications***								
(01)		~~State the tasks~~ Explain the function of the fuel system.	X	X	X	X	X			Reworded
~~LO (02)~~		~~Name the main components of a fuel system, and state their~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Reworded and editorial in

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		~~location and their function:~~ — lines; — centrifugal boost pump; — pressure valves; — fuel shut-off valve; — filter, strainer; — tanks (wing, tip, fuselage, tail); — bafflers; — sump; — vent system; — drain; — fuel-quantity sensor; — temperature sensor; — refuelling/defuelling system; — fuel dump/jettison system.								next line.
(02)		Name the main components of the fuel system and state their location and their function: — trim fuel tanks; — bafflers; — refuelling/defuelling system;	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— fuel dump/jettison system. *Remark: For completion of list, see 021 08 01 02 02.*								
(03)		~~Interpret the fuel system schematic appended to these Los.~~ Interpret a typical fuel system schematic to the level of detail as found in an aircraft FCOM.	X	X	X	X	X			Reworded
(04)		Explain the limitations in the event of loss of booster pump fuel pressure.	X	X	X	X	X			
~~LO (05)~~		~~Describe the construction of the different types of fuel tanks and state their advantages and disadvantages:~~ — ~~drum tank,~~ — ~~bladder tank,~~ — ~~integral tank.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Duplication of 021 08 01 02 (04)
~~LO (06)~~		~~Explain the function of cross-feed and transfer.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Duplication of 021 08 01 02 (05)
~~LO (07)~~		~~Define the term 'unusable fuel'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Duplication of 021 08 01 02 (06)
~~LO (08)~~		Describe the use and purpose of drip sticks (manual magnetic indicators).	X	X	~~X~~	~~X~~	~~X~~			No practical use for helicopters
(09)		Explain the considerations for fitting a fuel dump/jettison system and, if fitted, its function.	X	X	~~X~~	~~X~~	~~X~~			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
~~LO (10)~~		~~List the following parameters that are monitored for the fuel system:~~ — ~~fuel quantity (low-level warning);~~ — ~~fuel temperature.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Duplication of 021 08 01 02 (07)
021 09 00 00		**ELECTRICS**								
		Remark: Any reference to direction of current flow shall be using the conventional current flow, i.e. from positive to negative.								New remark
021 09 01 00		**General, definitions, basic applications: circuit breakers, logic circuits.**								
021 09 01 01		***Static electricity***								
(01)		Explain static electricity and describe the flying conditions where aircraft are most susceptible to build-up of static electricity.	X	X	X	X	X			Reworded
(02)		~~Describe a static discharger and explain its purpose.~~ Describe a static discharger and explain the following: — their purpose; — typical locations; — pilot's role of observing them during pre-flight inspection.	X	X	X	X	X			Reworded
(03)		Explain why an aircraft must first be grounded before refuelling/defuelling.	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(04)		Explain the reason for electrical bonding.	X	X	X	X	X			
021 09 01 02		***Direct current (DC)***								Reworded
(01)		~~State that a current can only flow in a closed circuit.~~ Explain the term 'direct current' (DC), and state that current can only flow in a closed circuit.	X	X	X	X	X			Reworded
(02)	X	Explain the basic principles of conductivity and give examples of conductors, semiconductors and insulators.	X	X	X	X	X			
(03)		~~State the operating principle of mechanical (toggle, rocker, push and pull), _hermos, time and proximity switches.~~ Describe the difference in use of the following mechanical switches: — toggle switch; — rocker switch; — pushbutton switch; — rotary switch. Explain the difference in observing their state (e.g. ON/OFF) and why some switches are guarded.	X	X	X	X	X			Reworded
(04)		~~Define 'voltage', 'current and resistance', and state their unit of measurement.~~ Define voltage and current, and state their unit of measurement.	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(05)	X	Explain Ohm's law in qualitative terms.	X	X	X	X	X			
(06)	X	Explain the effect on total resistance when resistors are connected in series or in parallel.	X	X	X	X	X			
(07)	X	State that resistances can have a positive or a negative temperature coefficient (PTC/NTC) and state their use.	X	X	X	X	X			
(08)		~~Define 'electrical work and power' in qualitative terms and state the unit of measurement.~~ Define electrical power and state the unit of measurement.	X	X	X	X	X			Reworded
~~LO (09)~~		~~Define the term 'electrical field' and 'magnetic field' in qualitative terms and explain the difference with the aid of the Lorentz force (Electromotive Force (EMF)).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(10)	X	Explain the term 'capacitance', and explain the use of a capacitor as a storage device.	X	X	X	X	X			
021 09 01 03		***Alternating current (AC)***								Reworded
(01)		~~Explain the term 'alternating current' (AC).~~ Explain the term 'alternating current' (AC), and compare its use to DC with regard to complexity.	X	X	X	X	X			Reworded
(02)		~~Define the term 'phase'.~~ Define the term 'phase', and explain the basic principle of single-phase and three-phase AC.	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(03)		~~Explain the principle of single-phase and three-phase AC and state its use in the aircraft.~~ State that aircraft can use single-phase or three-phase AC.	X	X	X	X	X			Reworded
(04)		~~Define 'frequency' in qualitative terms and state the unit of measurement.~~ Define frequency and state the unit of measurement.	X	X	X	X	X			Reworded
~~LO (05)~~		~~Explain the use of a particular frequency in aircraft.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(06)	X	Define 'phase shift' in qualitative terms.	X	X	X	X	X			
021 09 01 04		~~***Resistors, capacitors, inductance coil***~~ ***Intentionally left blank***								No practical use
~~LO (01)~~		~~Describe the relation between voltage and current of an ohmic resistor in an AC/DC circuit.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (02)~~		~~Describe the relation between voltage and current of a capacitor in an AC/DC circuit.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~Describe the relation between voltage and current of a coil in an AC/DC circuit.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
021 09 01 05		~~***Permanent magnets***~~ ***Intentionally left blank***								No practical use
~~LO (01)~~		~~Explain the term 'magnetic flux'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (02)~~		~~State the pattern and direction of the magnetic flux outside the magnetic poles and inside the magnet.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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021 09 01 06		***Electromagnetism***								
(01)		State that an electrical current produces a magnetic field ~~and define the direction of that field~~.	X	X	X	X	X			Reworded
(02)		Describe how the strength of the magnetic field changes with the magnitude of the current ~~if supported by a ferromagnetic core~~.	X	X	X	X	X			Reworded
(03)		Explain the purpose and the working principle of a solenoid.	X	X	X	X	X			
(04)		Explain the purpose and the working principle of a relay.	X	X	X	X	X			
(05)		Explain the principle of electromagnetic induction and how one electrical system may affect another.	X	X	X	X	X			Reworded
~~LO (06)~~		~~List the parameters affecting the inductance of a coil.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (07)~~		~~List the parameters affecting the induced voltage in a coil.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
021 09 01 07		***Circuit breakers***								
(01)		Explain the operating principle of a fuse and a circuit breaker.	X	X	X	X	X			
(02)		Explain how a fuse is rated.	X	X	X	X	X			
~~LO (03)~~		~~State the difference between a 'trip-free' and 'non-trip-free' circuit breaker.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)		~~List the following different types of circuit breakers:~~ Describe the principal difference between the following types of circuit breakers:	X	X	X	X	X			Reworded

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		— thermal circuit breaker sensing magnitude of current; — magnetic circuit breaker sensing direction of current.								
(05) New		Describe how circuit breakers may be used to reset aircraft systems/computers in the event of system failure when part of a described procedure.	X	X	X	X	X			New LO
021 09 01 08		***Semiconductors and logic circuits***								
(01)		~~State the differences between semiconductor materials and conductors and explain how the conductivity of semiconductors can be altered.~~ Describe the effect of temperature on semiconductors with regard to function and longevity of the component.	X	X	X	X	X			Reworded
~~LO (02)~~		~~State the principal function of diodes, such as rectification and voltage limiting.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~State the principal function of transistors, such as switching and amplification.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)		~~Explain~~ Describe the following five basic logic functions, as used in aircraft FCOM documentation, and recognise their schematic symbols: ~~AND, OR, NOT, NOR and NAND.~~ — AND~~,~~; — OR~~,~~; — NOT~~,~~;	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— NOR~~,~~; — NAND.								
~~LO (05)~~		~~Describe their associated symbols.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Combined with (04)
(06)		~~Interpret logic diagrams using a combination of these functions.~~ Interpret a typical logic circuit schematic to the level of detail as found in an aircraft FCOM.	X	X	X	X	X			Reworded
021 09 02 00		**Batteries**								
021 09 02 01		***Types, characteristics and limitations***								
(01)		State the function of an aircraft battery.	X	X	X	X	X			
(02)		Name the types of rechargeable batteries used in aircraft~~.~~: — lead-acid, — nickel-cadmium, — lithium-ion, — lithium-polymer.	X	X	X	X	X			Reworded
(03)		Compare ~~lead-acid and nickel-cadmium (Ni-Cd) batteries~~ the different battery types with respect to: ~~weight, voltage, load behaviour, self-discharge, charging characteristics, thermal runaway and storage life.~~ — load behaviour, — charging characteristics,	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— risk of thermal runaway.								
(04)		~~Explain the term 'cell voltage'.~~ Explain the term 'cell voltage' and describe how a battery may consist of several cells that combined provide the desirable voltage and capacity.	X	X	X	X	X			Reworded
~~LO (05)~~		~~State that a battery is composed of several cells.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Combined with (04)
(06)		Explain the difference between battery voltage and charging voltage.	X	X	X	X	X			
~~LO (07)~~		~~State the charging voltage that corresponds with different battery voltages.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(08)		Define the term 'capacity of batteries' and state the unit of measurement used.	X	X	X	X	X			
(09)		State the effect of temperature on battery capacity and performance.	X	X	X	X	X			Reworded
~~LO (10)~~		~~State the relationship between voltage and capacity when batteries are connected in series or in parallel.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(11)		State that in the case of loss of all generated power (battery power only) the remaining electrical power is time-limited.	X	X	X	X	X			
(12) New		Explain how particularly lithium-type batteries pose a threat to aircraft safety and what affects this risk:	X	X	X	X	X			New LO

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— numbers of batteries on board an aircraft including those brought on board by passengers; — temperature, both battery and environment; — physical condition of the battery; — battery charging.								
(13) New		Describe how to contain a battery thermal runaway highlighting the following: — how one cell can affect the neighbouring cells; — challenges if it happens in an aircraft during flight.	X	X	X	X	X			New LO
021 09 03 00		**Generation**								
		Remark: For standardisation purposes, the following standard expressions are used: — DC generator: produces DC output; — DC alternator: produces AC, rectified by integrated rectifying unit, the output is DC; — DC alternator: producing a DC output by using a rectifier; — AC generator: produces AC output; — starter generator: integrated combination of a ~~DC~~ generator ~~with DC output~~ and a starter motor ~~using battery DC~~; — permanent magnet alternator/ generator: self-exciting AC generator. ~~produces AC output without field excitation using~~	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		~~a permanent magnet~~								
021 09 03 01		***DC generation***								
(01)		Describe the basic working principle of a simple DC generator or DC alternator ~~and name its main components~~.	X	X	X	X	X			Reworded
~~LO (02)~~		~~State in qualitative terms how voltage depends on the number of windings, field strength, RPM and load.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (03)~~		~~List the differences between a DC generator and a DC alternator with regard to voltage response at low RPM, power–weight ratio, and brush sparking.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)		Explain the principle of voltage control and why it is required.	X	X	X	X	X			Reworded
(05)		~~Explain why reverse current flow from the battery to the generator must be prevented.~~ Explain the purpose of reverse current protection from the battery/busbar to the alternator.	X	X	X	X	X			Reworded
(06)		Describe the basic operating principle of a starter generator and state its purpose.	X	X	X	X	X			
021 09 03 02		***AC generation***								
(01)		~~Describe the components of a three-phase AC generator and the operating principle.~~ Describe the working principle of a brushless three-phase AC	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		generator.								
(02)		State that the generator field current is used to control voltage.	X	X	X	X	X			
(03)		~~State in qualitative terms the relation between frequency number of pole pairs and RPM of a three-phase generator.~~ State the relationship between output frequency and the RPM of an AC three-phase generator.	X	X	X	X	X			Reworded
(04)		Explain the term ~~'wild-frequency generator'~~ 'frequency wild generator'.	X	X	X	X	X			Reworded
~~LO (05)~~		~~Describe how a three-phase AC generator can be connected to the electrical system.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (06)~~		~~Describe the purpose and the working principle of a permanent magnet alternator/generator.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(07)		List the following different power sources that can be used for an aeroplane to drive an AC generator: — engine, — APU, — RAT, — hydraulic.	X	X						
(08)		List the following different power sources that can be used for a helicopter to drive an AC generator:			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— engine, — APU, — gearbox.								
021 09 03 03		***Constant ~~s~~Speed d~~D~~rive (CSD) and i~~I~~ntegrated d~~D~~rive g~~G~~enerator (IDG) systems~~.~~***								
(01)		Describe the function ~~and the working principle~~ of a CSD.	X	X						Reworded
(02)		Explain the parameters of a CSD that are monitored.	X	X						
(03)		Describe the function ~~and the working principle~~ of an IDG.	X	X						Reworded
(04)		Explain the consequences of a mechanical disconnection during flight for a CSD and an IDG.	X	X						
021 09 03 04		***Transformers, transformer rectifier units (TRU), static inverters***								Reworded
(01)		State the function of a transformer ~~and its operating principle~~.	X	X	X	X	X			Reworded
(02)		~~State the function of a Transformer Rectifier Unit (TRU), its operating principle and the voltage output.~~ State the function of a TRU and its purpose, including type of output.	X	X	X	X	X			Reworded
(03)		~~State the function of static inverters, their operating principle and the voltage output.~~ State the function of a static inverter and its purpose, including	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		type of output.								
021 09 04 00		**Distribution**								
021 09 04 01		***General***								
(01)		Explain the function of a busbar ~~bus (bus bar)~~.	X	X	X	X	X			Reworded
(02)		Describe the function of the following buses: — main bus, — tie bus, — essential bus, — emergency bus, — ground bus, — battery bus, — hot (battery) bus~~.~~, — AC bus, — DC bus, — emergency AC and/or DC bus, — essential AC and/or DC bus, — battery bus, — hot bus, — ground servicing/maintenance bus.	X	X	X	X	X			Reworded

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(03)		State that the aircraft structure can be used as a part of the electrical circuit (common earth) and explain the implications for electrical bonding.	X	X	X	X	X			
(04)		Explain the function of external power.	X	X	X	X	X			
(05)		State that a priority sequence exists between the different sources of electrical power on ground and in flight.	X	X	X	X	X			
(06)		~~Introduce~~ Explain the term 'load sharing'.	X	X	X	X	X			Reworded
~~LO (07)~~		~~Explain that load sharing is always achieved during parallel operations.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(08)		~~Introduce~~ Explain the term 'load shedding'.	X	X	X	X	X			Reworded
(09)		~~Explain that an AC load can be shed in case of generator overload.~~ Describe typical systems that can be shed in the event of a supply failure, such as passenger entertainment system and galley power.	X	X	X	X	X			Reworded
(10)		~~Interpret an electrical system schematic (appended to these LOs).~~ ~~*Remark: The system described is a split system.*~~ Interpret a typical electrical system schematic to the level of detail as found in an aircraft FCOM.	X	X	X	X	X			Reworded
(11) New		Explain the difference between a supply (e.g. generator) failure and a bus failure, and the operating consequences of either.	X	X	X	X	X			New LO

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021 09 04 02		***DC distribution***								
(01)		Describe a simple DC electrical system of a single-engine aircraft.	X	X	X	X	X			
(02)		Describe a DC electrical system of a multi-engine aircraft (CS-23/CS-27) including the distribution consequences of loss of generator(s) or bus failure.	X	X	X	X	X			
(03)		Describe the DC part of an electrical system of a transport aircraft (CS-25/CS-29) including the distribution consequences of loss of DC supply or bus failure.	X	X	X	X	X			
(04)		Give examples of DC consumers.	X	X	X	X	X			
021 09 04 03		***AC distribution***								
(01)		~~Describe the AC electrical system of a transport aircraft for split and parallel operation.~~ Explain the difference in principle of operation for a split AC electrical system and a parallel AC electrical system.	X	X	X	X	X			Reworded
(02)		~~Describe the distribution consequences of:~~ — APU electrical supply and external power priority switching; — loss of (all) generator(s); — bus failure. Describe the following distribution consequences: — power transfer between different power supplies;	X	X	X	X	X			Reworded

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		— power transfer in the event of a supply failure; — loss of all normal AC supplies.								
(03)		Give examples of AC consumers.	X	X	X	X	X			
(04)		Explain the conditions to be met for paralleling AC generators.	X	X	X	X	X			
(05)		~~Explain the terms 'real and reactive loads'.~~ State that volt-ampere (VA) is the unit for total power consumed in an AC system.	X	X	X	X	X			Reworded
(06)	X	State that the effect of real and reactive loads are compensated for in the case of paralleled AC generators.	X	X	X	X	X			Reworded
021 09 04 04		***Electrical load management and monitoring systems: automatic generators and bus switching during normal and failure operation, indications and warnings***								
(01)		Give examples of system control, monitoring and annunciators using the following terms: — generator control unit (GCU) for monitoring generator output and providing network protection; — exciter contactor/breaker/relay for control of generator exciter field; — generator contactor/breaker/relay for connecting the generator to the network; — bus-tie contactor/breaker/relay for connecting busbars	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		together; — generator switch on the flight deck for manual control of exciter contactor; — IDG/CSD disconnect switch on the flight deck for mechanical disconnection of the generator; — bus-tie switch on the flight deck with AUTO and OFF positions only.								
(02)		~~Describe, for normal (on ground/in flight) and degraded modes of operation, the following functions of an electrical load management system:~~ — D~~d~~istribution, — monitoring, — protection (overloading, over/undervoltage, incorrect frequency). Describe, for normal and degraded modes of operation, the following functions of an electrical load management system on ground and in flight using the terms in 021 09 04 04 (01): — distribution; — monitoring; — protection in the event of incorrect voltage; — protection in the event of incorrect frequency;	X	X	X	X	X			Reworded

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		— protection in the event of a differential fault.								
(03)		~~State which parameters are used to monitor an electrical system for parallel and split system operation.~~ Explain the difference in monitoring required for a parallel AC system compared to a split AC system with regard to synchronising the output from the various supplies.	X	X	X	X	X			Reworded
(04)		~~Describe how batteries are monitored.~~ Describe the requirement for monitoring the aircraft batteries.	X	X	X	X	X			Reworded
(05)		~~State that Ni-Cd batteries are monitored to avoid damage resulting from excessive temperature increase (thermal runaway).~~ Explain the importance of monitoring the battery temperature of nickel-cadmium and lithium-type batteries.	X	X	X	X	X			Reworded
(06)		Interpret various different ammeter indications of an ammeter which monitors the charge current of the battery.	X	X	X	X	X			
021 09 05 00		**Electrical motors**								
021 09 05 01		***General***								
(01)	X	State that the purpose of an electric motor is to convert electrical energy into mechanical energy.	X	X	X	X	X			
(02) New		State that because of the similarity in design, a generator and an electric motor may be combined into a starter generator.	X	X	X	X	X			New LO

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(03) New		Explain that the size of the engine determines how much energy is required for starting, and state the following: — small turbine engines may be able to use the battery for a very limited number of start attempts; — large turbine engines require one or more power sources, either external or on-board.								New LO
021 09 05 02		***Operating principle***								
(01)		~~Explain the operating principle of an electric motor as being an electrical current carrying conductor inside a magnetic field that experiences a Lorentz/electromotive (EMF) force.~~ Describe that the torque of an electrical motor is determined by the supplied voltage and current and the resulting magnetic fields within the machine.	X	X	X	X	X			Reworded
(02)	X	State that electrical motors can be either AC or DC type.	X	X	X	X	X			Reworded
(03) New		Explain the consequences of the following: — rotor seizure, — rotor runaway.	X	X	X	X	X			New LO
021 09 05 03		***Components***								
(01)	X	Name the following components of an electric motor ~~and explain their function~~:	X	X	X	X	X			Reworded

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		— rotor (rotating part of an electric motor); — stator (stationary part of an electric motor).								
021 10 00 00		**PISTON ENGINES**								
		Remark: This topic includes diesel engines and petrol engines.								
021 10 01 00		**General**								
021 10 01 01		***Types of internal-combustion engines: basic principles, definitions***								
(01)		Define the following terms and expressions: — RPM; — torque; — m~~M~~anifold a~~A~~bsolute p~~P~~ressure (MAP); — power output; — specific fuel consumption; — mechanical efficiency, thermal efficiency, volumetric efficiency; — compression ratio, clearance volume, swept (displaced) volume, total volume.	X	X	X	X	X			Reworded
~~LO (02)~~		~~Describe the influence of compression ratio on thermal efficiency.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			
021 10 01 02		***Engine: design, operation, components and materials***								
(01)		~~Describe the following main engine components and state their~~	X	X	X	X	X			Reworded

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		~~function.~~ — Cerankcase, — crankshaft, — connecting rod, — piston, — piston pin, — piston rings, — cylinder, — cylinder head, — valves, — valve springs, — push rod, — camshaft, — rocker arm, — camshaft gear, — bearings. Describe the basic operating principle of a piston engine.								
~~LO (02)~~		~~State the materials used for the following engine components:~~ — Cerankcase, — crankshaft,	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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		— connecting rod, — piston, — piston pin, — cylinder, — cylinder head, — valves, — camshaft.								
(03)		Name and identify the various types of engine design with regard to cylinder arrangement and their advantages/disadvantages~~, such as~~: — horizontal opposed, — in line, — radial, — and working cycle (four stroke: petrol and diesel).	X	X	X	X	X			Reworded
~~LO (04)~~		~~Describe the gas-state changes, the valve positions and the ignition timing during the four strokes of the theoretical piston-engine cycle.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~Explain the main differences between the theoretical (Otto cycle) and the practical four-stroke piston-engine cycles.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(06)		Describe the differences between petrol engines and diesel	X	X	X	X	X			Reworded

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		engines with respect to: — means of ignition; — maximum compression ratio; — regulating air or mixture supply to the cylinder; — specific power output (kW/kg); — thermal efficiency; — pollution from the exhaust.								
021 10 02 00		**Fuel**								
021 10 02 01		***Types, grades, characteristics, limitations***								
(01)		Name the type of fuel used for petrol engines including its colour (AVGAS).	X	X	X	X	X			
(02)		~~Name the types of fuel used for diesel engines (kerosene or diesel).~~ Name the type of fuel normally used for aviation diesel engines (JET-A1).	X	X	X	X	X			Reworded
(03)	X	Define the term ‘octane rating’.	X	X	X	X	X			
~~LO (04)~~		~~Describe the combustion process in a piston engine cylinder for both petrol and diesel engines.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~Define the term ‘flame front velocity’ and describe its variations depending on the fuel-air mixture for petrol engines.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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(06)		Define the term 'detonation' and describe the causes and effects of detonation for both petrol and diesel engines.	X	X	X	X	X			
(07)		Define the term 'pre-ignition' and describe the causes and effects of pre-ignition for both petrol and diesel engines.	X	X	X	X	X			
(08)		Identify the conditions and power settings that promote detonation for petrol engines.	X	X	X	X	X			
(09)		Describe how detonation in petrol engines is recognised.	X	X	X	X	X			
~~LO (10)~~		~~Name the anti-detonation petrol fuel additive (tetraethyl lead).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(11)		Describe the method and occasions for checking the fuel for water content.	X	X	X	X	X			
(12)		State the typical value of fuel density for aviation gasoline and diesel fuel.	X	X	X	X	X			
(13)		Explain volatility, viscosity and vapour locking for petrol and diesel fuels.	X	X	X	X	X			
021 10 03 00		**Engine fuel pumps**								
(01)		~~Describe~~ Explain the need for a separate engine-driven fuel pump.	X	X	X	X	X			Reworded
~~LO (02)~~		~~List the different types of engine-driven fuel pumps:~~ — Ggear type, — vane type.	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 10 04 00		**Carburettor/injection system**								
021 10 04 01		***Carburettor: design, operation, degraded modes of operation, indications and warnings***								
(01)		State the purpose of a carburettor.	X	X	X	X	X			
(02)		Describe the operating principle of the simple float chamber carburettor.	X	X	X	X	X			
~~LO (03)~~		~~Describe the method of achieving reliable idle operation.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)		Describe the methods of obtaining mixture control over the whole operating engine power setting range (compensation jet, diffuser).	X	X	X	X	X			
(05)		Describe the methods of obtaining mixture control over the whole operating altitude range.	X	X	X	X	X			
(06)		Explain the purpose and the operating principle of an accelerator pump.	X	X	X	X	X			
(07)		Explain the purpose of power enrichment.	X	X	X	X	X			
(08)		Describe the function of the carburettor heat system.	X	X	X	X	X			
(09)		Explain the effect of carburettor heat on mixture ratio and power output.	X	X	X	X	X			
(10)		Explain the purpose and the operating principle of a primer pump.	X	X	X	X	X			
(11)		Discuss other methods for priming an engine (acceleration pumps).	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(12)		Explain the danger of carburettor fire, including corrective measures.	X	X	X	X	X			
021 10 04 02		***Injection: design, operation, degraded modes of operation, indications and warnings***								
~~LO (01)~~		~~Describe the low pressure, continuous flow type, fuel injection system used on light aircraft piston petrol engines with the aid of a schematic diagram.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(02)		Explain the advantages and difference in operation of an injection system compared with a carburettor system.	X	X	X	X	X			Reworded
~~LO (03)~~		~~Explain the requirement for two different pumps in the fuel injection system and describe their operation.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (04)~~		~~Describe the task and explain the operating principle of fuel and mixture control valves in the injection system for petrol engines.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~Describe the task and explain the operating principle of the fuel manifold valve, the discharge nozzles and the fuel flow meter in the fuel injection system for petrol engines.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (06)~~		~~Describe the injection system of a diesel engine and explain the function of the following components:~~ — ~~H~~high-pressure fuel injection pump; — common-rail principle;	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— fuel lines; — fuel injectors.								
021 10 04 03		***Icing***								
(01)		Describe the causes and effects of carburettor icing and the action to be taken if carburettor icing is suspected.	X	X	X	X	X			
(02)		Name the meteorological conditions under which carburettor icing may occur.	X	X	X	X	X			
(03)		Describe the indications of the presence of carburettor icing with both a fixed pitch and a constant speed propeller.	X	X						
(04)		Describe the indications of the presence of carburettor icing with a helicopter.			X	X	X			
(05)		Describe the indications that will occur upon selection of carburettor heat depending on whether ice is present or not.	X	X	X	X	X			
(06)		Explain the reason for the use of alternate air on fuel injection systems and describe its operating principle.	X	X	X	X	X			
(07)		State the meteorological conditions under which induction-system icing may occur.	X	X	X	X	X			
021 10 05 00		**Cooling systems**								
021 10 05 01		***Design, operation, indications and warnings***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		Specify the reasons for cooling a piston engine.	X	X	X	X	X			
(02)		Describe the design features to enhance cylinder air cooling for aeroplanes.	X	X						
(03)		Describe the design features to enhance cylinder air cooling for helicopters (e.g. engine-driven impeller and scroll assembly, baffles).			X	X	X			
(04)		Compare the ~~advantages of~~ differences between liquid- and air-cooling systems.	X	X	X	X	X			Reworded
(05)		Identify the cylinder head temperature indication to monitor engine cooling.	X	X	X	X	X			
(06)		Describe the function and the operation of cowl flaps.	X	X						
021 10 06 00		**Lubrication systems**								
021 10 06 01		***Lubricants: characteristics, limitations***								
(01)		Describe the term ‘viscosity’ including the effect of temperature.	X	X	X	X	X			
(02)		Describe the viscosity grade numbering system used in aviation.	X	X	X	X	X			
021 10 06 02		***Design, operation, indications and warnings***								
(01)		State the functions of a piston-engine lubrication system.	X	X	X	X	X			
(02)		Describe the working principle of a dry-sump lubrication system and describe the functions of the following components:	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— oil tank (reservoir) and its internal components: hot well, de-aerator, vent, expansion space; — check valve (non-return valve); — pressure pump and pressure-relief valve; — scavenge pump; — filters (suction, pressure and scavenge); — oil cooler; — oil cooler bypass valve (anti-surge and thermostatic); — pressure and temperature sensors; — lines.								
(03)		Describe a wet-sump lubrication system.	X	X	X	X	X			
(04)		State the differences between a wet- and a dry-sump lubrication system and their advantages and disadvantages.	X	X	X	X	X			Reworded
~~LO (05)~~		~~State the advantages/disadvantages of each system.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Combined with (04)
(06)		List the following factors that influence oil consumption: — oil grade, — cylinder and piston wear, — condition of piston rings.	X	X	X	X	X			
(07)		Describe the interaction between oil pressure, oil temperature and oil quantity.	X	X	X	X	X			

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021 10 07 00		**Ignition circuits**								
021 10 07 01		***Design, operation***								
(01)		Describe the working principle of a magneto-ignition system and the functions of the following components: — magneto, — contact-breaker points, — capacitor (condenser), — coils or windings, — ignition switches, — distributor, — spark plug, — high-tension (HT) cable.	X	X	X	X	X			
(02)		State why piston engines are equipped with two electrically independent ignition systems.	X	X	X	X	X			
(03)		State the function and operating principle of the following methods of spark augmentation: — starter vibrator (booster coil), — impulse-start coupling.	X	X						
(04)		State the function and operating principle of the following methods of spark augmentation:			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— starter vibrator (booster coil), — both magnetos live.								
(05)		Explain the function of the magneto check.	X	X	X	X	X			
~~LO (06)~~		~~State the reasons for using the correct temperature grade for a spark plug.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (07)~~		~~Explain the function of ignition timing advance or retard.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(08)		Explain how combustion is initiated in diesel engines.	X	X	X	X	X			
021 10 08 00		**Mixture**								
021 10 08 01		***Definition, characteristic mixtures, control instruments, associated control levers, indications***								
(01)		Define the following terms: — mixture, — chemically correct ratio (stoichiometric), — best power ratio, — lean (weak) mixture (lean or rich side of the exhaust gas temperature (EGT) top), — rich mixture.	X	X	X	X	X			
(02)		State the typical fuel-to-air ratio values or range of values for the above mixtures.	X	X	X	X	X			

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(03)		Describe the advantages and disadvantages of weak and rich mixtures.	X	X	X	X	X			
(04)		Describe the relation between engine-specific fuel consumption and mixture ratio.	X	X	X	X	X			
(05)		Describe the use of the exhaust gas temperature as an aid to mixture-setting.	X	X	X	X	X			
(06)		Explain the relation between mixture ratio, cylinder head temperature, detonation and pre-ignition.	X	X	X	X	X			
(07)		Explain the absence of mixture control in diesel engines.	X	X	X	X	X			
021 10 09 00		**Aeroplane: propellers**								
021 10 09 01		***Definitions, general***								
		Remark: Definitions and aerodynamic concepts are detailed in S~~s~~ubject 081, T~~t~~opic 07 (Propellers), but need to be appreciated for this S~~s~~ubject as well.	X	X						
021 10 09 02		***Constant-speed propeller: design, operation, system components***								
(01)		Describe the operating principle of a constant-speed propeller system under normal flight operations with the aid of a schematic.	X	X						
(02)		Explain the need for a ~~Manifold Absolute Pressure (~~MAP~~)~~ indicator to control the power setting with a constant-speed propeller.	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(03)		State the purpose of a torque-meter.	X	X						
(04)		State the purpose and describe the operation of a low-pitch stop (centrifugal latch).	X	X						
(05)		Describe the operating principle of a single-acting and a double-acting variable pitch propeller for single- and multi-engine aeroplanes.	X	X						
(06)		Describe the function and the basic operating principle of synchronising and synchro-phasing systems.	X	X						
(07)		Explain the purpose and the basic operating principle of an auto-feathering system ~~including~~ and unfeathering.	X	X						Reworded
021 10 09 03		***Reduction gearing: design***								
(01)		State the purpose of reduction gearing.	X	X						
~~LO (02)~~		~~Explain the principles of design for reduction gearing.~~	~~X~~	~~X~~						No practical use
021 10 09 04		***Propeller handling: associated control levers, degraded modes of operation, indications and warnings***								
(01)		Describe the checks to be carried out on a constant-speed propeller system after engine start.	X	X						
(02)		Describe the operation of a constant-speed propeller system during flight at different true airspeeds (TAS) and RPM including an overspeeding propeller.	X	X						

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(03)		Describe the operating principle of a variable pitch propeller when feathering and unfeathering, including the operation of cockpit controls.	X	X						
(04)		Describe the operating principle of a variable pitch propeller when reverse pitch is selected, including the operation of cockpit controls.	X	X						
(05)		Describe the operation of the propeller levers during different phases of flight.	X	X						
021 10 10 00		**Performance and engine handling**								
021 10 10 01		***Performance***								
~~LO (01)~~		~~Engine performance: define 'pressure altitude' and 'density altitude'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			Covered in 032, 050 and 081
(02)		Describe the effect on power output of a petrol and diesel engine taking into consideration the following parameters: — ambient pressure, exhaust back pressure; — temperature; — density altitude; — humidity.	X	X	X	X	X			
(03)		Explain the term 'normally aspirated engine'.	X	X	X	X	X			
(04)		Power-augmentation devices: explain the requirement for power	X	X	X	X	X			

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		augmentation (turbocharging) of a piston engine.								
(05)		Describe the function and the principle of operation of the following main components of a turbocharger: — turbine, — compressor, — waste gate, — waste-gate actuator, — absolute-pressure controller, — density controller, — differential-pressure controller.	X	X	X	X	X			
(06)		Explain the difference between an altitude-boosted turbocharger and a ground-boosted turbocharger.	X	X	X	X	X			
(07)		Explain turbo lag.	X	X	X	X	X			
(08)		Define the term ‘critical altitude’.	X	X	X	X	X			
(090		Explain the function of an intercooler.	X	X	X	X	X			
(10)		Define the terms ‘full-throttle height’ and ‘rated altitude’.	X	X	X	X	X			
021 10 10 02		***Engine handling***								
(01)		State the correct procedures for setting the engine controls when increasing or decreasing power.	X	X	X	X	X			

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(02)		Define the following terms: — take-off power; — maximum continuous power.	X	X	X	X	X			
~~LO (03)~~		~~Describe the term 'hydraulicing' and the precautions to be taken prior to engine start.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(04)		Describe the start problems associated with extreme cold weather.	X	X	X	X	X			
(05)		~~FADEC for a piston engine: To be introduced at a later date.~~ Describe the principal difference between a full-authority digital engine control (FADEC) system-controlled engine and traditional manual engine controls.	X	X	X	X	X			Reworded
(06)		Describe the engine controls available on the flight deck for a FADEC-controlled engine.	X	X	X	X	X			New LO
(07)		Explain that the FADEC has full authority of the control of all engine parameters ensuring efficient and correct running of the engine, including protection in the event of failure.	X	X	X	X	X			New LO
(08)		Explain the need for FADEC redundancy with regard to power supply and data input and output.	X	X	X	X	X			New LO
021 11 00 00		**TURBINE ENGINES**								
021 11 01 00		**Basic principles**								

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021 11 01 01		***Basic generation of thrust and the thrust formula***								
(01)		Describe how thrust is produced by a basic gas turbine engine.	X	X						
(02)		Describe the simple form of the thrust formula for a basic, straight turbojet and perform simple calculations (including pressure thrust).	X	X						
(03)		State that thrust can be considered to remain approximately constant over the whole aeroplane subsonic speed range.	X	X						
021 11 01 02		***Design, types and components of turbine engines~~, components~~***								
(01)		List the main components of a basic gas turbine engine~~.~~: — inlet, — compressor, — combustion chamber, — turbine, — outlet.	X	X	X	X	X			
~~LO (02)~~		~~Describe the system of station numbering in a gas turbine engine.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(03)		Describe the variation of static pressure, temperature and axial velocity in a gas turbine engine under normal operating conditions and with the aid of a working cycle diagram.	X	X	X	X	X			
(04)		Describe the differences between absolute, circumferential (tangential) and axial velocity.	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(05)		List the different types of gas turbine engines: — straight jet, — turbofan, — turboprop.	X	X						
(06)		State that a gas turbine engine can have one or more spools.	X	X	X	X	X			
(07)		Describe how thrust is produced by turbojet and turbofan engines.	X	X						
(08)		Describe how power is produced by turboprop engines.	X	X						
(09)		Describe the term ‘equivalent horsepower’ (= thrust horsepower + shaft horsepower).	X	X						
(10)		Explain the principle of a free turbine or free-power turbine.	X	X	X	X	X			
(11)		Define the term ‘bypass ratio’ and perform simple calculations to determine bypass ratio.	X	X						
(12)		Define the terms ‘propulsive power’, ‘propulsive efficiency’, ‘thermal efficiency’ and ‘total efficiency’.	X	X						
(13)		Describe the influence of compressor-pressure ratio on thermal efficiency.	X	X	X	X	X			
(14)		Explain the variations of propulsive efficiency with forward speed for turbojet, turbofan and turboprop engines.	X	X						
(15)		Define the term ‘specific fuel consumption’ for turbojets and	X	X						

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		turboprops.								
021 11 01 03		***Coupled turbine engine: design, operation, components and materials***								
(01)		Name the main assembly parts of a coupled turbine engine and explain the operation of the engine.			X	X	X			
(02)		Explain the limitations of the materials used with regard to maximum turbine temperature, engine and drive train torque limits.			X	X	X			
(03)		Describe the possible effects on engine components when limits are exceeded.			X	X	X			
(04)		Explain that when engine limits are exceeded, this event must be reported.			X	X	X			
021 11 01 04		***Free-turbine engine: design, components and materials***								
(01)		Describe the design methods to keep the engine's size small for installation in helicopters.			X	X	X			
(02)		List the main components of a free-turbine engine.			X	X	X			
(03)		Describe how the power is developed by a turboshaft/free-turbine engine.			X	X	X			
(04)		Explain how the exhaust gas temperature is used to monitor turbine stress.			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 11 02 00		**Main-engine components**								
021 11 02 01		***Aeroplane: air intake***								
(01)		State the functions of the engine air inlet/air intake.	X	X						
(02)		Describe the geometry of a subsonic (pitot-type) air inlet.	X	X						
(03)		Explain the gas-parameter changes in a subsonic air inlet at different flight speeds.	X	X						
(04)		Describe the reasons for, and the dangers of, the following operational problems concerning the engine air inlet: — airflow separation, — inlet icing, — inlet damage, — f~~F~~oreign o~~O~~bject d~~D~~amage (FOD), — heavy in-flight turbulence.	X	X						
021 11 02 02		***Compressor and diffuser***								
(01)		State the purpose of the compressor.	X	X	X	X	X			
(02)		Describe the working principle of a centrifugal and an axial flow compressor.	X	X	X	X	X			
(03)		Name the following main components of a single stage and describe their function for a centrifugal compressor:	X	X	X	X	X			

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		— impeller, — diffuser.								
(04)		Name the following main components of a single stage and describe their function for an axial compressor: — rotor vanes, — stator vanes.	X	X	X	X	X			
(05)		Describe the gas-parameter changes in a compressor stage.	X	X	X	X	X			
(06)		Define the term 'pressure ratio' and state a typical value for one stage of a centrifugal and an axial flow compressor and for the complete compressor.	X	X	X	X	X			
(07)		State the advantages and disadvantages of increasing the number of stages in a centrifugal compressor.	X	X	X	X	X			
(08)		Explain the difference in sensitivity for ~~Foreign Object Damage (~~FOD~~)~~ of a centrifugal compressor compared with an axial flow type.	X	X	X	X	X			
(09)		Explain the convergent air annulus through an axial flow compressor.	X	X	X	X	X			
(10)		Describe the reason for twisting the compressor blades.	X	X	X	X	X			
(11)		State the tasks of inlet guide vanes (IGVs).	X	X	X	X	X			
(12)		State the reason for the clicking noise whilst the compressor slowly	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		rotates on the ground.								
(13)		State the advantages of increasing the number of spools.	X	X	X	X	X			
(14)		Explain the implications of tip losses and describe the design features to minimise the problem.	X	X	X	X	X			
(15)		Explain the problems of blade bending and flapping and describe the design features to minimise the problem.	X	X	X	X	X			
(16)		Explain the following terms: — compressor stall, — engine surge.	X	X	X	X	X			
(17)		State the conditions that are possible causes of stall and surge.	X	X	X	X	X			
(18)		Describe the indications of stall and surge.	X	X	X	X	X			
(19)		Describe the design features used to minimise the occurrence of stall and surge.	X	X	X	X	X			
(20)		Describe a compressor map (surge envelope) with RPM lines, stall limit, steady state line and acceleration line.	X	X	X	X	X			
(21)		Describe the function of the diffuser.	X	X	X	X	X			
021 11 02 03		***Combustion chamber***								
(01)		Define the purpose of the combustion chamber.	X	X	X	X	X			
(02)		List the requirements for combustion.	X	X	X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(03)		Describe the working principle of a combustion chamber.	X	X	X	X	X			
(04)		Explain the reason for reducing the airflow axial velocity at the combustion chamber inlet (snout).	X	X	X	X	X			
(05)		State the function of the swirl vanes (swirler).	X	X	X	X	X			
(06)		State the function of the drain valves.	X	X	X	X	X			
(07)		Define the terms ‘primary airflow’ and ‘secondary airflow’ and explain their purpose.	X	X	X	X	X			
(08)		Explain the following two mixture ratios: — primary airflow to fuel, — total airflow (within the combustion chamber) to fuel.	X	X	X	X	X			
(09)		Describe the gas-parameter changes in the combustion chamber.	X	X	X	X	X			
(10)		State a typical maximum value of the outlet temperature of the combustion chamber.	X	X	X	X	X			
(11)		Describe the following types of combustion chamber and state the differences between them: — can type; — can-annular, cannular or tubo-annular; — annular; — reverse-flow annular.	X	X	X	X	X			

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~~LO (12)~~		~~Describe the principle of operation of a simplex and a duplex fuel spray nozzle (atomiser).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
021 11 02 04		***Turbine***								
(01)		Explain the purpose of a turbine in different types of gas turbine engines.	X	X	X	X	X			
(02)		Describe the principles of operation of impulse, reaction and impulse-reaction axial flow turbines.	X	X	X	X	X			
(03)		Name the main components of a turbine stage and their function.	X	X	X	X	X			
(04)		Describe the working principle of a turbine.	X	X	X	X	X			
(05)		Describe the gas-parameter changes in a turbine stage.	X	X	X	X	X			
(06)		Describe the function and the working principle of active clearance control.	X	X	~~X~~	~~X~~	~~X~~			No practical use for helicopters
(07)		Describe the implications of tip losses and the means to minimise them.	X	X	X	X	X			
(08)		Explain why the available engine thrust is limited by the turbine inlet temperature.	X	X	~~X~~	~~X~~	~~X~~			No practical use for helicopters
(09)		Explain the divergent gas-flow annulus through an axial-flow turbine.	X	X	X	X	X			
~~LO (10)~~		~~Describe turbine-blade convection, impingement and film cooling.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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(11)		Explain the high mechanical-thermal stress in the turbine blades and wheels.	X	X	X	X	X			
~~LO (12)~~		~~Explain the term 'creep'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (13)~~		~~Explain the consequences of creep on the turbine.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (14)~~		~~Explain the terms 'low-cycle fatigue' and 'high-cycle fatigue'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
021 11 02 05		***Aeroplane: exhaust***								
(01)		Name the following main components of the exhaust unit and their function: — jet pipe, — propelling nozzle, — exhaust cone.	X	X						
(02)		Describe the working principle of the exhaust unit.	X	X						
(03)		Describe the gas-parameter changes in the exhaust unit.	X	X						
(04)		Define the term 'choked exhaust nozzle' (not applicable to turboprops).	X							
(06)		Explain how jet exhaust noise can be reduced.	X	X						
021 11 02 06		***Helicopter: air intake***								
(01)		Name and explain the main task of the engine air intake.			X	X	X			

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(02)		Describe the use of a convergent air-intake ducting on helicopters.			X	X	X			
(03)		Describe the reasons for and the dangers of the following operational problems concerning engine air intake: — airflow separations, — intake icing, — intake damage, — FOD~~foreign object damage~~, — heavy in-flight turbulence.			X	X	X			
(04)		Describe the conditions and circumstances during ground operations when FOD ~~foreign object damage~~ is most likely to occur.			X	X	X			
(05)		Describe and explain the principles of air intake filter systems that can be fitted to some helicopters for operations in icing and sand conditions.			X	X	X			
(06)		Describe the function of the heated pads on some helicopter air intakes.			X	X	X			
021 11 02 07		***Helicopter: exhaust***								
~~LO (01)~~		~~Name the following main components of the exhaust unit and their function.~~ — ~~jet pipe,~~			~~X~~	~~X~~	~~X~~			No practical use

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		— ~~exhaust cone.~~								
(02)		Describe the working principle of the exhaust unit.			X	X	X			
(03)		Describe the gas-parameter changes in the exhaust unit.			X	X	X			
021 11 03 00		**Additional components and systems**								
021 11 03 01		***Engine fuel system***								
(01)		Name the main components of the engine fuel system and state their function.	X	X	X	X	X			
(02)		Name the two types of engine-driven high-pressure pumps, such as: — gear-type, — swash plate-type.	X	X	X	X	X			
(03)		State the tasks of the fuel control unit.	X	X	X	X	X			
(04)		List the possible input parameters to a fuel control unit to achieve a given thrust/power setting.	X	X	X	X	X			
021 11 03 02		***Engine control system***								
(01)		State the tasks of the engine control system.	X	X	X	X	X			
(02)		List the following different types of engine control systems ~~(refer to AMC to CS-E 50 Engine control system (1) Applicability) and state their respective engine control (output) parameters~~:	X	X	X	X	X			Reworded

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		— hydro mechanical ~~(Main Engine Control (MEC))~~; — hydro mechanical with a limited authority electronic supervisor ~~(Power Management System/Control (PMS/PMC))~~; — single-channel ~~full-authority engine control~~ FADEC with hydro-mechanical backup; — dual-channel ~~full-authority electronic engine control~~ FADEC ~~system~~ with no backup or any other combination ~~(FADEC)~~.								
(03)		Describe a FADEC as a full-authority dual-channel system including functions such as an electronic engine control unit, wiring, sensors, variable vanes, active clearance control, bleed configuration, electrical signalling of thrust lever angle (TLA) (see also AMC to CS-E-50), and an EGT protection function and engine overspeed.	X		X	X				Reworded
(04)		Explain how redundancy is achieved by using more than one channel in a FADEC system.	X		X	X				
(05)		State the consequences of a FADEC single input data failure.	X		X	X				
(06)		State that all input and output data are checked by both channels in a FADEC system.	X		X	X				Reworded
(07)		State that a FADEC system uses its own sensors and that, in some cases, also data from aircraft systems is used.	X		X	X				
(08)		State that a FADEC must have its own source of electrical power.	X		X	X				
021 11 03 03		***Engine lubrication***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		State the tasks of an engine lubrication system.	X	X						
(02)		Name the following main components of a lubrication system and state their function: — oil tank and centrifugal breather, — oil pumps (pressure and scavenge pumps), — oil filters (including the bypass), — oil sumps, — chip detectors, — coolers.	X	X						
(03)		Explain that each spool is fitted with at least one ball bearing and two or more roller bearings.	X	X						Reworded
(04)		Explain the use of compressor air in oil-sealing systems (e.g. labyrinth seals).	X	X						
021 11 03 04		***Engine auxiliary gearbox***								
(05)		State the tasks of the auxiliary gearbox.	X	X						
(06)		Describe how the gearbox is driven and lubricated.	X	X						
021 11 03 05		***Engine ignition***								
(01)		State the task of the ignition system.	X	X						
(02)		Name the following main components of the ignition system and	X	X						

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		state their function: — power sources, — trembler mechanism (vibrator), — transformer, — diodes, — capacitors, — discharge gap (high-tension (HT) tube), — igniters.								
(03)		State why jet turbine engines are equipped with two electrically independent ignition systems.	X	X						
(04)		Explain the different modes of operation of the ignition system.	X	X						
021 11 03 06		***Engine starter***								
(01)		Name the main components of the starting system and state their function.	X	X						
(02)		Explain the principle of a turbine engine start.	X	X						
(03)		Describe the following two types of starters: — electric, — pneumatic.	X	X						
(04)		Describe a typical start sequence (on ground/in flight) for a	X	X						

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		turbofan.								
(05)		Define 'self-sustaining RPM'.	X	X						
021 11 03 07		***Reverse thrust***								
(01)		Name the following main components of a reverse-thrust system and state their function: — reverse-thrust select lever, — power source (pneumatic or hydraulic), — actuators, — doors, — annunciations.	X	X						
(02)		Explain the principle of a reverse-thrust system.	X	X						
(03)		Identify the advantages and disadvantages of using reverse thrust.	X	X						
(04)		Describe and explain the following different types of thrust-reverser systems: — hot-stream reverser, — clamshell or bucket-door system, — cold-stream reverser (only turbofan engines), — blocker doors, — cascade vanes.	X	X						

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(05)		Explain the implications of reversing the cold stream (fan reverser) only on a high bypass ratio engine.	X	X						
(06)		Describe the protection features against inadvertent thrust-reverse deployment in flight as present on most transport aeroplanes.	X	X						
(07)		Describe the controls and indications provided for the thrust-reverser system.	X	X						
021 11 03 08		***Helicopter specifics on design, operation and components for: a~~A~~dditional components and systems such as lubrication system, ignition circuit, starter, accessory gearbox***								
(01)		State the task of the lubrication system.			X	X	X			
(02)		List and describe the common helicopter lubrication systems.			X	X	X			
(03)		Name the following main components of a helicopter lubrication system: — reservoir; — pump assembly; — external oil filter; — magnetic chip detectors, electronic chip detectors; — thermostatic oil coolers; — breather.			X	X	X			

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(04)		Identify and name the components of a helicopter lubrication system from a diagram.			X	X	X			
(05)		Identify the indications used to monitor a lubrication system including warning systems.			X	X	X			
(06)		Explain the differences and appropriate use of straight oil and compound oil, and describe the oil numbering system for aviation use.			X	X	X			
(07)		Explain and describe the ignition circuit for engine start and engine relight facility when the selection is set for both automatic and manual functions.			X	X	X			
(08)		Explain and describe the starter motor and the sequence of events when starting, and that for most helicopters the starter becomes the generator after the starting sequence is over.			X	X	X			
(09)		Explain and describe why the engine drives the accessory gearbox.			X	X	X			
021 11 04 00		**Engine operation and monitoring**								
021 11 04 01		***General***								
(01)		Explain the following aeroplane engine ~~limitations~~ ratings: — take-off, — go-around, — maximum continuous thrust/power,	X	X						Reworded

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		— maximum climb thrust/power.								
(02)		Explain spool-up time.	X	X	X	X	X			
(03)		Explain the reason for the difference between ground and approach flight idle values (RPM).	X	X						
(04)		State the parameters that can be used for setting and monitoring the thrust/power.	X	X	X	X	X			
(05)		Describe the terms ‘alpha range’, ‘beta range’ and ‘reverse thrust’ as applied to a turboprop power lever.	X	X						
(06)		Explain the dangers of inadvertent beta-range selection in flight for a turboprop.	X	X						
(07)		Explain the purpose of engine trending.	X	X	~~X~~	~~X~~				No practical use for helicopters
(08)		Explain how the exhaust gas temperature is used to monitor turbine stress.	X	X	X	X	X			
(09)		Describe the effect of engine acceleration and deceleration on the EGT.	X	X	X	X				
(10)		Describe the possible effects on engine components when EGT limits are exceeded.	X	X	X	X	X			
(11)		Explain why engine-limit exceedances must be reported.	X	X	X	X				

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(12)		Explain the limitations on the use of the thrust-reverser system at low forward speed.	X	X						
(13)		Explain the term 'engine seizure'.	X	X	X	X				
(14)		State the possible causes of engine seizure and explain their preventative measures.	X	X	X	X				
(15)		Explain the reason for the difference in the pressures of the fuel and oil in the heat exchanger.	X	X	X	X				
(16)		Explain oil-filter clogging (blockage) and the implications for the lubrication system.	X	X	X	X				
(17)		Give examples of monitoring instruments of an engine.	X	X	X	X				
(18) New		Describe how to identify and assess engine damage based on instrument indications.	X	X	X	X				New LO
021 11 04 02		***Starting malfunctions***								
(01)		Describe the indications and the possible causes of the following aeroplane starting malfunctions: — false (dry or wet) start, — tailpipe fire (torching), — hot start, — abortive (hung) start, — no N1 rotation,	X	X						

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		— no FADEC indications.								
(02)		Describe the indications and the possible causes of the following helicopter starting malfunctions: — false (dry or wet) start, — tailpipe fire (torching), — hot start, — abortive (hung) start, — no N1 rotation, — freewheel failure~~.~~, — no FADEC indications.			X	X	X			Reworded Old LO (03) incorporated
~~LO (03)~~		~~— no FADEC indications.~~			~~X~~	~~X~~				Combined with (02)
021 11 04 03		***Relight envelope***								
(01)		Explain the relight envelope.	X	X						
021 11 05 00		**Performance aspects**								
021 11 05 01		***Thrust, performance aspects, and limitations***								
(01)		Describe the variation of thrust and specific fuel consumption with altitude at constant TAS.	X	X						
(02)		Describe the variation of thrust and specific fuel consumption with TAS at constant altitude.	X	X						

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(03)		Explain the term 'flat-rated engine' by describing the change of take-off thrust, turbine inlet temperature and engine RPM with outside air temperature (OAT).	X	X						
(04)		Define the term 'eEngine pPressure rRatio' (EPR).	X	X						
(05)		Explain the use of reduced (flexible) and derated thrust for take-off, and explain the advantages and disadvantages when compared with a full-rated take-off.	X	X						
(06)		Describe the effects of use of bleed air on RPM, EGT, thrust and specific fuel consumption.	X	X						
021 11 05 02		***Helicopter engine ratings, engine performance and limitations, engine handling: torque, performance aspects, engine handling and limitations.***								
(01)		Describe engine rating torque limits for take-off, transient and maximum continuous.			X	X	X			
(02)		Describe turbine outlet temperature (TOT) limits for take-off.			X	X	X			
(03)		Explain why TOT is a limiting factor for helicopter performance.			X	X	X			
(04)		Describe and explain the relationship between maximum torque available and density altitude, which leads to decreasing torque available with the increase of density altitude.			X	X	X			
(05)		Explain that hovering downwind on some helicopters will			X	X	X			

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		noticeably increase the engine TOT.								
(06)		Explain the reason why the engine performance is less when aircraft accessories ~~are switched on~~, i.e. anti-ice, heating, hoist, filters~~.~~, are switched on.			X	X	X			
(07)		Describe the effects of use of bleed air on engine parameters.			X	X	X			
(08)		Explain that on some helicopter exceeding the TOT limit may cause the main rotor to droop (slow down).			X	X	X			
(09)		Describe overtorquing and show the consequences.			X	X	X			Moved from 082 08 02 02 (03)
021 11 06 00		**Auxiliary p~~P~~ower u~~U~~nit (APU)**								
021 11 06 01		***Design, operation, functions, operational limitations***								
(01)		State that an APU is a gas turbine engine and list its tasks.	X		X	X				
(02)		State the difference between the two types of APU inlets.	X		X	X				
(03)		Define ‘maximum operating and maximum starting altitude’.	X		X	X				
(04)		Name the typical APU control and monitoring instruments.	X		X	X				
(05)		Describe the APU’s automatic shutdown protection.	X		X	X				
021 12 00 00		**PROTECTION AND DETECTION SYSTEMS**								
021 12 01 00		**Smoke detection**								

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021 12 01 01		***Types, design, operation, indications and warnings***								
(01)		Explain the operating principle of the following types of smoke detection sensors: — optical, — ionising.	X	X						
(02)		Give an example of warnings, indications and function tests.	X	X						
021 12 02 00		**Fire-protection systems**								
021 12 02 01		***Fire extinguishing (engine and cargo compartments)***								
(01)		Explain the operating principle of a built-in fire-extinguishing system and describe its components.	X	X	X	X	X			
(02)		State that two discharges must be provided for each engine (see CS 25.1195(c)).	X	X						
021 12 02 02		***Fire detection***								
(01)		Explain the following principles involved in fire detection: — resistance and capacitance, — gas pressure.	X	X	X	X	X			
(02)		Explain fire-detection applications such as: — bimetallic, — continuous loop,	X	X	X	X	X			

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		— gaseous loop (gas-filled detectors).								
(03)		Explain why generally double-loop systems are used.	X	X	X	X	X			
(04)		Give an example of warnings, indications and function test of a fire-protection system.	X	X	X	X	X			
021 12 03 00		**Rain-protection system**								
(01)		Explain the principle and method of operation of the following windshield rain-protecting systems for an aeroplane: — wipers, — liquids (rain-repellent), — coating.	X	X						
(02)		Explain the principle and method of operation of wipers for a helicopter.			X	X	X			
021 13 00 00		**OXYGEN SYSTEMS**								
(01)		Describe the basic operating principle of a cockpit oxygen system and describe the following different modes of operation: — normal (diluter demand), — 100 %, — emergency.	X	X						
(02)		Describe the operating principle and the purposes of the following two portable oxygen systems:	X	X						

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		— smoke hood, — portable bottle.								
(03)		Describe the following two oxygen systems that can be used to supply oxygen to passengers: — fixed system (chemical oxygen generator or gaseous); — portable.	X	X						
(04)		Describe the actuation methods (automatic and manual) and the functioning of a passenger oxygen mask.	X	X						
(05)		Compare chemical oxygen generators to gaseous systems with respect to: — capacity, — flow regulation.	X	X						
(06)		State the dangers of grease or oil related to the use of oxygen systems.	X	X						
021 14 00 00		**HELICOPTER: MISCELLANEOUS SYSTEMS**								
021 14 01 00		**Variable rotor speed**								
~~LO (01)~~		~~Explain the system when pilots can 'beep' the N R an additional amount when manoeuvring, landing and taking off, normally at higher altitudes to obtain extra tail rotor thrust, which makes manoeuvring more positive and safer.~~			~~X~~	~~X~~	~~X~~			No practical use

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(02)		Explain the system for 'beeping' the N_R to its upper limit ~~to enable safer take-off~~.			X	X	X			Reworded
021 14 02 00		**Active vibration suppression**								
(01)		Explain and describe how the active vibration suppression system works through high-speed actuators and accelerometer inputs.			X	X	X			
021 14 03 00		**Night-vision goggles**								
(01)		To be introduced at a later date.			X	X	X			
021 15 00 00		**HELICOPTER: ROTOR HEADS**								
021 15 01 00		**Main rotor**								
021 15 01 01		***Types***								
(01)		Describe the following rotor-head systems: — teetering (semi-articulated), — articulated, — hingeless (rigid), — bearingless (semi-articulated).			X	X	X			Reworded
(02)		Describe in basic terms the following configuration of rotor systems and their advantages and disadvantages: — tandem,			X	X	X			Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— coaxial, — side by side.								
(03)		Explain how flapping, dragging and feathering is achieved in each rotor-head system.			X	X	X			
021 15 01 02		***Structural components and materials, stresses, structural limitations***								
(01)		Identify from a diagram the main structural components of the main types of rotor-head systems.			X	X	X			
(02)		List and describe the methods used on how to detect damage and cracks.			X	X	X			
(03)		Explain and describe the structural limitations to respective rotor systems, including the dangers of negative G inputs to certain rotor-head systems.			X	X	X			
(04)		Describe the various rotor-head lubrication methods.			X	X	X			
021 15 01 03		***Design and construction***								
(01)		Describe the material technology used in rotor-head design, including construction, using the following materials or mixture of materials: — composites, — fibreglass,			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— alloys, — elastomers.								
021 15 01 04		***Adjustment***								
(01)		Describe and explain the methods of adjustment which are possible on various helicopter rotor-head assemblies.			X	X	X			
021 15 02 00		**Tail rotor**								
021 15 02 01		***Types***								
(01)		Describe the following tail-rotor systems: — delta 3 hinge; — multi-bladed delta 3 effect; — Fenestron or ducted fan tail rotor; — no tail rotor (NOTAR) low-velocity air jet flows from tangential slots (the Coandă effect); — ~~No Tail Rotor (~~NOTAR~~)~~ high-velocity air jet flows from adjustable nozzles (the Coandă effect).			X	X	X			Reworded
(02)		Identify from a diagram the main structural components of the four main types of tail-rotor systems.			X	X	X			
(03)		Explain and describe the methods to detect damage and cracks on the tail rotor and assembly.			X	X	X			
(04)		Explain and describe the structural limitations to the respective			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		tail-rotor systems and possible limitations regarding the turning rate of the helicopter.								
(05)		Explain and describe the following methods that helicopter designers use to minimise tail-rotor drift and roll: — reducing the couple arm (tail rotor on a pylon); — offsetting the rotor mast; — use of 'bias' in cyclic control mechanism.			X	X	X			
(06)		Explain pitch-input mechanisms.			X	X	X			
(07)		Explain the relationship between tail-rotor thrust and engine power.			X	X	X			
(08)		Describe how the vertical fin ~~on some helicopters~~ reduces the power demand of the Fenestron.			X	X	X			Reworded
021 15 02 02		***Design and construction***								
(01)		List and describe the various tail-rotor designs and construction methods used on current helicopters in service.			X	X	X			
~~***021 15 02 03***~~		~~***Adjustment***~~								No practical use
~~LO (01)~~		~~Describe the rigging and adjustment of the tail-rotor system to obtain optimum position of the pilot's yaw pedals.~~			~~X~~	~~X~~	~~X~~			No practical use
021 16 00 00		**HELICOPTER: TRANSMISSION**								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 16 01 00		**Main gearbox**								
021 16 01 01		***Different types, design, operation, limitations***								
(01)		Describe the following main principles of helicopter transmission systems for single- and twin-engine helicopters: — drive for the main and tail rotor; — accessory drive for the generator(s), alternator(s), hydraulic and oil pumps, oil cooler(s) and tachometers.			X	X	X			
(02)		Describe the reason for limitations on multi-engine helicopter transmissions in various engine-out situations.			X	X	X			
(03)		Describe how the passive vibration control works with gearbox mountings.			X	X	X			
021 16 02 00		**Rotor brake**								
(01)		Describe the main function of the disc type of rotor brake.			X	X	X			
(02)		Describe both hydraulic- and cable-operated rotor-brake systems.			X	X	X			
(03)		Describe the different options for the location of the rotor brake.			X	X	X			
(04)		List the following operational considerations for the use of rotor brakes: — rotor speed at engagement of rotor brake; — risk of blade sailing in windy conditions;			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— risk of rotor-brake overheating and possible fire when brake is applied above the maximum limit, particularly when spilled hydraulic fluid is present; — avoid stopping blades over jet-pipe exhaust with engine running; — cockpit annunciation of rotor-brake operation.								
021 16 03 00		**Auxiliary systems**								
(01)		Explain how the hoist/winch can be driven by an off-take from the auxiliary gearbox.			X	X	X			
(02)		Explain how power for the air-conditioning system is taken from the auxiliary gearbox.			X	X	X			
021 16 04 00		**Driveshaft and associated installation**								
(01)		Describe how power is transmitted from the engine to the main-rotor gearbox.			X	X	X			
(02)		Describe the material and construction of the driveshaft.			X	X	X			
(03)		Explain the need for alignment between the engine and the main-rotor gearbox.			X	X	X			
(04)		Identify how temporary misalignment occurs between driving and driven components.			X	X	X			
(05)		Explain the use of:			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		— flexible couplings, — Thomas couplings, — flexible disc packs, — driveshaft support bearings and temperature measurement, — subcritical and supercritical driveshafts.								
(06)		Explain the relationship between the driveshaft speed and torque.			X	X	X			
(07)		Describe the methods with which power is delivered to the tail rotor.			X	X	X			
(08)		Describe and identify the construction and materials of tail-rotor/Fenestron driveshafts.			X	X	X			
021 16 05 00		**Intermediate and tail gearbox**								
(01)		Explain and describe the various arrangements when the drive changes direction and the need for an intermediate or tail gearbox.			X	X	X			
(02)		Explain the lubrication requirements for intermediate and tail-rotor gearboxes and methods of checking levels.			X	X	X			
(03)		Explain how on most helicopters the tail-rotor gearbox contains gearing, etc., for the tail-rotor pitch-change mechanism.			X	X	X			
021 16 06 00		**Clutches**								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		Explain the purpose of a clutch.			X	X	X			
(02)		Describe and explain the operation of a: — centrifugal clutch, — actuated clutch.			X	X	X			
(03)		List the typical components of the various clutches.			X	X	X			
(04)		Identify the following methods by which clutch serviceability can be ascertained: — brake-shoe dust; — vibration; — main-rotor run-down time; — engine speed at time of main-rotor engagement; — belt tensioning; — start protection in a belt-drive clutch system.			X	X	X			
021 16 07 00		**Freewheels**								
(01)		Explain the purpose of a freewheel.			X	X	X			
(02)		Describe and explain the operation of a: — cam and roller type freewheel, — sprag-clutch type freewheel.			X	X	X			
(03)		List the typical components of the various freewheels.			X	X	X			

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(04)		Identify the various locations of freewheels in power plant and transmission systems.			X	X	X			
(05)		Explain the implications regarding the engagement and disengagement of the freewheel.			X	X	X			
021 17 00 00		**HELICOPTER: BLADES**								
021 17 01 00		**Main-rotor design and blade design**								Reworded
021 17 01 01		***Design, construction***								
(01)		Describe the different types of blade construction and the need for torsional stiffness.			X	X	X			
(02)		Describe the principles of heating systems/pads on some blades for anti-icing/de-icing.			X	X	X			
(03)		Describe the fully articulated rotor with hinges and feathering ~~bearings/~~hinges.			X	X	X			Moved from 082 05 04 02 (01) Reworded
021 17 01 02		***Structural components and materials***								
(01)		List the materials used in the construction of main-rotor blades.			X	X	X			
(02)		List the main structural components of a main-rotor blade and their function.			X	X	X			
(03)		Describe the drag hinge of the fully articulated rotor and the lag			X	X	X			Moved from

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
		flexure in the hingeless rotor.								082 05 03 02 (01)
(04)		Explain the necessity for drag dampers.			X	X	X			Moved from 082 05 03 02 (02)
021 17 01 03		***~~Stresses~~ Forces and stresses***								Reworded
(01)		Describe main-rotor blade-loading on the ground and in flight.			X	X	X			
(02)		Describe where the most common stress areas are on rotor blades.			X	X	X			
(03)		Show how the centrifugal forces depend on rotor RPM and blade mass and how they pull on the blade's attachment to the hub. ~~Apply the formula to an example.~~ Justify the upper limit of the rotor RPM.			X	X	X			Moved from 082 05 01 01 Reworded
(04)		Assume a rigid attachment and show how thrust may cause huge oscillating bending moments which stress the attachment.			X	X	X			Moved from 082 05 01 01
(05)		Explain why flapping hinges do not transfer such moments. Show the small flapping hinge offset on fully articulated rotors and zero offset in the case of teetering rotors.			X	X	X			Moved from 082 05 01 01
(06)		Describe the working principle of the flexible element in the hingeless rotor and describe the equivalent flapping hinge offset compared to that of the articulated rotor.			X	X	X			Moved from 082 05 01 01
021 17 01 04		***Structural limitations***								

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
(01)		Explain the structural limitations in terms of bending and rotor RPM.			X	X	X			
021 17 01 05		***Adjustment***								
(01)	X	Explain the use of trim tabs.			X	X	X			
021 17 01 06		***Tip shape***								
(01)		Describe the various blade-tip shapes used by different manufacturers and compare their advantages and disadvantages.			X	X	X			
~~LO (02)~~		~~Describe how on some rotor blade tips, static and dynamic balancing weights are attached to threaded rods and screwed into sockets in the leading edge spar and others in a support embedded into the blade tip.~~			~~X~~	~~X~~	~~X~~			No practical use
021 17 01 07		***Origins of the vertical vibrations***								New paragraph number Moved from 082 05 06 01
(01)		Explain the lift (thrust) variations per revolution of a blade and the resulting vertical ~~(total) rotor thrust~~ total rotor thrust (TRT) variation in the case of perfectly identical blades.			X	X	X			Moved from 082 05 06 01 Reworded
(02)		Show the resulting frequencies and amplitudes as a function of the number of blades.			X	X	X			Moved from 082 05 06 01
(03)		Explain the thrust variation in the case of an out-of-track blade, causes, and frequencies (one-per-revolution).			X	X	X			Moved from 082 05 06 01 Reworded

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
021 17 01 08		***Lateral vibrations***								New paragraph number Moved from 082 05 06 02
(01)		Explain blade imbalances ~~of a blade~~, causes, and effects.			X	X	X			Moved from 082 05 06 02 Reworded
021 17 02 00		**Tail-rotor design and blade**								Reworded
021 17 02 01		***Design, construction***								
(01)		Describe the most common design of tail-rotor blade construction, consisting of stainless steel shell reinforced by a honeycomb filler and stainless steel leading abrasive strip.			X	X	X			
(02)		Explain that ballast weights are located at the inboard trailing edge and tip of blades, and that the weights used are determined when the blades are manufactured.			X	X	X			
(03)		Describe how anti-icing/de-icing systems are designed into the blade construction of some helicopters.			X	X	X			
(04)		Describe the two-bladed rotor with a teetering hinge, ~~the~~ and rotors with more than two blades.			X	X	X			Moved from 082 06 01 01 Reworded
(05)		Describe the dangers to ground personnel and to the rotor blades, and ~~the possibilities of minimising~~ how to minimise these dangers.			X	X	X			Moved from 082 06 01 01 Reworded
~~***021 17 02 02***~~		~~***Structural components and materials***~~								No practical use

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
~~LO (01)~~		~~List the materials used in the construction of tail-rotor blades.~~			~~X~~	~~X~~	~~X~~			Covered in 021 17 02 01 (01)
~~LO (02)~~		~~List the main structural components of a tail-rotor blade and their function.~~			~~X~~	~~X~~	~~X~~			Covered in 021 17 02 01 (01)
021 17 02 03		***Stresses, vibrations and balancing***								Reworded
(01)		Describe the tail-rotor blade-loading on the ground and in flight.			X	X	X			
(02)		Explain the sources of vibration of the tail rotor and the resulting high frequencies.			X	X	X			Moved from 082 06 04 01
(03)		Explain balancing and tracking of the tail rotor.			X	X	X			Moved from 082 06 04 02 (01)
021 17 02 04		***Structural limitations***								
(01)		Describe the structural limitations of tail-rotor blades.			X	X	X			
(02)		Describe the method of checking the strike indicators placed on the tip of some tail-rotor blades.			X	X	X			
021 17 02 05		***Adjustment***								
(01)		Describe the adjustment of yaw pedals in the cockpit to obtain full-control authority of the tail rotor.			X	X	X			
021 17 02 06		***The Fenestron***								New paragraph number Entire paragraph moved

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			ATPL	CPL	ATPL/ IR	ATPL	CPL			
										from 082 06 02 00
(01)		~~Show~~ Describe the technical ~~details~~ layout of a Fenestron tail rotor.			X	X	X			Reworded
(02)		Explain the advantages and disadvantages of a Fenestron tail rotor.			X	X	X			Reworded
021 17 02 07		***No tail rotor (NOTAR)***								New paragraph number Moved from 082 06 03 00
(01)		~~Show~~ Describe the technical layout of a NOTAR design.			X	X	X			Reworded
(02)		Explain the control concepts of a NOTAR.			X	X	X			Reworded
(03)		Explain the advantages and disadvantages of a NOTAR design.			X	X	X			Reworded

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SUBJECT 022 — INSTRUMENTATION

Syllabus reference	BK	Syllabus details and associated Learning Objectives	Aeroplane		Helicopter			IR	CBIR(A) & EIR	Comments
			ATPL	CPL	ATPL /IR	ATPL	CPL			
020 00 00 00		**AIRCRAFT GENERAL KNOWLEDGE**								
022 00 00 00		**AIRCRAFT GENERAL KNOWLEDGE — INSTRUMENTATION**								
022 01 00 00		**SENSORS AND INSTRUMENTS**								
022 01 01 00		**Pressure gauge**								
(01)	X	Define 'pressure', 'absolute pressure' and 'differential pressure'.	X	X	X	X	X			
(02)	X	List the following units used for pressure: — Pascal, — bar, — inches of mercury (in Hg), — pounds per square inch (PSI).	X	X	X	X	X			
(03)	X	State the relationship between the different units.	X	X	X	X	X			
~~LO (04)~~		~~List and describe the following different types of sensors used according to the pressure to be measured:~~ — ~~aneroid capsules,~~ — ~~bellows,~~ — ~~diaphragms,~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— ~~bourdon tube.~~								
~~LO (05)~~		~~Solid-state sensors (to be introduced at a later date)~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(06)		~~For each type of sensor identify applications such as:~~ Identify pressure measurements that are applicable on an aircraft: — liquid-pressure measurement (fuel, oil, hydraulic); — air-pressure measurement (bleed air systems, air-conditioning systems); — engine-pressure measurement MAP, engine pressure ratio (EPR)). — ~~Manifold Absolute Pressure (~~MAP~~)~~ gauge.	X	X	X	X	X			Reworded
~~LO (07)~~		~~Pressure probes for Engine Pressure Ratio (EPR).~~	~~X~~	~~X~~						Combined with (06)
(08)		~~Give examples of display for each of the applications above.~~ Identify and read pressure measurement indications both for engine indications and other systems.	X	X	X	X	X			Reworded
~~LO (09)~~		~~Explain the need for remote indicating systems.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(10) New		Explain the implications of the following pressure measurement errors, both for engine indications and other systems:	X	X	X	X	X			New LO

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— loss pressure sensing; — incorrect pressure indications.								
022 01 02 00		**Temperature sensing**								
(01)	X	Explain temperature.	X	X	X	X	X			
(02)	X	List the following units that can be used for temperature measurement: — Kelvin, — Celsius, — Fahrenheit.	X	X	X	X	X			
(03)	X	State the relationship ~~and calculate~~ between these ~~different~~ units and convert between them.	X	X	X	X	X			Reworded
~~LO (04)~~		~~Describe and explain the operating principles of the following types of sensors:~~ ~~— expansion type (bimetallic strip),~~ ~~— electrical type (resistance, thermocouple).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
~~LO (05)~~		~~State the relationship for a thermocouple between the electromotive force and the temperature to be measured.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(06)		~~For each type, identify applications such as:~~ Identify temperature measurements that are applicable on an aircraft:	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— gas temperature measurement (ambient air, bleed air systems, air-conditioning systems, air inlet, exhaust gas, gas turbine outlets); — liquid-temperature measurement (fuel, oil, hydraulic); — component-temperature measurement (generator, transformer rectifier unit (TRU), pumps (fuel, hydraulic), power transfer unit (PTU).								
(07)		~~Give examples of display for each of the applications above.~~ Identify and read temperature measurement indications for both engine indications and other systems.	X	X	X	X	X			Reworded
022 01 03 00		**Fuel gauge**								
(01)		State that the quantity of fuel can be measured by volume or mass.	X	X	X	X	X			
(02)		List the following units used for fuel quantity ~~when measured by mass~~: — kilogramme~~;~~, — pound~~;~~, — litres, — gallons (US and imperial).	X	X	X	X	X			Reworded

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
(03)		~~State the relationship between these different units.~~ Convert between the various units.	X	X	X	X	X			Reworded
~~LO (04)~~		~~Define 'capacitance' and 'permittivity', and state their relationship with density.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(05)		~~List and~~ Eexplain the parameters that can affect the measurement of the volume and/or mass of the fuel in a ~~wing~~ fuel tank: — temperature; — aircraft accelerations and attitudes; and explain how the fuel-gauge system design compensates for these changes.	X	X	X	X	X			Reworded
(06)		Describe and explain the operating principles of the following types of fuel gauges: — float system; — capacitance type fuel-gauge system. — ultrasound type of fuel gauge: to be introduced at a later date.	X	X	X	X	X			Reworded
(07) New		Describe and complete a typical post-refuelling procedure for a pilot: — recording the volume that was filled; — converting to the appropriate unit used by the	X	X	X	X	X			New LO

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		aircraft fuel gauge(s) to compare the actual indicated fuel content to the calculated fuel content; — assess appropriate action if the numbers does not compare.								
022 01 04 00		**Fuel flowmeters**								
(01)		Define 'fuel flow' and where it is measured.	X	X	X	X	X			
(02)		State that fuel flow may be measured by volume or mass per unit of time.	X	X	X	X	X			
(03)		List the following units used for fuel flow when measured by mass per hour: — kilogrammes/hour, — pounds/hour.	X	X	X	X	X			
(04)		List the following units used for fuel flow when measured by volume per hour: — litres/hour, — US gallons/hour.	X	X	X	X	X			
~~LO (05)~~		~~List and describe the following different types of fuel flowmeter:~~ — ~~mechanical,~~ — ~~electrical (analogue),~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use

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		— ~~electronic (digital),~~ ~~and explain how the signal can be corrected to measure mass flow.~~								
(06)		Explain how total fuel consumption is obtained.	X	X	X	X	X			
022 01 05 00		**Tachometer**								
(01)	X	List the following types of tachometers, describe their basic operating principle and give examples of use: — mechanical (rotating magnet); — electrical (three-phase tacho-generator); — electronic (impulse measurement with speed probe and phonic wheel)~~,~~; and describe the operating principle of each type.	X	X	X	X	X			
~~LO (02)~~		~~For each type, identify applications such as engine-speed measurement (crankshaft speed for piston engines, spool speed for gas turbine engines), wheel speed measurement for anti-skid systems (anti-skid systems for aeroplane only), and give examples of display.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~			No practical use
(03)		~~State that engine speed is most commonly displayed as a percentage.~~ Explain the typical units for engine speed: — RPM for piston-engine aircraft;	X	X	X	X	X			Reworded

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		— percentage for turbine-engine aircraft.								
(04) New		Explain that some types of RPM indicators require electrical power to provide an indication.	X	X	X	X	X			New LO
022 01 06 00		**Thrust measurement**								
(01)		List and describe the following two parameters used to represent thrust~~.~~: — N1, — EPR.	X	X						Editorial
(02)		~~Explain the operating principle of the EPR gauge and the consequences for the pilot in case of a malfunction including blockage and leakage.~~ Explain the operating principle of using an engine with EPR indication and explain the consequences of incorrect or missing EPR to the operation of the engine, including reverting to N1 mode.	X	X						Reworded
(03)		Give examples of display for N1 and EPR.	X	X						
022 01 07 00		**Engine torquemeter**								
(01)		Define ‘torque’.	X	X	X	X	X			
(02)		Explain the relationship between power, torque and RPM.	X	X	X	X	X			
(03)		List the following units used for torque:	X	X	X	X	X			

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		— Newton meters, — inch or foot pounds.								
(04)		State that engine torque can be displayed as a percentage.	X	X	X	X	X			
(05)	X	List and describe the following different types of torquemeters, and explain their operating principles: — mechanical~~;~~, — electronic. ~~and explain their operating principles.~~	X	X	X	X	X			Editorial
(06)	X	Compare the two systems with regard to design and weight.	X	X	X	X	X			
(07)		Give examples of display.	X	X	X	X	X			
022 01 08 00		**Synchroscope**								
(01)		State the purpose of a synchroscope.	X	X						
(02)	X	Explain the operating principle of a synchroscope.	X	X						
(03)		Give examples of display.	X	X						
022 01 09 00		**Engine-vibration monitoring**								
(01)		State the purpose of a vibration-monitoring system for a jet engine.	X	X						

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(02)	X	Describe the operating principle of a vibration-monitoring system using the following two types of sensors: — piezoelectric crystal, — magnet.	X	X						
(03)		~~State that no specific unit is displayed for a vibration monitoring system.~~ Explain that there is no specific unit for vibration monitoring, i.e. it is determined by specified numeric threshold values.	X	X						Reworded
(04)		Give examples of display.	X	X						
022 01 10 00		**Time measurement**								
(01)		~~Explain the use of time/date measurement and recording for engines and system maintenance.~~ Explain that the on-board aircraft clock provides a time reference for several of the on-board systems including aircraft communications addressing and reporting system (ACARS) and engine and systems maintenance.	X	X	X	X	X			Reworded
022 02 00 00		**MEASUREMENT OF AIR-DATA PARAMETERS**								
022 02 01 00		**Pressure measurement**								
022 02 01 01		***Definitions***								

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(01)		~~Define 'static, total and dynamic pressures' and state the relationship between them.~~ Define the following pressure measurements and state the relationship between them: — static pressure, — dynamic pressure, — total pressure.	X	X	X	X	X	X		Reworded
~~LO (02)~~		~~Define 'impact pressure' as total pressure minus static pressure and discuss the conditions when dynamic pressure equals impact pressure.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
022 02 01 02		***Pitot/static system: design and errors***								
(01)		Describe the design and the operating principle of a: — static port/source, — pitot tube, — combined pitot/static probe.	X	X	X	X	X	X	X	Reworded
(02)		For each of these indicate the various locations and describe the following associated errors and how to correct, minimise the effect of or compensate for them: — position errors; — instrument errors;	X	X	X	X	X	X	X	Reworded

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		— errors due to a non-longitudinal axial flow (including manoeuvre-induced errors). ~~and the means of correction and/or compensation.~~								
(03)		Describe a typical pitot/static system and list the possible outputs.	X	X	X	X	X	X		
(04)		Explain the redundancy and the interconnections ~~of typical~~ that typically exist in complex pitot/static systems found in large aircraft.	X	X	X	X	X	X		Reworded
(05)		Explain the purpose of pitot/static system heating ~~and interpret the effect of heating on sensed pressure~~.	X	X	X	X	X	X	X	Reworded
~~LO (06)~~		~~List the affected instruments and explain the consequences for the pilot in case of a malfunction including blockage and leakage.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	Covered in the LOs for the individual instrument types
(07)		Describe alternate static sources and their effects when used, particularly in unpressurised aircraft.	X	X	X	X	X	X	X	Reworded
(08)		~~Solid-state sensors (to be introduced at a later date).~~ Describe a modern pitot static system using solid-state sensors near the pitot probe or static port converting the air data to numerical data (electrical signals) before being sent to the air-data computer(s).	X	X	X	X	X	X		Reworded
022 02 02 00		**Temperature measurement**								

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022 02 02 01		***Definitions***								
(01)		~~Define 'OAT', 'SAT', 'TAT' and 'measured temperature'.~~ Define the following and explain the relationship between them: — outside air temperature (OAT); — total air temperature (TAT); — static air temperature (SAT).	X	X	X	X	X	X	X	Reworded Incorporates old 061 04 05 02 (02) & (04)
(02)		~~Define~~ Explain the term 'ram rise' and convert TAT to SAT. ~~and 'recovery factor'.~~	X					X		Reworded Incorporates 061 04 05 02 (03)
~~LO (03)~~		~~State the relationship between the different temperatures according to Mach number.~~	~~X~~							No practical use
(04) New		Explain why TAT is often displayed and which systems require TAT as an input.	X	X	X	X	X	X	X	New LO
022 02 02 02		***Design and operation***								
~~LO (01)~~		~~Describe the following types of air temperature probes and their features:~~ — ~~expansion type: bimetallic strip, direct reading;~~ — ~~electrical type wire resistance, remote reading.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(02)		~~For each of these indicate the various locations, and~~	X	X	X	X	X	X		Reworded

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		~~describe the following associated errors:~~ — ~~position errors,~~ — ~~instrument errors,~~ ~~and the means of correction and/or compensation.~~ Indicate typical locations for both direct reading and remote reading temperature probes, and describe the following errors: — position error, — instrument error.								
(03)		Explain the purpose of temperature probe heating and interpret the effect of heating on sensed temperature unless automatically compensated for.	X	X	X	X	X	X		Reworded
022 02 03 00		**Angle-of-attack (AoA) measurement**								
(01)		Describe the following two types of AoA~~angle-of-attack~~ sensors: — null-seeking (slotted) probe, — vane detector.	X	X						
(02)		For each type, explain the operating principles.	X	X						
(03)		Explain how both types are protected against ice.	X	X						
(04)		Give examples of systems that use the AoA~~angle of attack~~	X	X						

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		as an input, such as: — air-data computer; — sStall-wWarning sSystems; — flight-envelope protection systems.								
(05)		Give examples of different types of ~~angle of attack (~~AoA~~)~~ displays.	X	X						
(06) New		Explain the implications for the pilot if the AoA indication becomes incorrect but still provides data, e.g. if the sensor is frozen in a fixed position.	X	X						New LO
(07) New		Explain how an incorrect AoA measurement can affect the controllability of an aircraft with flight-envelope protection.	X	X						New LO
022 02 04 00		**Altimeter**								
~~LO (01)~~	~~X~~	~~Define 'ISA'.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		Covered in 050
(02)		List the following two units used for altimeters and state the relationship between them: — feet, — metres. ~~and state the relationship between them.~~	X	X	X	X	X	X		Editorial
(03)	X	Define the following terms:	X	X	X	X	X	X	X	Covered in 050

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		— height, altitude; — indicated altitude, true altitude; — pressure altitude, density altitude.								
(04)	X	Define the following barometric references: 'QNH', 'QFE', '1013,25'.	X	X	X	X	X	X	X	Covered in 050
(05)		Explain the operating principles of an altimeter.	X	X	X	X	X	X	X	
(06)	X	Describe and compare the following three types of altimeters and reason(s) why particular designs may be required in certain airspace: — simple altimeter (single capsule); — sensitive altimeter (multi-capsule); — servo-assisted altimeter.	X	X	X	X	X	X	X	Reworded
(07)	X	Give examples of associated displays: pointer, multi-pointer, drum, vertical straight scale.	X	X	X	X	X	X	X	
(08)		Describe the following errors: — ~~pitot/~~static system errors; — instrument error; — barometric error; — temperature error (air column not at ISA conditions); — ~~time~~ lag (altimeter response to change of height)~~;~~.	X	X	X	X	X	X	X	Reworded

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		~~and the means of correction.~~								
(09)		~~Give examples of altimeter corrections table from an Aircraft Operating Handbook (AOH).~~ Demonstrate the use of an altimeter corrections table for the following errors: — temperature corrections, — aircraft position errors.	X	X	X	X	X	X	X	Reworded
(10)		Describe the effects of a blockage or a leakage on the static pressure line.	X	X	X	X	X	X	X	
(11) New		Describe the use of GPS altitude as an alternative means of checking erroneous altimeter indications, and highlight the limitations of the GPS altitude indication.	X	X	X	X	X	X	X	New LO
022 02 05 00		**Vertical s~~S~~peed i~~I~~ndicator (VSI)**								
(01)		List the two units used for VSI and state the relationship between them: — metres per second, — feet per minute~~,~~. ~~and state the relationship between them.~~	X	X	X	X	X	X		Editorial
(02)		Explain the operating principles of a VSI and an	X	X	X	X	X	X	X	Reworded

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		instantaneous vertical speed indicator (IVSI).								
(03)		Describe and compare the following ~~two~~ types of VSIs~~vertical speed indicators~~: — barometric type (VSI); — instantaneous barometric type (IVSI); — inertial type (inertial information provided by an inertial reference unit).	X	X	X	X	X	X	X	Reworded
(04)		Describe the following VSI errors: — ~~pitot/~~static system errors; — instrument error; — time lag~~;~~. ~~and the means of correction.~~	X	X	X	X	X	X	X	Reworded
(05)		Describe the effects on a VSI of a blockage or a leakage on the static pressure line.	X	X	X	X	X	X	X	
(06)		Give examples of a VSI display.	X	X	X	X	X	X		
(07) New		Compare the indications of a VSI and an IVSI during flight in turbulence and appropriate pilot technique during manoeuvring using either type.	X	X	X	X	X	X		New LO
022 02 06 00		**Airspeed i~~i~~ndicator (ASI)**								
(01)		List the following three units used for airspeed and state	X	X	X	X	X	X		Editorial

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		the relationship between them: — nautical miles/hour ~~(knots)~~ (kt), — statute miles/hour (mph), — kilometres/hour (km/h)~~,~~. ~~and state the relationship between them.~~								
(02)		~~Define 'IAS', 'CAS', 'EAS', 'TAS' and state and explain the relationship between these speeds.~~ Define and explain the relationship between the following: — indicated airspeed (IAS); — calibrated airspeed (CAS); — true airspeed (TAS).	X	X	X	X	X	X	X	Reworded
(03)		Describe the following ASI errors and state when they must be considered: — pitot/static system errors; — instrument error; — position error; — compressibility error; — density error.	X	X	X	X	X	X	X	Reworded
(04)		Explain the operating principles of an ASI (as appropriate	X	X	X	X	X	X	X	

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		to aeroplanes or helicopters).								
(05)		Give examples of an ASI display: pointer, vertical straight scale.	X	X	X	X	X	X		
(06)		~~Interpret ASI corrections tables as used in an Aircraft Operating Handbook (AOH).~~ Demonstrate the use of an ASI corrections table for position error.	X	X	X	X	X	X		Reworded
(07)		Define and explain the following colour codes that can be used on an ASI: — white arc (flap operating speed range); — green arc (normal operating speed range); — yellow arc (caution speed range); — red line (VNE) or barber's pole (VMO); — blue line (best rate of climb speed, one-engine-out for multi-engine piston light aeroplanes).	X	X						Reworded
(08)		Describe the effects on an ASI of a blockage or a leakage in the static and/or total pressure line(s).	X	X	X	X	X	X	X	
(09) New		Define the term 'unreliable airspeed' and describe the means by which it can be recognised such as: — different airspeed indications between ASIs;	X	X	X	X	X	X	X	New LO

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		— unexpected aircraft behaviour; — buffeting; — aircraft systems warning.								
(10) New		Describe the appropriate procedures available to the pilot in the event of unreliable airspeed indications: — combination of a pitch attitude and power setting; — ambient wind noise inside the aircraft; — use of GPS speed indications and the limitations of this.	X	X	X	X	X	X	X	New LO
022 02 07 00		**Machmeter**								
(01)		Define 'Mach number' and 'l~~L~~ocal s~~S~~peed of s~~S~~ound' (LSS). ~~and perform simple calculations that include these terms~~ Calculate between LSS, TAS and Mach number.	X					X		Reworded
(02)	X	Describe the operating principle of a Machmeter.	X					X		
(03)	X	Explain why a Machmeter does not suffer from compressibility error. ~~suffers only from pitot/static system errors.~~	X					X		Reworded
(04)		Give examples of a Machmeter display: pointer, drum, vertical straight scale, digital.	X					X		
(05)		Describe the effects on a Machmeter of a blockage or a	X					X		

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		leakage in the static and/or total pressure line(s).								
(06)		~~State the relationship between Mach number, CAS and TAS, and interpret their variations according to FL and temperature changes.~~ Explain the relationship between CAS, TAS and Mach number. Explain how CAS, TAS and Mach number vary in relation to each other during a climb, a descent, or in level flight.	X					X		Reworded
(07)		State the existence of MMO.	X					X		
(08) New		Describe typical indications of MMO and VMO on analogue and digital instruments.	X					X		New LO
(09) New		Describe the relationship between MMO and VMO with change in altitude and the implications of climbing at constant IAS and descending at constant Mach number with respect to the margin to MMO and VMO.	X					X		New LO
(10) New		Describe the implications of climbing at constant Mach number or constant IAS with respect to the margin to the stall speed.	X					X		New LO
022 02 08 00		**Air-d~~D~~ata c~~C~~omputer (ADC)**								
(01)		Explain the operating principle of an ADC.	X	X	X	X	X	X		

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(02)	X	List the following possible input data: — TAT, — static pressure, — total pressure, — measured temperature, — ~~angle of attack~~AoA, — flaps and landing gear position, — stored aircraft data.	X	X	X	X	X	X		
(03)	X	List the following possible output data: — IAS, — TAS, — SAT, — TAT, — Mach number, — ~~angle of attack~~AoA, — altitude, — vertical speed, — VMO/MMO pointer.	X	X	X	X	X	X		
~~LO (04)~~		~~For each output, list the datum/data sensed and explain the principle of calculation.~~	~~X~~		~~X~~	~~X~~				No practical use

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(05)		Explain how position, instrument, compressibility and density errors can be compensated/corrected to achieve a TAS calculation.	X	X	X	X	X	X		
~~LO (06)~~		~~Explain why accuracy is improved for each output datum when compared to raw data.~~	~~X~~		~~X~~	~~X~~				No practical use
(07)		Give examples of instruments and/or systems which may use ADC output data.	X	X	X	X	X	X		
(08)		~~State that an ADC can be a stand-alone system or integrated with the Inertial Reference Unit (ADIRU).~~ Explain that an air data inertial reference unit (ADIRU) is an ADC integrated with an inertial reference unit (IRU), that there will be separate controls for the ADC part and inertial reference (IR) part, and that incorrect selection during failure scenarios may lead to unintended and potentially irreversible consequences.	X	X	X	X	X	X		Reworded
(09)	X	Explain the ADC architecture for air-data measurement including sensors, processing units and displays, as opposed to stand-alone air-data measurement instruments.	X	X	X	X	X	X		
~~LO (10)~~		~~Explain the advantage of an ADC for air-data information management compared to raw data.~~	~~X~~		~~X~~	~~X~~				No practical use

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(11) New		Describe the consequences of the loss of an ADC compared to the failure of individual instruments.	X	X	X	X	X	X		New LO
022 03 00 00		**MAGNETISM — DIRECT-READING COMPASS AND FLUX VALVE**								
022 03 01 00		**Earth's magnetic field**								
(01)		Describe the magnetic field of the Earth.	X	X	X	X	X	X		Incorporates 061 02 01 01 (01) & (02)
(02)	X	Explain the properties of a magnet.	X	X	X	X	X	X		
(03)		Define the following terms: — magnetic variation, — magnetic dip (inclination).	X	X	X	X	X	X		Incorporates 061 01 04 02 (04)
(04) New		Describe that a magnetic compass will align itself with the horizontal component of the Earth's magnetic field thus will not function in the vicinity of the magnetic poles.	X	X	X	X	X	X		New LO Incorporates relevant parts of old 061 01 04 02 (01) & 061 01 04 02 (05) & 061 01 04 02 (07)
(05) New		Demonstrate the use of variation values (given as East/West (E/W) or +/–) to calculate: — true heading to magnetic heading; — magnetic heading to true heading.	X	X	X	X	X	X		New LO Incorporates 061 02 01 01 (02)

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022 03 02 00		**Aircraft magnetic field**								
(01)	X	~~Define and explain the following terms:~~ — ~~magnetic and non-magnetic material;~~ — ~~hard and soft iron;~~ — ~~permanent magnetism and electromagnetism.~~ Explain the following differences between permanent magnetism and electromagnetism: — when they are present; — what affects their magnitude.	X	X	X	X	X	X		Reworded
(02)	X	Explain the principles and the reasons for: — compass swinging (determination of initial deviations); — compass compensation (correction of deviations found); — compass calibration (determination of residual deviations).	X	X	X	X	X	X		Incorporates relevant elements of 061 01 04 03 04 & 061 02 01 03 01 Other content of 061 01 04 03 (04) & 061 02 01 03 (01) deleted
(03)		~~List the causes of the aircraft's magnetic field and explain how it affects the accuracy of the compass indications.~~ Explain how permanent magnetism within the aircraft structure and electromagnetism from the aircraft systems affect the accuracy of a compass.	X	X	X	X	X	X		Reworded

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(04)		Describe the purpose and the use of a deviation correction card.	X	X	X	X	X	X		
(05) New		Demonstrate the use of deviation values (either given as E/W or +/–) from a compass deviation card to calculate: — compass heading to magnetic heading; — magnetic heading to compass heading.	X	X	X	X	X	X	X	New LO Incorporates 061 02 01 01 (02)
022 03 03 00		**Direct-reading magnetic compass**								Incorporates 061 02 01 01 01
(1)		~~Define the role~~ Explain the purpose of a direct-reading magnetic compass.	X	X	X	X	X	X		Reworded
~~LO (02)~~		~~Describe and explain the design of a vertical card type compass.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (03)~~		~~Describe the deviation compensation.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(04)		~~Describe and interpret the effects of the following errors:~~ — ~~acceleration,~~ — ~~turning,~~ — ~~attitude,~~ — ~~deviation.~~ Describe how the direct-reading magnetic compass will only show correct during straight, level and unaccelerated flight, and that an error will occur during the following	X	X	X	X	X	X		Reworded

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		flight manoeuvres (no numerical examples): — acceleration and deceleration, — turning, — during pitch-up or pitch-down manoeuvres.								
(05)		~~Explain how to use and interpret the direct-reading compass indications during a turn.~~ Explain how the use of timed turns eliminates the problem of the turning errors of a direct-reading magnetic compass and calculate duration of a rate-1 turn for a given change of heading.	X	X	X	X	X	X		Reworded
(06) New		Describe the serviceability check for a direct-reading magnetic compass prior to flight, such as: — the physical appearance of the device; — comparing the indication to another known direction such as a different compass or runway direction.	X	X	X	X	X	X	X	New LO Incorporates 061 02 01 02 (01) & 061 02 01 02 (02)
022 03 04 00		**Flux valve**								
(01)		Explain the purpose of a flux valve.	X	X	X	X	X	X		
(02)	X	Explain its operating principle.	X	X	X	X	X	X		
(03)		~~Indicate various locations and precautions needed.~~ Indicate typical locations of the flux valve(s).	X	X	X	X	X	X		Reworded

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(04)		Give the remote-reading compass system as example of application.	X	X	X	X	X	X		
(05)		~~State that because of the electromagnetic deviation correction, the flux valve output itself does not have a deviation correction card.~~ Explain that deviation is compensated for and therefore eliminating the need for a deviation correction card.	X	X	X	X	X	X		Reworded
(06)		~~Describe and interpret the effects of the following errors:~~ — ~~acceleration,~~ — ~~turning,~~ — ~~attitude,~~ — ~~deviation.~~ Explain that a flux valve does not suffer from the same magnitude of errors as a direct-reading magnetic compass when turning, accelerating or decelerating and during pitch-up or pitch-down manoeuvres.	X	X	X	X	X	X		Reworded
022 04 00 00		**GYROSCOPIC INSTRUMENTS**								
022 04 01 00		**Gyroscope: basic principles**								
(01)	X	Define a ‘gyro’.	X	X	X	X	X	X	X	
(02)	X	Explain the fundamentals of the theory of gyroscopic	X	X	X	X	X	X	X	

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		forces.								
~~LO (03)~~		~~Define the 'degrees of freedom' of a gyro.~~ ~~*Remark: As a convention, the degrees of freedom of a gyroscope do not include its own axis of rotation (the spin axis).*~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	No practical use
(04)	X	Explain the following terms: — rigidity, — precession, — wander (drift/topple).	X	X	X	X	X	X		
(05)		~~Distinguish between:~~ — ~~real wander and apparent wander;~~ — ~~apparent wander due to the rotation of the Earth and transport wander.~~ Explain the three types of gyro wander: — real wander, — apparent wander, — transport wander.	X	X	X	X	X	X		Reworded
~~LO (06)~~		~~Describe a free (space) gyro and a tied gyro.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(07)		~~Describe and compare electrically and pneumatically driven gyroscopes.~~	X	X	X	X	X	X	X	

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		Describe the two ways of driving gyroscopes and any associated indications: — air/vacuum, — electrically.								
~~LO (08)~~		~~Explain the construction and operating principles of a:~~ — ~~rate gyro,~~ — ~~rate-integrating gyro.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
022 04 02 00		**Rate-of-turn indicator — Turn coordinator — Balance (slip) indicator**								
(01)		Explain the purpose of a rate-of-turn and balance (slip) indicator.	X	X	X	X	X	X	X	
(02)		Define a 'rate-1~~one~~ turn'.	X	X	X	X	X	X	X	
(03)		~~Describe the construction and principles of operation of a rate-of-turn indicator.~~ Describe the indications given by a rate-of-turn indicator.	X	X	X	X	X	X	X	Reworded
~~LO (04)~~		~~State the degrees of freedom of a rate-of-turn indicator.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(05)		Explain the relation between bank angle, rate of turn and TAS, and how bank angle becomes the limiting factor at high speed (no calculations).	X	X	X	X	X	X	X	Reworded
~~LO (06)~~		~~Explain why the indication of a rate-of-turn indicator is~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	No practical use

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		~~only correct for one TAS and when turn is coordinated.~~								
~~LO (07)~~		~~Describe the construction and principles of operation of a balance (slip) indicator.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	No practical use
(08)		Explain the purpose of a balance (slip) indicator and its principle of operation.	X	X	X	X	X	X	X	Reworded (combined with (07))
(09)		Describe the indications of a rate-of-turn and balance (slip) indicator during a balanced, slip or skid turn.	X	X	X	X	X	X	X	
(10)		~~Describe the construction and principles of operation of a turn coordinator (or turn-and-bank indicator).~~ Describe the indications given by a turn coordinator (or turn-and-bank indicator).	X	X	X	X	X	X	X	Reworded
(11)		Compare the indications on the rate-of-turn indicator and the turn coordinator.	X	X	X	X	X	X	X	Reworded
022 04 03 00		**Attitude indicator (artificial horizon)**								
(01)		Explain the purpose of the attitude indicator.	X	X	X	X	X	X	X	
(02)		~~Describe the different designs and principles of operation of attitude indicators (air-driven, electric).~~ Identify the two types of attitude indicators: — attitude indicator; — attitude and director indicator (ADI).	X	X	X	X	X	X	X	Reworded

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~~LO (03)~~		~~State the degrees of freedom.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (04)~~		~~Describe the gimbal system.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (05)~~		~~Describe the effects of the aircraft's acceleration and turns on instrument indications.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(06)		Describe ~~the~~ a typical attitude display and instrument markings.	X	X	X	X	X	X	X	Reworded
~~LO (07)~~		~~Explain the purpose of a vertical gyro unit.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (08)~~		~~List and describe the following components of a vertical gyro unit:~~ ~~— inputs: pitch and roll sensors;~~ ~~— transmission and amplification (synchros and amplifiers);~~ ~~— outputs: display units such as Attitude Direction Indicator (ADI), auto-flight control systems.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (09)~~		~~State the advantages and disadvantages of a vertical gyro unit compared to an attitude indicator with regard to:~~ ~~— design (power source, weight and volume);~~ ~~— accuracy of the information displayed;~~ ~~— availability of the information for several systems (ADI, AFCS).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use

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022 04 04 00		**Directional gyroscope**								
(01)		Explain the purpose of the directional gyroscope.	X	X	X	X	X	X	X	
(02)		~~Describe the following two types of directional gyroscopes:~~ — ~~air-driven directional gyro;~~ — ~~electric directional gyro.~~ Identify the two types of gyro-driven direction indicators: — direction indicator; — horizontal situation indicator (HSI).	X	X	X	X	X	X	X	Reworded
~~LO (03)~~		~~State the degrees of freedom.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (04)~~		~~Describe the gimbal system.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (05)~~		~~Define the following different errors:~~ — ~~design and manufacturing imperfections (random wander);~~ — ~~apparent wander (rotation of the Earth);~~ — ~~transport wander (movement relative to the Earth's surface);~~ ~~and explain their effects.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
~~LO (06)~~		~~Calculate the apparent wander (apparent drift rate in degrees per hour) of an uncompensated gyro according to~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use

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		~~latitude.~~								
(07) New		Explain how the directional gyroscope will drift over time due to the following: — rotation of the Earth; — aircraft manoeuvring; — aircraft movement over the Earth's surface/direction of travel.	X	X	X	X	X	X		New LO
(08) New		Describe the procedure for the pilot to align the directional gyroscope to the correct compass heading.	X	X	X	X	X	X		New LO
022 04 05 00		**Remote-reading compass systems**								
(01)		Describe the principles of operation of a remote-reading compass system.	X	X	X	X	X	X	X	
(02)		Using a block diagram, list and explain the function of the following components of a remote-reading compass system: — flux detection unit; — gyro unit; — transducers, precession amplifiers, annunciator; — display unit (compass card, synchronising and set-heading knob, DG/compass/slave/free switch).	X	X	X	X	X	X	X	Reworded

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~~LO (03)~~		~~State the advantages and disadvantages of a remote reading compass system compared to a direct reading magnetic compass with regard to:~~ — ~~design (power source, weight and volume);~~ — ~~deviation due to aircraft magnetism;~~ — ~~turning and acceleration errors;~~ — ~~attitude errors;~~ — ~~accuracy and stability of the information displayed;~~ — ~~availability of the information for several systems (compass card, RMI, AFCS).~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
022 04 06 00		**Solid-state systems — attitude and heading reference system (AHRS)** ~~**(the following paragraph is to be introduced at a later date)**~~	X	X	X	X	X	X		Reworded
(01)		~~State that the Micro Electromechanical Sensors (MEMS) technology can be used to make:~~ Explain that the AHRS is a replacement for traditional gyros using solid-state technology with no moving parts and is a single unit consisting of: — solid-state accelerometers; — solid-state rate sensor gyroscopes; — solid-state magnetometers (measurement of the	X	X	X	X	X	X	X	Reworded

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		Earth's magnetic field).								
~~LO (02)~~		~~Describe the basic principle of a solid-state Attitude and Heading Reference System (AHRS) using a solid state 3-axis rate sensor, 3-axis accelerometer and a 3-axis magnetometer.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	No practical use
~~LO (03)~~		~~Compare the solid-state AHRS with the mechanical gyroscope and flux gate system with regard to:~~ ~~— size and weight,~~ ~~— accuracy,~~ ~~— reliability,~~ ~~— cost.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(04) New		Explain that the AHRS senses rotation and acceleration for all three axes and senses the direction of the Earth's magnetic field where the indications are normally provided on electronic screens (electronic flight instrument system (EFIS)).	X	X	X	X	X	X	X	New LO
022 05 00 00		~~**INERTIAL NAVIGATION AND REFERENCE SYSTEMS (INS AND IRS)**~~ **INTENTIONALLY LEFT BLANK**								The entire topic of 022 05 is moved to 061 'General navigation'
~~**022 05 01 00**~~		~~**Inertial Navigation Systems (INS) (stabilised inertial platform)**~~								

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~~***022 05 01 01***~~		~~***Basic principles***~~								
~~LO~~		~~Explain the basic principles of inertial navigation.~~	~~X~~		~~X~~	~~X~~		~~X~~		
~~***022 05 01 02***~~		~~***Design***~~								
~~LO~~		~~List and describe the main components of a stabilised inertial platform.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~Explain the different corrections made to stabilise the platform.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~List the following two effects that must be compensated for:~~ — ~~Coriolis,~~ — ~~centrifugal.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~Explain the alignment of the system, the different phases associated and the conditions required.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~Explain the Schuler condition and give the value of the Schuler period.~~	~~X~~		~~X~~	~~X~~				
~~***022 05 01 03***~~		~~***Errors, accuracy***~~								
~~LO~~		~~State that there are three different types of errors:~~ — ~~bounded errors,~~ — ~~unbounded errors,~~	~~X~~		~~X~~	~~X~~				

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		— other errors.								
LO		Give average values for bounded and unbounded errors according to time.	X		X	X				
LO		State that an average value for the position error of the INS according to time is 1,5 NM/hour or more.	X		X	X				
022 05 01 04		***Operation***								
LO		Give examples of INS control and display panels.	X		X	X				
LO		Give an average value of alignment time at midlatitudes.	X		X	X				
LO		List the outputs given by an INS.	X		X	X				
LO		Describe and explain the consequences concerning the loss of alignment by an INS in flight.	X		X	X				
022 05 02 00		**Inertial Reference Systems (IRS) (strapped-down)**								
022 05 02 01		***Basic principles***								
LO		Describe the operating principle of a strapped-down IRS.	X		X	X				
LO		State the differences between a strapped-down inertial system (IRS) and a stabilised inertial platform (INS).	X		X	X				
022 05 02 02		***Design***								
LO		List and describe the following main components of an IRS:	X		X	X		X		

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		~~— rate sensors (laser gyros),~~ ~~— inertial accelerometers,~~ ~~— high-performance processors,~~ ~~— display unit.~~								
~~LO~~		~~Explain the construction and operating principles of a Ring Laser Gyroscope (RLG).~~	~~X~~		~~X~~	~~X~~		~~X~~		
~~LO~~		~~Explain the different computations and corrections to be made to achieve data processing.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~Explain the alignment of the system, the different phases associated and the conditions required.~~	~~X~~		~~X~~	~~X~~		~~X~~		
~~LO~~		~~Explain why the Schuler condition is still required.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~Describe the 'lock in' (laser lock) phenomena and the means to overcome it.~~	~~X~~		~~X~~	~~X~~				
~~LO~~		~~State that an IRS can be a stand-alone system or integrated with an ADC (ADIRU).~~	~~X~~		~~X~~	~~X~~		~~X~~		
~~***022 05 02 03***~~		~~***Errors, accuracy***~~								
~~LO~~		~~Compare IRS and INS for errors and accuracy.~~	~~X~~		~~X~~	~~X~~				
~~***022 05 02 04***~~		~~***Operation***~~								
~~LO~~		~~Compare IRS and INS, and give recent examples of control~~	~~X~~		~~X~~	~~X~~		~~X~~		

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		~~panels.~~								
~~LO~~		~~List the outputs given by an IRS.~~	~~X~~		~~X~~	~~X~~		~~X~~		
~~LO~~		~~Give the advantages and disadvantages of an IRS compared to an INS.~~	~~X~~		~~X~~	~~X~~				
022 06 00 00		**AEROPLANE: AUTOMATIC FLIGHT CONTROL SYSTEMS**								
022 06 01 00		**General: d~~D~~efinitions and control loops**								
(01)		~~State~~ Describe the following purposes of an a~~A~~utomatic f~~F~~light c~~C~~ontrol s~~S~~ystem (AFCS): — enhancement of flight controls; — reduction of pilot workload.	X	X				X		Reworded
(02)		Define and explain the following two functions of an AFCS: — aircraft control: ~~control of the aeroplane's movement about~~ stabilise the aircraft around its centre of gravity (CG); — aircraft guidance: guidance of the ~~aeroplane's CG (flight path)~~ aircraft's flight path.	X	X				X		Reworded
(03)		~~Define and explain 'closed loop' and open loop.~~ Describe the following two automatic control principles: — closed loop, where a feedback from an action or state is compared to the desired action or state;	X	X						Reworded

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		— open loop, where there is no feedback loop.								
~~LO (04)~~		~~Explain that the inner loop is for aircraft control and outer loop is for aircraft guidance.~~	~~X~~	~~X~~						No practical use
(05)		List the following ~~different~~ elements of a closed-loop control system and explain their basic function: — input signal; — error detector; — signal processing (computation of output signal according to control laws); — output signal; — signal processor providing a measured output signal according to set criteria or laws; — control element such as an actuator; — feedback signal to error detector for comparison with input signal.	X	X						Reworded
(06) New		Describe how a closed-loop system may enter a state of self-induced oscillation if the system overcompensates for deviations from the desired state.	X	X						New LO
(07) New		Explain how a state of self-induced oscillations may be detected and describe the effects of self-induced oscillations:	X	X						New LO

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		— aircraft controllability; — aircraft safety; — timely manual intervention as a way of mitigating loss of control.								
022 06 02 00		**Autopilot system: design and operation**								
(01)		Define the three basic control channels.	X	X						
(02)		~~List the following different types of autopilot systems: 1-axis, 2-axis and 3-axis.~~ Define the three different types of autopilots: — single or 1 axis (roll); — 2 axis (pith and roll); — 3 axis (pitch, roll and yaw);	X	X						Reworded
(03)		~~List and describe the main components of an autopilot system.~~ Describe the purpose of the following components of an autopilot system: — flight control unit (FCU), mode control panel (MCP) or equivalent; — flight mode annunciator (FMA) (022 06 04 00 00); — autopilot computer;	X	X						Reworded

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		— actuator.								
(04)		~~Explain and describe the following lateral modes: roll, heading, VOR/LOC, NAV or LNAV.~~ Explain the following lateral modes: — heading (HDG)/track (TRK); — VOR (VOR)/localiser (LOC); — lateral navigation/managed navigation (LNAV or NAV);	X	X						Reworded
(05)		Describe the purpose of control laws for pitch and roll modes.	X	X						
(06)		~~Explain and describe the following longitudinal (or vertical) modes: pitch, vertical speed, level change, altitude hold (ALT), profile or VNAV, G/S.~~ Explain the following vertical modes: — vertical speed (V/S); — level change (LVL CHG)/open climb (OP CLB) or open descent (OP DES); — speed reference system (SRS); — altitude (ALT) hold; — vertical navigation (VNAV)/managed climb (CLB) or descent (DES);	X	X						Reworded

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		— glideslope (G/S).								
~~LO (07)~~		~~Give basic examples for pitch and roll channels of inner loops and outer loops with the help of a diagram.~~	~~X~~	~~X~~						
(08)		~~Explain the influence of gain variation on precision and stability.~~ Describe how the autopilots use speed, aircraft configuration and/or flight phase as a measure for the magnitude of control inputs and how this may affect precision and stability.	X	X						Reworded Combined with (09)
~~LO (09)~~		~~Explain gain adaptation with regard to speed, configuration or flight phase.~~	X	X						Covered in (08)
(10)		~~Explain and describe the following common (or mixed) modes: take-off, go-around and approach.~~ ~~*Remark: The landing sequence is studied in 022 06 04 00.*~~ Explain the following mixed modes: — take-off, — go-around, — approach (APP).	X	X						Reworded
(11)		~~List the different types of actuation configuration and compare their advantages/disadvantages.~~ Describe the two types of autopilot configurations and	X	X						Reworded

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		explain implications to the pilot for either and when comparing the two principles: — flight deck controls move with the control surface when the autopilot is engaged; — flight deck controls remain static when the autopilot is engaged.								
(12)		~~List the inputs and outputs of a 3-axis autopilot system.~~ Describe the purpose of the following inputs and outputs for an autopilot system: — attitude information; — control surface position information; — airspeed information; — aircraft configuration information; — FCU/MCP selections; — FMAs.	X	X						Reworded
(13)		~~Describe and explain the synchronisation function.~~ Describe the purpose of the synchronisation function when engaging the autopilot and explain why the autopilot should be engaged when the aircraft is in trim.	X	X						Reworded
~~LO (14)~~		~~Give examples of engagement and disengagement systems and conditions.~~	~~X~~	~~X~~						Covered in new (20) to (28)

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(15)		~~Define the 'Control Wheel Steering' (CWS) mode according to CS 25 (see AMC 25.1329, paragraph 4.3).~~ Define the control wheel steering (CWS) mode as manual manoeuvring of the aircraft through the autopilot computer and autopilot servos/actuators using the control column/control wheel.	X	X						Reworded (Ref.: AMC No. 1 to CS 25.1329 paragraph 5.1)
(16)		~~Describe the CWS mode operation.~~ Describe the following elements of CWS: — CWS as an autopilot mode; — flight phases where CWS cannot be used; — whether the pilot or the autopilot is controlling the flight path; — the availability of flight path/performance protections; — potential different feel and control response compared to manual flight.	X	X						Reworded
~~LO (17)~~		~~Describe with the help of a control panel of an autopilot system and a flight mode annunciator/indicator the actions and the checks performed by a pilot through a complete sequence:~~ — ~~from Heading (HDG) selection to VOR/LOC guidance~~	~~X~~	~~X~~						Covered in new (20) to (28)

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		~~(arm/capture/track);~~ — ~~from Altitude selection (LVL change) to Altitude (ALT) hold (arm/intercept/hold).~~								
~~LO (18)~~		~~Describe and explain the different phases and the associated annunciations/indications from level change to altitude capture and from heading mode to VOR/LOC capture.~~	~~X~~	~~X~~						Covered in new (20) to (28)
~~LO (19)~~		~~Describe and explain the existence of operational limits for lateral modes (LOC capture) with regard to speed/angle of interception/distance to threshold, and for longitudinal modes (ALT or G/S capture) with regard to V/S.~~	~~X~~	~~X~~						Covered in new (20) to (28)
(20) New		Describe touch control steering (TCS) and highlight the differences when compared to CWS: — autopilot remains engaged but autopilot servos/actuators are disconnected from the control surfaces; — manual control of the aircraft as long as TCS button is depressed; — autopilot servos/actuators reconnect when TCS button is released and the autopilot returns to previously engaged mode(s).	X	X				X		New LO

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(21) New		Explain that only one autopilot may be engaged at any time except for when APP is armed in order to facilitate a fail-operational autoland.	X	X				X		New LO
(22) New		Explain the difference between an armed and an engaged mode: — not all modes have an armed state available; — a mode will only become armed if certain criteria are met; — an armed mode will become engaged (replacing the previously engaged mode, if any) when certain criteria are met.	X	X				X		New LO
(23) New		Describe the sequence of events when a mode is engaged and the different phases: — initial phase where attitude is changed to obtain a new trajectory in order to achieve the new parameter; — the trajectory will be based on rate of closure which is again based on the difference between the original parameter and the new parameter; — capture phase where the aircraft will follow a predefined rate of change of trajectory to achieve the new parameter without overshooting/	X	X				X		New LO

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		undershooting; — tracking or hold phase where the aircraft will maintain the set parameter until a new change has been initiated.								
(24) New		Explain automatic mode reversion and typical situations where it may occur: — no suitable data for the current mode such as flight plan discontinuity when in LNAV/managed NAV; — change of parameter during capture phase for original parameter such as change of altitude target during ALT ACQ/ALT*; — mismanagement of a mode resulting in engagement of the autopilot envelope protection, e.g. selecting excessive V/S resulting in a loss of speed control.	X	X				X		New LO
(25) New		Explain the dangers of mismanagement of the following modes: — use of V/S and lack of speed protection, i.e. excessive V/S may be selected with subsequent uncontrolled loss or gain of airspeed; — arming VOR/LOC or APP outside the protected area of the localiser or ILS.	X	X				X		New LO
(26) New		Describe how failure of other systems may influence the	X	X				X		New LO

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		availability of the autopilot and how incorrect data from other systems may result in an undesirable aircraft state, potentially without any failure indications. Explain the importance of prompt and appropriate pilot intervention during such events.								
(27) New		Explain an appropriate procedure for disengaging the autopilot and why both aural and visual warnings are used to indicate the autopilot being disengaged: — temporary warning for intended disengagement using the design method; — continuous warning for unintended disengagement or using a method other than the design method.	X	X				X		New LO
(28) New		Explain the following regarding autopilot and aircraft with manual trim: — the autopilot may not engage unless the aircraft controls are in trim; — the aircraft will normally be in trim when the autopilot is disconnected.	X	X				X		New LO
022 06 03 00		**Flight d~~D~~irector: design and operation**								
(01)		~~State~~ Explain the purpose of a flight director ~~(FD)~~ system.	X	X				X		Reworded
~~LO (02)~~		~~List and describe the main components of an FD system.~~	~~X~~	~~X~~						No practical use

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(03)		~~List~~ Describe the different types of display: — pitch and roll crossbars; — V-bar.	X	X				X		Reworded
(04)		Explain the differences between a flight director and an autopilot ~~(AP) system~~ and how the flight director provides a means of cross-checking the control/guidance commands sent to the autopilot.	X	X				X		Reworded
(05)		~~Explain how an FD and an AP can be used together, separately (AP with no FD, or FD with no AP), or none of them.~~ Explain why the flight director must be followed when engaged/shown, and describe the appropriate use of the flight director: — flight director only; — autopilot only; — flight director and autopilot; — typical job share between pilots (pilot flying (PF)/pilot monitoring (PM)) for selecting the parameters when autopilot is engaged versus disengaged.	X	X				X		Reworded
(06)		~~Give examples of different situations with the respective~~	X	X				X		Reworded

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		~~indications of the command bars.~~ Give examples of different scenarios and the resulting flight director indications.								
(07) New		Explain that the flight director computes and indicates the direction and magnitude of control inputs required in order to achieve an attitude to follow a trajectory.	X	X				X		New LO
(08) New		Explain how the modes available for the flight director are the same as those available for the autopilot, and that the same panel (FCU/MCP) is normally used for selection.	X	X				X		New LO
022 06 04 00		**Aeroplane: f~~F~~light m~~M~~ode a~~A~~nnunciator (FMA)**								
(01)		~~Explain the purpose and the importance of the FMA.~~ Explain the purpose of FMAs and their importance being the only indication of the state of a system rather than a switch position.	X	X				X		Reworded
~~LO (02)~~		~~State that the FMA provides:~~ — ~~AFCS lateral and vertical modes;~~ — ~~auto-throttle modes;~~ — ~~FD selection, AP engagement and automatic landing capacity;~~ — ~~failure and alert messages.~~	~~X~~	~~X~~						Covered in new (03) to (07)

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(03) New		Describe where the FMAs are normally shown and how the FMAs will be divided into sections (as applicable to aircraft complexity): — vertical modes; — lateral modes; — autothrust modes; — autopilot and flight director annunciators; — landing capability.	X	X				X		New LO
(04) New		Explain why FMAs for engaged or armed modes have different colour and/or different font size.	X	X				X		New LO
(05) New		Describe the following FMA display scenarios: — engagement of a mode; — mode change from armed to becoming engaged; — mode reversion.	X	X				X		New LO
(06) New		Explain the importance of monitoring the FMAs and announcing mode changes at all times (including when selecting a new mode) and why only certain mode changes will be accompanied by an aural notification or additional visual cues.	X	X				X		New LO
(07) New		Describe consequences of not understanding what the FMAs imply or missing mode changes and how it may lead	X	X				X		New LO

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		an undesirable aircraft state.								
022 06 05 00		**Autoland: design and operation**								
(01)		Explain the purpose of an autoland system.	X					X		
(02)		~~List and describe the main components of an autoland system.~~ Explain the significance of the following components required for an autoland: — autopilot, — autothrust, — radio altimeter, — ILS/MLS receivers.	X					X		Reworded
(03)		~~Define~~ Explain the following terms (reference to CS-AWO 'All Weather Operations'): — fail-passive automatic landing system; — fail-operational ~~(fail active)~~ automatic landing system; — fail-operational hybrid landing system; — alert height~~;~~. ~~according to CS-AWO.~~	X					X		Reworded
(04)		~~Describe and explain the autoland sequence and the~~	X							Reworded

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		~~associated annunciations/indications from initial approach to roll-out (AP disengagement) or go-around.~~ Describe the autoland sequence including the following: — FMAs regarding the landing capability of the aircraft; — the significance of monitoring the FMAs to ensure the automatic arming/engagement of modes triggered by defined radio altitudes or other thresholds; — in the event of a go-around, that the aircraft performs the go-around manoeuvre both by reading the FMAs and supporting those readings by raw data; — during the landing phase that 'FLARE' mode engages at the appropriate radio altitude, including typical time frame and actions if 'FLARE' does not engage; — after landing that 'ROLL-OUT' mode engages and the significance of disconnecting the autopilot prior to vacating the runway.								
(05)		~~List and explain the operational limitations to perform an autoland.~~ Explain that there are operational limitations in order to legally perform an autoland beyond the technical	X					X		Reworded

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		capability of the aircraft.								
(06) New		Explain the purpose and significance of alert height, describe the indications and implications, and consider typical pilot actions for a failure situation: — above the alert height; — below the alert height.	X					X		New LO
(07) New		Describe typical failures that, if occurring below the alert height, will trigger a warning: — all autopilots disengage; — loss of ILS/MLS signal or component thereof; — excessive ILS/MLS deviations; — radio-altimeter failure.	X					X		New LO
(08) New		Describe how the failure of various systems, including systems not directly involved in the autoland process, can influence the ability to perform an autoland or affect the minima down to which the approach may be conducted.	X					X		New LO
(09) New		Describe the fail-operational hybrid landing system as a primary fail-passive automatic landing system with a secondary independent guidance system such as a head-up display (HUD) to enable the pilot to complete a manual landing if the primary system fails.	X					X		New LO

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022 07 00 00		**HELICOPTER: AUTOMATIC FLIGHT CONTROL SYSTEMS**								
022 07 01 00		**General principles**								
022 07 01 01		***Stabilisation***								
(01)		Explain the similarities and differences between SAS and AFCS (the latter can actually fly the helicopter to perform certain functions selected by the pilot). Some AFCSs just have altitude and heading hold whilst others include a vertical speed or IAS hold mode, where a constant rate of climb/decent or IAS is maintained by the AFCS.			X	X	X			
022 07 01 02		***Reduction of pilot workload***								
(01)		Appreciate how effective the AFCS is in reducing pilot workload by improving basic aircraft control harmony and decreasing disturbances.			X	X	X			
022 07 01 03		***Enhancement of helicopter capability***								
(01)		Explain how an AFCS improves helicopter flight safety during: — search and rescue (SAR) because of increased capabilities; — flight by sole reference to instruments; — underslung load operations;			X	X	X			

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		— white-out conditions in snow-covered landscapes; — an approach to land with lack of visual cues.								
(02)		Explain that the ~~Search and Rescue (~~SAR~~)~~ modes of AFCS include the following functions: — ability to autohover; — automatically transition down from cruise to a predetermined point or over-flown point; — ability for the rear crew to move the helicopter around in the hover; — the ability to automatically transition back from the hover to cruise flight; — the ability to fly various search patterns.			X	X	X			
(03)		Explain that the earlier autohover systems use Doppler velocity sensors and the later systems use inertial sensors plus GPS, and normally include a two-dimensional hover-velocity indicator for the pilots.			X	X	X			
(04)		Explain why some SAR helicopters have both radio-altimeter height hold and barometric altitude hold.			X	X	X			
022 07 01 04		***Failures***								
(01)		Explain the various redundancies and independent systems that are built into the AFCSs.			X	X	X			

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(02)		Appreciate that the pilot can override the system in the event of a failure.			X	X	X			
(03)		Explain a series actuator 'hard over' which equals aircraft attitude runaway.			X	X	X			
(04)		Explain the consequences of a saturation of the series actuators.			X	X	X			
022 07 02 00		**Components: o~~O~~peration**								
022 07 02 01		***Basic sensors***								
(01)		Explain the basic sensors in the system and their functions.			X	X	X			
(02)		Explain that the number of sensors will be dependent on the number of couple modes of the system.			X	X	X			
022 07 02 02		***Specific sensors***								
(01)		Explain the function of the microswitches and strain gauges in the system which sense pilot input to prevent excessive feedback forces from the system.			X	X	X			
022 07 02 03		***Actuators***								
(01)		Explain the principles of operation of the series and parallel actuators, spring-box clutches and the autotrim system.			X	X	X			

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(02)		Explain the principle of operation of the electronic hydraulic actuators in the system.			X	X	X			
022 07 02 04		***Pilot/system interface: control panels, system indication, warnings***								
(01)		Describe the typical layout of the AFCS control panel.			X	X	X			
(02)		Describe the system indications and warnings.			X	X	X			
022 07 02 05		***Operation***								
(01)		Explain the functions of the redundant sensors' simplex and duplex channels (single/dual channel).			X	X	X			
022 07 03 00		**Stability aAugmentation sSystem (SAS)**								
022 07 03 01		***General principles and operation***								
(01)		Explain the general principles and operation of an SAS with regard to: — rate damping; — short-term attitude hold; — effect on static stability; — effect on dynamic stability; — aerodynamic cross-coupling; — effect on manoeuvrability;			X	X	X			

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— control response; — engagement/disengagement; — authority.								
(02)		Explain and describe the general working principles and primary use of SAS by damping pitch, roll and yaw motions.			X	X	X			
(03)		Describe a simple SAS with forced trim system which uses magnetic clutch and springs to hold cyclic control in the position where it was last released.			X	X	X			
(04)		Explain the interaction of trim with SAS/sStability and cControl aAugmentation sSystem (SCAS).			X	X	X			
(05)		Appreciate that the system can be overridden by the pilot and individual channels deselected.			X	X	X			
(06)		Describe the operational limits of the system.			X	X	X			
(07)		Explain why the system should be turned off in severe turbulence or when extreme flight attitudes are reached.			X	X	X			
(08)		Explain the safety design features built into some SASs to limit the authority of the actuators to 10–20 % of the full-control throw in order to allow the pilot to override if actuators demand an unsafe control input.			X	X	X			

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(09)		Explain how cross-coupling produces an adverse effect on roll-to-yaw coupling, when the helicopter is subject to gusts.			X	X	X			
(10)		Explain the collective-to-pitch coupling, side-slip-to-pitch coupling and inter-axis coupling.			X	X	X			
022 07 04 00		**Autopilot — a~~A~~utomatic stability equipment**								
022 07 04 01		***General principles***								
(01)		Explain the general autopilot principles with regard to: — long-term attitude hold; — fly-through; — changing the reference (beep trim, trim release).			X	X	X			
022 07 04 02		***Basic modes (3/4 axes)***								
(01)		Explain the AFCS operation on cyclic axes (pitch/roll), yaw axis, and on collective (fourth axis).			X	X	X			
022 07 04 03		***Automatic guidance (upper modes of AFCS)***								
(01)		Explain the function of the attitude-hold system in an AFCS.			X	X	X			
(02)		Explain the function of the heading-hold system in an AFCS.			X	X	X			

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(03)		Explain the function of the vertical-speed hold system in an AFCS.			X	X	X			
(04)		Explain the function of the navigation-coupling system in an AFCS.			X	X	X			
(05)		Explain the function of the VOR-/ILS-coupling system in an AFCS.			X	X	X			
(06)		Explain the function of the hover-mode system in an AFCS (including Doppler and radio-altimeter systems).			X	X	X			
(07)		Explain the function of the SAR mode (automatic transition to hover and back to cruise) in an AFCS.			X	X	X			
022 07 04 04		***Flight d~~D~~irector: design and operation***								
(01)		Explain the purpose of a f~~F~~light d~~D~~irector ~~(FD)~~ system.			X	X	X			
(02)		List the different types of display.			X	X	X			
(03)		State the difference between the flight director ~~FD~~ system and the autopilot system. Explain how each can be used independently.			X	X	X			
(04)		List and describe the main components of a~~n~~ flight director ~~FD~~ system.			X	X	X			
(05)		Give examples of different situations with the respective indications of the command bars.			X	X	X			

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(06)		Explain the architecture of the different flight directors ~~FDs~~ fitted to helicopters and the importance to monitor other instruments as well as the flight director. ~~FD, because on~~ Explain how some helicopter types ~~which~~ have the collective setting as a ~~on the~~ flight director ~~FD~~ command~~,~~; however, the command does not provide~~, there is no~~ protection against a ~~collective~~ transmission overtorque.			X	X	X			
(07)		Describe the collective setting and yaw depiction on flight director ~~FD~~ for some helicopters.			X	X	X			
022 07 04 05		***Automatic f~~F~~light c~~C~~ontrol p~~P~~anel (AFCP)***								
(01)		Explain the purpose and ~~the~~ importance of the AFCP.			X	X	X			
(02)		State that the AFCP provides: — AFCS basic and upper modes; — flight director ~~FD~~ selection, SAS and AP engagement; — failure and alert messages.			X	X	X			
022 08 00 00		**TRIMS — YAW DAMPER — FLIGHT-ENVELOPE PROTECTION**								
022 08 01 00		**Trim systems: design and operation**								
(01)		Explain the purpose of the trim system and describe the	X	X						Reworded

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		layout with one trim system for each control axis, depending on the complexity of the aircraft.								Incorporates (02)
~~LO (02)~~		~~State the existence of a trim system for each of the three axes.~~	~~X~~	~~X~~						Included in (01)
(03)		Give examples of trim indicators and their function and explain the significance of a 'green band/area' for the pitch trim.	X	X						Reworded
(04)		Describe and explain an automatic pitch-trim system for a conventional aeroplane.	X	X						
(05)		Describe and explain an automatic pitch-trim system for an FBW~~fly-by-wire~~ aeroplane and that it is also operating during manual flight; however, during certain phases it may be automatically disabled to alter the handling characteristics of the aircraft.	X	X						Reworded Incorporates (06)
~~LO (06)~~		~~State that for a fly-by-wire aeroplane the automatic pitch-trim system operates also during manual flight.~~	~~X~~							Included in (05)
(07)		Describe the consequences of manual operation on the trim wheel when the automatic pitch-trim system is engaged.	X	X						
(08)		Describe and explain the engagement and disengagement conditions of the autopilot according to trim controls.	X	X						

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(09)		Define 'Mach trim' and state that the Mach-trim system can be independent.	X	X						
~~LO (10)~~		~~State that for a fly-by-wire aeroplane an autotrim system can be available for each of the three axes.~~ ~~*Remark: For the fly-by-wire LOs, please refer to reference 21.5.4.0.*~~	~~X~~	~~X~~						No practical use
(11) New		Describe the implications for the pilot in the event of a runaway trim or significant out-of-trim state.	X	X						New LO
022 08 02 00		**Yaw damper: design and operation**								
(01)		Explain the purpose of the yaw-damper system.	X	X						
~~LO (02)~~		~~List and describe the main components of a yaw-damper system.~~	~~X~~	~~X~~						No practical use
(03)		Explain the purpose of the Dutch-roll filter (filtering of the yaw input signal).	X	X						
(04)		Explain the operation of a yaw-damper system and state the difference between a yaw-damper system and a 3-axis autopilot operation on the rudder channel.	X	X						
022 08 03 00		**Flight-e~~E~~nvelope p~~P~~rotection (FEP)**								
(01)		Explain the purpose of the ~~(~~FEP~~)~~.	X	X				X		Reworded

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(02)		~~List the~~ Explain typical input parameters ~~of~~ to the FEP: — AoA, — aircraft configuration, — airspeed information.	X	X				X		Reworded
(03)		Explain the following functions of the FEP: — stall protection, — overspeed protection.	X	X				X		
(04)		~~State that~~ Explain how the stall protection function and the overspeed protection function apply to both mechanical/conventional and FBW~~fly-by-wire~~ control systems, but other functions (e.g. pitch or bank limitation) can only apply to FBW~~fly-by-wire~~ control systems.	X	X				X		Reworded
022 09 00 00		~~**AUTO-THROTTLE — AUTOMATIC THRUST CONTROL SYSTEM**~~ **AUTOTHRUST – AUTOMATIC THRUST CONTROL SYSTEM**								Reworded (conforms with CS-25)
(01)		~~State~~ Describe the purpose of the ~~auto-throttle (AT)~~ autothrust system and explain how the FMAs will be the only indication on active autothrust modes.	X							Reworded
(02)		Explain the operation of an ~~AT~~ autothrust system with regard to the following modes:	X							Reworded

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		— take-off/go-around (TOGA); — climb or maximum continuous thrust (MCT), N1 or EPR targeted (THR CLB, THR MCT, N1, THR HOLD, EPR); — speed (SPEED, MCP SPD); — idle thrust (THR IDLE, RETARD/ARM); — landing ~~('flare' or 'retard')~~ (RETARD, THR IDLE).								
~~LO (03)~~		~~Describe the control loop of an AT system with regard to:~~ — ~~inputs: mode selection unit and switches (disengagement and engagement: TO GA switches), radio altitude, air–ground logic switches;~~ — ~~error detection: comparison between reference values (N1 or EPR, speed) and actual values;~~ — ~~signal processing (control laws of the thrust lever displacement according to error signal);~~ — ~~outputs: AT servo-actuator;~~ — ~~feedback: Thrust Lever Angle (TLA), data from ADC (TAS, Mach number), engine parameters (N1 or EPR).~~	~~X~~							Covered in revised and new (01) to (10)
(04)		~~State the existence of AT systems where thrust modes are determined by the lever position (no thrust mode panel or thrust rating panel, no TOGA switches).~~	X							Reworded

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		Describe the two main variants of autothrust systems: — mode selections available on the FCU/MCP and thrust levers move with autothrust commands; — mode selections made using the thrust levers which remain static during autothrust operation.								
(05)		~~Explain the limitations of an AT system in case of turbulence.~~ Explain how flight in turbulence/wind shear giving erratic airspeed indications may lead to the autothrust overcompensating in an oscillating manner and that manual thrust may be required to settle the airspeed.	X							Reworded
(06) New		Explain the threats associated with the use of autothrust resulting in the pilot losing the sense of speed awareness.	X							New LO
(07) New		Explain the relationship between autopilot pitch modes and autothrust modes and how the autopilot and autothrust will interact upon selecting modes for one of the systems.	X							New LO
(08) New		Explain the principles of speed control and how speed can be controlled: — by varying the engine thrust; — by varying the aircraft pitch.	X							New LO

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(09) New		Explain the potential implications on speed control when the autothrust controls speed and the autopilot pitch channel has a fixed pitch target for the following mode combinations: — MCP SPD/SPEED and ALT HOLD/ALT; — MCP SPD/SPEED and VSP (climb); — MCP SPD/SPEED and VSP (descent).	X							New LO
(10) New		Explain the potential implications on speed control when the autothrust has a fixed thrust target and the autopilot pitch channel controls speed for the following mode combinations: — N1/THR CLB and LVL CHG/OP CLB; — ARM/THR IDLE and LVL CHG/OP DES.	X							New LO
022 10 00 00		**COMMUNICATION SYSTEMS**								
022 10 01 00		**Voice communication, datalink transmission**								
022 10 01 01		***Definitions and transmission modes***								
(01)		~~State~~ Describe the purpose of a datalink transmission system.	X							Reworded
(02)		Compare voice communication versus datalink transmission systems.	X							

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(03)		~~State that VHF, HF and SATCOM devices can be used for voice communication and data link transmission.~~ Describe the communication links that are used in aircraft: — high-frequency communications (HF); — very high-frequency communications (VHF); — satellite communications (SATCOM).	X							Reworded
(04)		~~State the advantages and disadvantages of each transmission mode with regard to:~~ — R~~r~~ange; — line-of-sight limitations; — quality of the signal received; — interference due to ionospheric conditions; — data transmission speed. Consider the properties of the communication links with regard to: — signal quality; — range/area coverage; — data transmission speed.	X							Reworded Combined with (05)
~~LO (05)~~		~~State that the satellite communication networks do not~~	~~X~~							Included in (04)

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		~~cover extreme polar regions.~~								
(06)		~~Define 'downlink and uplink communications'.~~ Define and explain the following terms in relation to aircraft datalink communications: — message/data uplink; — message/data downlink.	X							Reworded
~~LO (07)~~		~~State that a D-ATIS is an ATIS message received by data link.~~	~~X~~							No practical use
022 10 01 02		***Systems: a~~A~~rchitecture, design and operation***								
~~LO (01)~~		~~Name the two following data link service providers:~~ — ~~SITA,~~ — ~~ARINC,~~ ~~and state their function.~~	~~X~~							No practical use
(02)		Describe the purpose of the ACARS network.	X							Reworded
(03)		~~Describe the two following systems using the VHF/HF/SATCOM data link transmission:~~ — ~~Aircraft Communication Addressing and Reporting System (ACARS);~~ — ~~Air Traffic Service Unit (ATSU).~~ Describe the systems using the ACARS network through	X							Reworded

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		the air traffic service unit (ATSU) suite: — aeronautical/airline operational control (AOC); — air traffic control (ATC).								
(04)		~~List and describe the following possible onboard components of an ATSU:~~ — ~~communications management unit (VHF/HF/SATCOM);~~ — ~~Data Communication Display Unit (DCDU);~~ — ~~Multi-Control Display Unit (MCDU) for AOC, ATC and messages from the crew (downlink communication);~~ — ~~ATC message visual warning;~~ — ~~printer.~~ Explain the purpose of the following parts of the on-board equipment: — ATSU computer; — control display unit (CDU)/multifunction control display unit (MCDU); — data communication display unit (DCDU); — ATC message visual annunciator; — printer.	X							Reworded
(05)		Give examples of airline operations communications	X							Reworded

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		(AOC) datalink messages such as: — out of the gate, off the ground, on the ground, into the gate (OOOI); — load sheet; — passenger information (connecting flights); — digital ATIS (D-ATIS); — weather reports (METAR, TAF); — maintenance reports (engine exceedances); — aircraft technical data; — free-text messages.								
(06)		Give examples of ~~air traffic communications (~~ATC~~)~~ datalink messages such as: — departure clearance; — oceanic clearance; — controller-pilot data link communications (CPDLC).	X							Reworded
022 10 02 00		**Future a~~A~~ir n~~N~~avigation s~~S~~ystems (FANSs)**								
(01)		~~State~~ Describe the existence of the ICAO communication, navigation, surveillance/air traffic management (CNS/ATM) concept.	X							Reworded
(02)		~~Define and explain the 'FANS concept' (including FANS A~~	X							Reworded

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		~~and FANS B).~~ Explain the two version of FANSs: — FANS A/FANS 1 using the ACARS network; — FANS B/FANS 2 using the ACARS network and the aeronautical telecommunication network (ATN).								Combined with (03)
~~LO (03)~~		~~State that FANS A/FANS 1 uses the ACARS network.~~	~~X~~							Included in (02)
(04)		List and explain the following FANS A/FANS 1 applications: — ATS facility notification (AFN); — automatic dependent surveillance (ADS); — CPDLC.	X							Editorial
(05)		Compare the ADS application with the secondary surveillance radar function, and the CPDLC application with VHF communication systems.	X							
(06)		State that an ~~ATC centre~~ (ATCU) can use the ADS application only, or the CPDLC application only, or both of them (not including AFN).	X							Reworded
(07)		~~Describe a notification phase (LOG ON) and state its purpose.~~ Describe the AFN process for logging on with an ATCU and typical data that will be included in the message.	X							Reworded

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(08)		~~List the different types of messages of the CPDLC function and give examples of CPDLC data link messages.~~ Describe typical types of CPDLC messages and the typical pilot work practices when requesting or accepting a CPDLC clearance.	X							Old LO moved to 091 02 13 00 Reworded
(09)		List and describe the different types of ADS contracts that are controlled by the ATCU and beyond the control of the pilot: — periodic: data sent at set time intervals; — on demand: data sent when requested; — on event: data sent when an event occurs (e.g. heading change, climb initiated, etc.);~~.~~ — emergency mode.	X							Reworded
~~LO (10)~~		~~State that the controller can modify the 'periodic', 'on demand' and 'on event' contracts or the parameters of these contracts (optional data groups), and that these modifications do not require crew notification.~~	~~X~~							No practical use
(11)		~~Describe the 'emergency mode'.~~ Describe the purpose of the ADS emergency mode contract and highlight the difference to the ATCU controlled contracts.	X							Reworded

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022 11 00 00		**FLIGHT MANAGEMENT SYSTEM (FMS)/FLIGHT MANAGEMENT AND GUIDANCE SYSTEM (FMGS)**								
~~LO~~		~~*Remark: The use of an FMS as a navigation system is detailed in Radio Navigation (062), reference 062 05 04 00.*~~								Not relevant as all areas covered in 022
022 11 01 00		**Design**								
(01)		~~State~~ Explain the purpose of an FMS.	X		X	X		X		Reworded Incorporates 062 05 04 01 (02)
(02)		Describe a typical dual FMS architecture including the following components: — flight management computer (FMC); — CDU/ MCDU; — cross-talk bus.	X		X	X				Reworded Incorporates 062 05 04 02 (01)
(03)		~~Describe the different possible configurations of this architecture during degraded modes of operation.~~ Describe the following failures of a dual FMS architecture and explain the potential implications to the pilots: — failure of one FMC; — failure of one CDU/MCDU;	X		X	X				Reworded

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		— failure of the cross-talk bus.								
(04)		~~List the possible inputs and outputs of an FMS.~~ ~~*Remark: No standard of FMS can be given because the FMS is type specific for aircraft manufacturers and the FMS standard is defined by the airline customer.*~~ Describe how the FMS integrates with other systems and gathers data in order to provide outputs depending on its level of complexity.	X		X	X		X		Reworded Combined with (05) and (06)
~~LO (05)~~		~~Describe the interfaces of the FMS with AFCS.~~	~~X~~		~~X~~	~~X~~				Included in (04)
~~LO (06)~~		~~Describe the interfaces of the FMS with the AT system.~~	~~X~~							Included in (04)
(07) New		Explain how the FMS may provide the following functions: — navigation; — lateral and vertical flight planning; — performance parameters.	X	X	X	X		X		New LO Incorporates 062 05 04 01 (03)
022 11 02 00		~~**Navigation database, aircraft database**~~ **FMC databases**								Reworded
~~LO (01)~~		~~Describe the contents and the main features of the navigation database and of the aircraft database: read-only information, updating cycle.~~	~~X~~		~~X~~	~~X~~		~~X~~		Included in 022 11 02 01 (01)
~~LO (02)~~		~~Define and explain the 'performance factor'.~~	~~X~~		~~X~~	~~X~~				Included in

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										022 11 02 02 (04)
022 11 02 01		***Navigation database***								New paragraph Combined with 062 05 04 03
(01) New		Explain the purpose of, and describe typical content of, the navigation database.	X		X	X		X		Incorporates 062 05 04 03 (01)
(02) New		Describe the 28-day aeronautical information regulation and control (AIRAC) update cycle of the navigation database and explain the reason for having two navigation databases (one active, one standby) and the implication this has to the pilot.	X		X	X		X		Incorporates 062 05 04 03 (02)
(03) New		Explain the purpose of typical user-defined waypoints such as: — latitude/longitude coordinates; — place/bearing/distance (PBD); — place/bearing place/bearing (PBX); — place/distance (PD).	X		X	X		X		New LO
(04) New		Explain that the pilot cannot change or overwrite any of the data in the navigation database and that any user-defined waypoints, routes and inputted data will be erased when a different database is activated.	X		X	X		X		Incorporates 062 05 04 03 (03)

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(05) New		Explain the threats and implications to the pilot of changing the database by error either on the ground or while flying.	X		X	X		X		New LO
022 11 02 02		***Aircraft/performance database***								New paragraph Combined with 062 05 04 04
(01) New		Explain the purpose of, and describe the typical content of, the aircraft/performance database.	X		X	X		X		Incorporates 062 05 04 01 (01) & 062 05 04 01 (02)
(02) New		Explain the importance of verifying that the aircraft/ performance database is based on the correct data, such as engine type and aircraft variant.	X		X	X		X		New LO
(03) New		Explain that the contents of the aircraft/performance database cannot be modified by the pilot.	X		X	X		X		Incorporates 062 05 04 01 (01)
(04) New		Explain the purpose of performance factor and how it influences the calculations.	X		X	X		X		New LO
(05) New		Explain the purpose of cost index (CI) and how it influences the calculations.	X							Combined with 022 11 03 00 (03)
022 11 03 00		**Operations, limitations**								
(01)		~~List and describe data computation and functions~~	X		X	X		X		Reworded

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		~~including position computations (multisensors), flight management, lateral/vertical navigation and guidance.~~ Describe typical data that may be provided by the FMS: — lateral and vertical navigation guidance; — present position; — time projections; — fuel projections; — altitude/flight level projections.								Incorporates 062 05 04 05 (02)
(02)		~~State the difference between computations based on measured data (use of sensors) and computations based on database information and give examples.~~ Explain how the FMS will use a combination of inputted/database and measured data in order to calculate projections and provide output data. Explain the issues and threats using inputted/database data and give examples of consequences of entering the data incorrectly/using incorrect data.	X		X	X		X		Reworded Incorporates 062 05 04 05 (01)
~~LO (03)~~		~~Define and explain the 'Cost Index' (CI).~~	~~X~~							Included in 022 11 02 02 (05)
~~LO (04)~~		~~Describe navigation accuracy computations and approach capability, degraded modes of operation: back up~~	~~X~~		~~X~~	~~X~~				Included in 022 11 03 00 (09)

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		~~navigation, use of raw data to confirm position/RAIM function for RNAV procedures.~~								
(05)		~~Describe fuel computations with standard and non-standard configurations including one engine out, landing gear down, flaps, spoilers, use of the anti-icing system, increase of consumption due to an MEL/CDL item, etc.~~ Describe fuel consumption calculations during standard operations and explain typical data that will have an influence on the accuracy of the calculations. Explain the implications on the accuracy of the calculations during flight in abnormal configurations such as engine out, gear down, flaps extended, spoilers extended, etc., if the FMS is unable to detect the failure.	X		X	X				Reworded
(06)		~~Describe automatic radio navigation and tuning (COMM, NAV).~~ Describe and explain the purpose of an FMS having dedicated radio-navigation receivers that it will tune automatically.	X		X	X				Reworded Combined with 062 05 04 06
(07) New		Explain typical position inputs to an FMS: — GPS, — IRS, — DME,	X		X	X				Incorporates 062 05 04 06 (01)

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		— VOR, — LOC, — runway threshold (RWY THR).								
(08) New		Explain how the FMS will use position data from the various navigation inputs in order to create its own FMS position fix and that the FMS calculations will be based on the FMS position.	X		X	X				Incorporates 062 05 04 06 (02)
(09) New		Explain the implications of a reduction in available position inputs to the FMS, especially GPS in relation to the capability of performing RNAV/GNSS approaches.	X		X	X				New LO
(10) New		Explain the difference between following the FMS data compared to following raw data from radio-navigation receivers and describe how there may be limitations for using FMS data as primary source to follow an instrument approach procedure (IAP) such as LOC, VOR or NDB.	X		X	X		X		New LO
022 11 04 00		**Man–machine interface (CDU/MCDU)**								Reworded Combined with 062 05 05 01
~~LO (01)~~		~~Give examples and describe the basic functions of the man–machine interface (MCDU).~~	~~X~~		~~X~~	~~X~~				Covered in new (02) to (06)
(02) New		Describe the purpose of a CDU/MCDU.	X		X	X		X		Incorporates

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										062 05 05 01 (01)
(03) New		Describe the typical layout of a CDU/MCDU and the general purpose of the following: — screen; — line select keys; — menu select keys; — alphanumerical keys.	X		X	X		X		Incorporates 062 05 05 01 (02)
(04) New		Explain the function of the 'scratchpad' part of the screen.	X		X	X		X		New LO
(05) New		Describe how input of some data is compulsory for the function of the FMS and other data is optional, and that different symbology is used to highlight this: — rectangular boxes = compulsory information; — dashed line = optional information.	X		X	X		X		New LO
(06) New		Describe a typical FMS pre-flight set-up process through the CDU/MCDU to cover the most basic information (with the aim to create awareness of required information as this is irrespective of aircraft type and FMS/FMGS make): — ident page (who am I = aircraft type/variant, engine type/rating and appropriate navigation database; — position initialisation (where am I = position for aligning the IRS and FMS position);	X							New LO

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		— route initialisation (where am I going = place of departure/destination and alternate(s)); — route programming (how will I get there = SIDs, STARS, route (company or otherwise)); — performance initialisation (when will I arrive = weights, flap setting, FLEX/assumed temperature/derate, take-off speeds).								
022 12 00 00		**ALERTING SYSTEMS, PROXIMITY SYSTEMS**								
022 12 01 00		**General**								
(01)		State definitions, category, criteria and characteristics of alerting systems according to CS-25/AMJ 25.1322 for aeroplanes and CS-29 for helicopters as appropriate.	X	X	X	X	X			
022 12 02 00		**Flight w~~W~~arning s~~S~~ystems (FWSs)**								
(01)		~~State the purpose of an FWS and list the typical sources (abnormal situations) of a warning and/or an alert.~~ State the annunciations given by the FWS and typical location for the annunciator(s): — master warning; — master caution; — advisory.	X	X	X	X	X	X		Reworded

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~~LO (02)~~		~~List the main components of an FWS.~~	~~X~~		~~X~~	~~X~~	~~X~~			No practical use
(03) New		Explain master warning: — colour of annunciator: red; — nature of aural alerts: continuous; — typical failure scenarios triggering the alert.	X	X	X	X	X	X		New LO
(04) New		Explain master caution: — colour of the annunciator: amber or yellow; — nature of aural alerts: attention-getter; — typical failure scenarios triggering the alert.	X	X	X	X	X	X		New LO
(05) New		Describe a typical procedure following a master warning or master caution alert: — acknowledging the failure; — silencing the aural warning; — initiating the appropriate response/procedure.	X	X	X	X	X	X		New LO
(06) New		Explain advisory: — colour of the annunciator: any other than red, amber, yellow or green; — absence of aural alert; — typical scenarios triggering the advisory.	X	X	X	X	X	X		New LO

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022 12 03 00		**Stall w~~W~~arning s~~S~~ystems (SWSs)**								
(01)		~~State the function of an SWS.~~ Describe the function of an SWS and explain why the warning must be unique.	X	X						Reworded Combined with (02)
~~LO (02)~~		~~State the characteristics of an SWS according to CS 25.207(c).~~	~~X~~	~~X~~						Included in (01)
(03)		~~List~~ Describe the different types of SWSs~~stall warning systems~~.	X	X						Reworded
(04)		List the main components of an SWS.	X	X						
~~LO (05)~~		~~List the inputs and outputs of an SWS.~~	~~X~~	~~X~~						No practical use
(06) New		Explain the difference between the stall warning speed and the actual stalling speed of the aeroplane.	X	X						New LO
022 12 04 00		**Stall protection**								
(01)		~~State~~ Describe the function of a stall protection system.	X							Reworded
(02)		~~List~~ Describe the different types of stall protection systems including the difference between mechanical and FBW~~fly-by-wire~~ controls.	X							Reworded
~~LO (03)~~		~~List the main components of a stall protection system.~~	~~X~~							No practical use
~~LO (04)~~		~~List the inputs and outputs of a stall protection system.~~	~~X~~							No practical use

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(05)		Explain the difference between a stall warning system and a stall protection system.	X							
022 12 05 00		**Overspeed warning**								
(01)		Explain the purpose of an overspeed warning system (VMO/MMO pointer).	X	X						
~~LO (02)~~		~~Explain the design of a mechanical VMO/MMO pointer.~~	~~X~~	~~X~~						Included in (04)
(03)		State that for large aeroplanes~~,~~ an aural warning must be associated to the overspeed warning if an electronic display is used (see AMC 25.11, paragraph 10.b(2), p. 2-GEN-22).	X	X						
(04)		Describe and g~~G~~ive examples of VMO/MMO pointer: barber's pole pointer, barber's pole vertical scale.	X	X						Reworded Includes (02)
022 12 06 00		**Take-off warning**								
(01)		~~State~~ Explain the purpose of a take-off warning system and list the typical abnormal situations which generate a warning (see AMC 25.703, paragraphs 4 and 5).	X							Reworded
022 12 07 00		**Altitude alert system**								
(01)		~~State~~ Describe the function and ~~describe~~ an altitude alert system.	X	X	X	X	X	X		Reworded

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(02)		~~List and~~ Describe ~~the~~ different types of displays and possible alerts.	X	X	X	X	X	X		Reworded
022 12 08 00		**Radio altimeter**								
(01)		~~State~~ Explain the ~~function~~ purpose of a low-altitude radio altimeter.	X	X	X	X	X	X		Reworded
(02)		Describe the principle of the distance (height) measurement.	X	X	X	X	X	X		
~~LO (03)~~		~~State the bandwidth and frequency range used.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(04)		~~List the different components of a radio altimeter and~~ Describe the different types of radio-altimeter displays.	X	X	X	X	X	X		Reworded
(05)		~~List the systems using radio altimeter information.~~ Describe how the radio altimeter provides input to other systems and how a radio-altimeter failure may impact on the functioning of these systems.	X	X	X	X	X	X		Reworded
(06)		State the range ~~and accuracy~~ of a radio altimeter.	X	X	X	X	X	X		Reworded
~~LO (07)~~		~~Describe and explain the cable length compensation.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(08) New		Explain the potential implications of an incorrect radio-altimeter indication and how this in particular may affect the following systems: — autothrust,	X	X				X		New LO

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		— ground-proximity warning systems (GPWSs).								
022 12 09 00		**Ground-proximity warning systems (GPWS)**								
022 12 09 01		***GPWS: design, operation, indications***								
(01)		~~State~~ Explain the purpose of a ~~ground-proximity warning system (~~GPWS~~)~~.	X		X	X				Reworded
~~LO (02)~~		~~List the components of a GPWS.~~	~~X~~		~~X~~	~~X~~				No practical use
(03)		~~List the~~ Explain inputs and outputs of a GPWS and describe its working principle.	X		X	X				Reworded
(04)		List and describe the different modes of operation of a GPWS.	X		X	X				
022 12 09 02		***Terrain-a~~A~~voidance w~~W~~arning s~~S~~ystem (TAWS), other name: e~~E~~nhanced GPWS (EGPWS)***								
(01)		~~State~~ Explain the purpose of a TAWS for aeroplanes and HTAWS for helicopters, and explain the difference from a GPWS.	X		X	X				Reworded
~~LO (02)~~		~~List the components of a TAWS/ HTAWS.~~	~~X~~		~~X~~	~~X~~				No practical use
(03)		~~List the~~ Explain inputs and outputs of a TAWS/HTAWS and describe its working principle.	X		X	X				Reworded
(04)		Give examples of terrain displays and list the different	X		X	X				

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		possible alerts.								
(05)		Give examples of time response left to the pilot according to look-ahead distance, speed and aircraft performances.	X		X	X				
(06)		Explain why the TAWS/HTAWS must be coupled to a precise-position sensor.	X		X	X				
(07) New		Explain the possibility of triggering spurious TAWS/HTAWS warnings as a result of mismanaging the flight path in the proximity to obstacles: — high rate of descent; — high airspeed; — a combination of high rate of descent and high airspeed.	X		X	X				New LO
022 12 09 03		~~***Runway awareness and advisory system*** (to be introduced at a later date)~~ ***Intentionally left blank***								No practical use
~~LO (01)~~		~~Explain that a runway awareness and advisory system is a software upgrade of the existing TAWS (EGPWS) to reduce runway incursions.~~	~~X~~							No practical use
022 12 10 00		***ACAS/TCAS principles and operations***	X	X	X	X	X	X		
(01)		State that ACAS II is an ICAO standard for anti-collision purposes.	X	X	X	X	X	X		

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~~LO (02)~~		~~State that TCAS II version 7 is compliant with the ACAS II standard.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(03)		Explain that ACAS II is an anti-collision system and does not guarantee any specific separation.	X	X	X	X	X	X		
(04)		Describe the purpose of an ACAS II system as an anti-collision system.	X	X	X	X	X	X		
(05)		~~Define a 'Resolution Advisory' (RA) and a 'Traffic Advisory' (TA)~~ Describe the following outputs from a TCAS: — other intruders; — proximate intruders; — traffic advisory (TA); — resolution advisory (RA).	X	X	X	X	X	X		Reworded
(06)		~~State that RAs are calculated in the vertical plane only (climb or descent).~~ State that ACAS II will issue commands in the vertical plane only (climb, descent or maintain), and that the commands are complied with as a manual manoeuvre.	X	X	X	X	X	X		Reworded
(07)		~~Explain the difference between a corrective RA and a preventive RA (no modification of vertical speed).~~ Explain that an RA may or may not require any active	X	X	X	X	X	X		Reworded

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		control input and the implications of reacting instinctively without awareness of actual control inputs required to comply with the RA.								
(08)		Explain that if two aircraft are fitted with ACAS II, the RA will be coordinated.	X	X	X	X	X	X		
(09)		State that ACAS II equipment can take into account several threats simultaneously.	X	X	X	X	X	X		
(10)		State that a detected aircraft without altitude-reporting can only generate a TA; describe typical type of traffic and how this can create distractions during flight in certain areas of significant air traffic activity.	X	X	X	X	X	X		Reworded
(11)		~~Describe the TCAS II system in with regard to:~~ — A~~a~~ntenna used; — computer and links with radio altimeter, air-data computer and mode-S transponder. Describe the interaction between the TCAS II system and the transponder, radio altimeter and the air-data computer.	X	X	X	X	X	X		Reworded
~~LO (12)~~		~~Identify the inputs and outputs of TCAS II.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(13)		Explain the principle of TCAS II interrogations.	X	X	X	X	X	X		
(14)		State ~~that~~ the typical standard detection range for TCAS II:	X	X	X	X	X	X		Reworded

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		— 35–40 NM horizontally; — approximately 2 000 ft above and below (any setting); — extension to approximately 10 000 ft above (ABV selected) or approximately 10 000 ft below (BLW selected).								
~~LO (15)~~		~~State that the normal interrogation period is 1 second.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(16)		Explain the principle of 'reduced surveillance'.	X	X	X	X	X	X		
(17)		~~Explain that in high-density traffic areas the period can be extended to 5 seconds and the transmission power reduction can reduce the range detection down to 5 NM.~~ Explain that in high-density traffic areas the range may automatically be decreased in order to enable detection of the threats in the proximity of the aircraft due to a limitation of the maximum number of possible intruders the system is able to process.	X	X	X	X	X	X		Reworded
(18)		Identify the equipment which an intruder must be fitted with in order to be detected by TCAS II.	X	X	X	X	X	X		
(19)		Explain in the anti-collision process: — ~~that~~ the criteria used to trigger an alarm (TA or RA) are the time to reach the closest point of approach	X	X	X	X	X	X		

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		(CPA) (called TAU) and the difference of altitude; — ~~that~~ an intruder will be classified as 'proximate' when being less than 6 NM and 1 200 ft from the TCAS-equipped aircraft; — ~~that~~ the time limit to CPA is different depending on aircraft altitude, is linked to a sensitivity level (SL), and state that the value to trigger an RA is from 15 to 35 seconds; — ~~that,~~ in case of an RA, the intended vertical separation varies from 300 to 600 ft (700 ft above FL420), depending on the sensitivity level (SL); — ~~that~~ below 1 000 ft above ground, no RA can be generated; — ~~that~~ below 1 450 ft (radio-altimeter value) 'increase descent' RA is inhibited; — ~~that, in~~ at high altitude, performances of the type of aircraft are taken into account to inhibit 'climb' and 'increase climb' RA.								
(20)		List and interpret the following information available from TCAS: — the different possible statuses of a detected aircraft: other, proximate, intruder;	X	X	X	X	X	X		

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		— the appropriate graphic symbols and their position on the horizontal display; — different aural warnings.								
(21)		~~Explain that an RA is presented as a possible vertical speed on a TCAS indicator or on the Primary Flight Display (PFD).~~ Explain the indications of a TA and an RA and how an RA will generate a red area and a green area on the VSI to indicate the required manoeuvre to comply with the RA.	X	X	X	X	X	X		Reworded Combined with (22)
~~LO (22)~~		~~Describe the possible presentation of an RA on a VSI or on a PFD.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		Included in (21)
(23)		Explain that the pilot must not interpret the horizontal track of an intruder upon the display.	X	X	X	X	X	X		
022 12 11 00		**Rotor/engine overspeed alert system**								
022 12 11 01		***Design, operation, displays, alarms***								
(01)		Describe the basic design principles, operation, displays and warning/alarm systems fitted to different helicopters.			X	X	X			
022 13 00 00		**INTEGRATED INSTRUMENTS — ELECTRONIC DISPLAYS**								
022 13 01 00		**Electronic display units**								
022 13 01 01		***Design, limitations***								

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(01)		List the different technologies used, e.g. CRT and LCD, and the associated limitations: — cockpit temperature~~;~~, — glare~~.~~, — resolution.	X	X	X	X	X	X	X	Reworded
022 13 02 00		**Mechanical integrated instruments: a~~A~~ttitude and d~~D~~irector i~~I~~ndicator (ADI)/h~~H~~orizontal s~~S~~ituation i~~I~~ndicator (HSI)**								
(01)		Describe an ADI and an HSI.	X	X	X	X	X	X	X	
(02)		List all the information that can be displayed on ~~for~~ either instruments.	X	X	X	X	X	X	X	
022 13 03 00		**Electronic f~~F~~light i~~I~~nstrument s~~S~~ystems (EFISs)**								
		~~*Remarks:*~~ ~~*1 — The use of EFIS as navigation display system is also detailed in Radio Navigation (062), reference 062 05 05 02 (EFIS instruments).*~~ ~~*2 — Reference to AMC 25 1322 can be used for aeroplanes only.*~~								No practical use
022 13 03 01		***Design, operation***								
~~LO (01)~~		~~List and describe the different components of an EFIS.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	No practical use

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(02)		List the following ~~possible inputs and outputs~~ parts of an EFIS: — control panel, — display units, — symbol generator, — remote light sensor.	X	X	X	X	X	X		Reworded
~~LO (03)~~		~~Describe the function of the symbol generator unit.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
(04) New		Describe the typical layout of the EFIS display units and how there may be a facility to transfer the information from one display unit on to another if a display unit fail.	X	X	X	X	X	X		Incorporates 062 05 05 02 (01)
(05) New		Explain the need for standby instruments to supplement the EFIS in the event of all the display units failing and the challenge of using these standby instruments, namely their size and position on the flight deck.	X	X	X	X	X	X		New LO
(06) New		Explain the difference between a symbol generator failing and a display unit failing and the implications if there are redundant symbol generators available.	X	X	X	X	X	X		New LO
(07) New		Describe the purpose of an EFIS control panel and typical selections that may be available: — altimeter pressure setting; — navigation display (ND) mode selector;	X	X	X	X	X	X		Combined with 022 13 03 03 (08)

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		— ND range selector; — ND data selector; — radio navigation aids selector (VOR 1/2 or ADF 1/2); — decision altitude(DA)/decision height (DH) selection.								
022 13 03 02		***Primary ~~f~~Flight d~~D~~isplay (PFD), e~~E~~lectronic a~~A~~ttitude d~~D~~irector i~~I~~ndicator (EADI)***								
(01)		~~State~~ Describe that a PFD (or an EADI) presents a dynamic colour display of all the parameters necessary to control the aircraft, and that the main layout conforms with the 'basic T' principle: — attitude information in the centre; — airspeed information on the left; — altitude information on the right; — heading/track indication lower centre.	X	X	X	X	X	X	X	Reworded Combined with (02) Incorporates 062 05 05 02 (02)
~~LO (02)~~		~~List and describe the following information that can be displayed on the PFD unit of an aircraft:~~ — F~~f~~light mode annunciation~~;~~, — basic T~~:~~. • ~~attitude,~~ • ~~IAS,~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	Covered in new (04) to (09)

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		~~• altitude,~~ ~~• heading/track indications;~~ — ~~vertical speed;~~ — ~~maximum airspeed warning;~~ — ~~selected airspeed;~~ — ~~speed trend vector;~~ — ~~selected altitude;~~ — ~~current barometric reference;~~ — ~~steering indications (FD command bars);~~ — ~~selected heading;~~ — ~~flight path vector (FPV);~~ — ~~radio altitude;~~ — ~~decision height;~~ — ~~ILS indications;~~ — ~~ACAS (TCAS) indications;~~ — ~~failure flags and messages.~~								
~~LO (03)~~		~~List and describe the following information that can also be displayed on the PFD unit of an aeroplane:~~ — T~~t~~ake-off and landing reference speeds; — minimum airspeed;	~~X~~							Covered in new (04) to (09)

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— lower selectable airspeed; — Mach number.								
(04) New		Describe the typical design of the attitude information: — artificial horizon with aircraft symbol; — superimposed flight director command bars.	X	X	X	X	X	X	X	Incorporates 062 05 05 02 (02)
(05) New		Describe the typical design of the speed tape: — rolling speed scale with numerical read-out of current speed; — limiting airspeeds according to configuration; — speed trend vector; — bug/indication for selected airspeed.	X	X	X	X	X	X	X	Incorporates 062 05 05 02 (02)
(06) New		Explain the Mach number indications and how a selected Mach number is presented with the speed bug on a corresponding IAS on the speed tape with the Mach number shown as a numerical indication outside of the speed tape.	X							Incorporates 062 05 05 02 (02)
(07) New		Describe the typical design of the altitude information: — rolling altitude scale with numerical read-out of current altitude; — altimeter pressure setting;	X	X	X	X	X	X	X	Incorporates 062 05 05 02 (02)

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		— bug/indication for selected altitude; — means of highlighting the altitude if certain criteria are met.								
(08) New		Describe the typical design of the heading/track information: — rolling compass scale/rose with numerical read-out of current heading/track. — bug/indication for selected heading/track.	X	X	X	X	X	X	X	Incorporates 062 05 05 02 (02)
(09) New		Describe the typical design and location of the following information: — flight mode annunciators (FMAs); — vertical speed indicator including TCAS RA command indications; — radio altitude; — ILS localiser/glideslope or horizontal/vertical flight path deviation indicator; — decision altitude/height (DA/H).	X	X	X	X	X	X	X	Incorporates 062 05 05 02 (02)
022 13 03 03		***Navigation d~~D~~isplay (ND), e~~E~~lectronic h~~H~~orizontal s~~S~~ituation i~~I~~ndicator (EHSI)***								
(01)		~~State~~ Describe that an ND (or an EHSI) provides a mode-selectable colour flight ND~~navigation display~~.	X	X	X	X	X	X	X	Reworded

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(02)		List ~~and describe~~ the following four modes typically available to be displayed on an ND unit: — MAP (or ARC), — VOR (or ROSE VOR), — APP (or ROSE LS), — PLAN.	X	X	X	X	X	X		Reworded Incorporates 062 05 05 03 (01)
~~LO (03)~~		~~List and explain the following information that can be displayed with the MAP (or ARC) mode on an ND unit:~~ — ~~selected and current track;~~ — ~~selected and current heading (magnetic or true north reference);~~ — ~~cross-track error;~~ — ~~origin and destination airport with runway selected;~~ — ~~bearings to or from the tuned and selected stations;~~ — ~~active and/or secondary flight plan;~~ — ~~range marks;~~ — ~~ground speed;~~ — ~~TAS and ground speed;~~ — ~~wind direction and speed;~~ — ~~next waypoint distance and estimated time of arrival;~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		Reworded in the next LO

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		— ~~additional navigation facilities (STA), waypoint (WPT) and airports (ARPT);~~ — ~~weather radar information;~~ — ~~traffic information from the ACAS (TCAS);~~ — ~~terrain information from the TAWS or HTAWS (EGPWS);~~ — ~~failure flags and messages.~~								
(03)		List and explain the following information that can be displayed with the MAP (or ARC) mode selected on an ND unit: — aircraft symbol, compass scale and range markers; — current heading and track (either one may be 'up' depending on selection), true or magnetic; — selected heading and track; — TAS/GS; — wind direction and speed (W/V); — raw data radio magnetic indicator (RMI) needles/pointers for VOR/automatic direction-finding equipment (ADF) if selected including the frequency and/or ident of the selected navigation facility;	X	X	X	X	X	X		Reworded (from above) Incorporates 062 05 05 04 01 & 062 05 05 04 02 & 062 05 05 04 03 & 062 05 05 04 04 & 062 05 05 04 05

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— route/flight plan data from the FMS; — TO/next waypoint data from the FMS; — data from the navigation database such as airports, waypoints or navigation facilities as selected; — weather radar information; — TCAS traffic information (no TCAS commands); — TAWS (EGPWS) terrain information; — f~~F~~ailure flags and messages.								
~~LO (04)~~		~~List and explain the following information that can be displayed with the VOR/APP (or ROSE VOR/ROSE LS) mode on an ND unit:~~ — ~~selected and current track;~~ — ~~selected and current heading (magnetic or true north reference)~~ — ~~VOR course or ILS localizer course~~ — ~~VOR (VOR or ROSE VOR mode) or LOC course deviation (APP or ROSE LS);~~ — ~~glide slope pointer (APP or ROSE LS);~~ — ~~frequency or identifier of the tuned station;~~ — ~~ground speed;~~ — ~~TAS and ground speed;~~	X	X	X	X	X	X		Reworded (see below)

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— ~~wind direction and speed;~~ — ~~failure flags and messages.~~								
(04)		List and explain the following information that can be displayed with the VOR or APP (or ROSE VOR or ROSE LS) mode selected on an ND unit: — aircraft symbol and compass scale; — current heading and track (either one may be 'up' depending on selection), true or magnetic; — selected heading and track; — TAS/ground speed (GS); — wind direction and speed (W/V); — VOR or ILS frequency and identification of the selected navigation aid; — VOR selected course, deviation indicator and a TO/FROM indicator in a HSI type display format when in VOR mode; — localiser selected course, deviation indicator and glideslope indicator in a HSI type display format when in APP mode. — weather radar information; — TCAS traffic information (no TCAS commands);	X	X	X	X	X	X		Reworded (from above) Incorporates 062 05 05 04 01 & 062 05 05 04 02 & 062 05 05 04 03 & 062 05 05 04 04 & 062 05 05 04 05

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		— TAWS (EGPWS) terrain information; — failure flags and messages.								
~~LO (05)~~		~~List and explain the following information that can be displayed with the PLAN mode on an ND unit:~~ — ~~selected and current track;~~ — ~~origin and destination airport with runway selected;~~ — ~~active and/or secondary flight plan;~~ — ~~range marks;~~ — ~~ground speed;~~ — ~~TAS and ground speed;~~ — ~~wind direction and speed;~~ — ~~next-waypoint distance and estimated time of arrival;~~ — ~~additional navigation facilities (STA), waypoint (WPT) and airports (ARPT);~~ — ~~failure flags and messages.~~	~~X~~	~~X~~						Reworded (see below)
(06)		List and explain the following information that can be displayed with the PLAN mode selected on an ND unit: — north-up compass rose and range markers; — aircraft symbol oriented according to aircraft heading;	X	X	X	X	X	X		Reworded (from above) Incorporates 062 05 05 04 06

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— TAS/GS; — wind direction and speed (W/V); — route/flight plan data from the FMS; — TO/next waypoint data from the FMS; — data from the navigation database such as airports, waypoints or navigation facilities as selected; — failure flags and messages.								
~~LO (07)~~		~~Give examples of possible transfers between units.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		Combined with 022 13 03 01 (04)
~~LO (08)~~		~~Give examples of EFIS control panels.~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		Combined with 022 13 03 01 (07)
(09) New		Explain the purpose of PLAN mode and it characteristics such as: — no compass information; — north is up on the display unit at all times; — the centre waypoint is the selected waypoint on the FMS CDU; — scrolling through the flight plan on the CDU will shift the map view along the flight path; — the aircraft symbol will be positioned in the appropriate place along the flight path;	X	X	X	X	X	X		New LO

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		— using PLAN mode as the primary mode during flight may lead to disorientation and loss of situational awareness.								
(10) New		Distinguish the difference between the appearance of an EXPANDED or FULL/ROSE mode and how the displayed range differs between them.	X	X	X	X	X	X		New LO
(11) New		Explain the combination of mode and range selection including how selecting the appropriate range and displayed data can improve situational awareness for a phase of flight.	X	X	X	X	X	X		New LO
022 13 04 00		**Engine parameters, crew warnings, aircraft systems, procedure and mission display systems**								
(01)		State the purpose of the following systems: — engine instruments centralised display unit; — crew alerting system ~~associated with an~~ and electronic checklist display unit; — that the aircraft systems display unit enables the display of normal and degraded modes of operation of the aircraft systems~~.~~; — that the aircraft systems display unit is able to show pictorial systems diagrams/schematics and associated parameters.	X		X	X				Reworded

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(02)		~~Describe the architecture of each system and give examples of display.~~ Describe the similarities to EFIS with regard to basic system architecture.	X		X	X				Reworded
(03)		Give the following different names by which engine parameters, crew warnings, aircraft systems and procedures display systems are known: — m~~M~~ultifunction d~~D~~isplay u~~U~~nit (MFDU); — e~~E~~ngine i~~I~~ndication and c~~C~~rew a~~A~~lerting s~~S~~ystems (EICASs); — e~~E~~ngine and w~~W~~arning d~~D~~isplay (EWD); — e~~E~~lectronic c~~C~~entralised a~~A~~ircraft m~~M~~onitor (ECAM)~~.~~; — systems display (S/D).	X							Rearranged and reworded
(04)		Give the names of the following different display systems and describe their main functions: — v~~V~~ehicle e~~E~~ngine m~~M~~onitoring d~~D~~isplay (VEMD); — i~~I~~ntegrated i~~I~~nstruments d~~D~~isplay s~~S~~ystem (IIDS).			X	X				
(05)		State the purpose of a mission display unit.			X	X				
(06)		Describe the architecture of each system and give examples of display.			X	X				

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(07) New		Explain why awareness of the consequences of the actions commanded by the automatic checklist is required. Explain the limited ability of the computer to assess a situation other than using the exceedance of certain thresholds to trigger the main and subsequent events and programmed actions.	X		X	X				New LO
(08) New		Describe an appropriate procedure for following an on-screen checklist associated with a failure scenario including the following: — confirming the failure with the other crew member prior to performing any of the actions; — seeking confirmation prior to manipulating any guarded switches or thrust levers; — follow the checklist slowly and methodically; — assess the possible implications of making certain selections such as opening the fuel cross-feed if there is a fuel leak even though the electronic checklist may ask for the action.	X		X	X				New LO
022 13 05 00		**Engine first limit indicator**								
(01)		Describe the principles of design and operation, and compare the different indications and displays available.			X	X	X			

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(02)		Describe what information can be displayed on the screen, when in the limited screen composite mode.			X	X	X			
022 13 06 00		**Electronic f~~F~~light b~~B~~ag (EFB)** ~~(to be introduced at a later date)~~								Reworded
(01) New		Explain the purpose of the EFB and list typical equipment: — computer laptop; — tablet device; — integrated avionics suite in the aircraft.	X	X	X	X	X	X		New LO
(02) New		Describe the 'class' hardware certification: — portable: portable electronic device (PED) that can be used inside or outside the aircraft that is not part of the certified aircraft configuration and does not require tools to remove from the flight-deck cradle, if one exists; — installed: an electronic device that is considered an aircraft part covered by the aircraft airworthiness approval, thus is a minimum equipment list (MEL) item in the event of failure.	X		X	X				New LO
(03) New		Describe the 'type' software certification: — type A: applications where misuse or malfunctions	X		X	X				New LO

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		have no adverse effect on flight safety; — type B: applications where evaluation of the hazards presented by misuse or malfunctions is required.								
(04) New		Explain implications of malfunctions with the EFB installation in a fully electronic flight-deck environment: — mass and balance calculations; — performance calculations; — access to charts; — access to manuals.	X		X	X				New LO
022 14 00 00		**MAINTENANCE, MONITORING AND RECORDING SYSTEMS**								
~~LO (01)~~		~~State the basic technologies used for this equipment and its performances.~~ ~~*Remark: No knowledge of the applicable operational requirements is necessary.*~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~	~~X~~		No practical use
022 14 01 00		**Cockpit v~~V~~oice r~~R~~ecorder (CVR)**								
(01)		~~State~~ Describe the purpose of a CVR, its typical location, and explain the implications of knowingly erasing or tampering with any information or equipment.	X	X						Reworded
(02)		List the main components of a CVR:	X	X						Reworded

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— a shock-resistant tape recorder or digital storage associated with an underwater locating ~~device~~ beacon (ULB); — an area microphone; — a control unit with the following controls: auto/on, test and erase, and a headset jack~~.~~; — limited flight-deck controls such as erase and test switches.								
(03)		List the following main parameters recorded on the CVR: — voice communications transmitted from or received on the flight deck; — the aural environment of the flight deck; — voice communication of flight crew members using the aeroplane's interphone system; — voice or audio signals introduced into a headset or speaker; — voice communication of flight crew members using the interphone and/or public address system, when installed.	X	X						Reworded
022 14 02 00		**Flight d~~D~~ata r~~R~~ecorders (FDRs)**								
(01)		~~State~~ Describe the purpose of an FDR and its typical	X	X						Reworded

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		location.								
(02)		List the main components of an FDR: — a shock-resistant data recorder associated with a ULB; — a data interface and acquisition unit; — a recording system (digital flight data recorder); — two control units (start sequence, event mark setting); — limited flight-deck controls but includes an event switch.	X	X						Reworded
(03)		List the following main parameters recorded on the FDR: — time or relative time count; — attitude (pitch and roll); — airspeed; — pressure altitude; — heading; — normal acceleration; — propulsive/thrust power on each engine and ~~cockpit~~ flight deck thrust/power lever position, if applicable; — flaps/slats configuration or cockpit selection;	X	X						

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— ground spoilers and/or speed brake selection.								
(04)		State that additional parameters can be recorded according to FDR capacity and the applicable operational requirements.	X							
022 14 03 00		**Maintenance and monitoring systems**								
022 14 03 01		***Helicopter oOperations mMonitoring pProgramme (HOMP): design, operation, performance***								
(01)		Describe the HOMP as a helicopter version of the aeroplane fFlight dData mMonitoring (FDM) programmes.			X	X				
(02)		State that the HOMP software consists of three integrated modules: — fFlight dData eEvents (FDEs); — fFlight dData mMeasurements (FDMs); — fFlight dData tTraces (FDTs).			X	X				
(03)		Describe and explain the information flow of HOMP.			X	X				
(04)		Describe HOMP operation and management processes.			X	X				
022 14 03 02		***Integrated hHealth & uUsage mMonitoring sSystem (IHUMS): design, operation, performance***								
(01)		Describe the main features of IHUMS:			X	X				

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— rotor system health; — cockpit voice recorder (CVR)/flight data recorder (FDR); — gearbox system health; — engine health; — exceedance monitoring; — usage monitoring; — transparent operation; — ground station features; — ~~exceedance monitoring;~~ — monitoring; — ~~gearbox health;~~ — rotor track and~~&~~ balance; — engine performance trending; — ~~usage monitoring;~~ — quality controlled to level 2.								
(02)		Describe the ground station features of IHUMS.			X	X				
(03)		Summarise the benefits of IHUMS including: — reduced risk of catastrophic failure of rotor or gearbox;			X	X				

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			ATPL	CPL	ATPL /IR	ATPL	CPL			
		— improved rotor track and~~&~~ balance giving lower vibration levels; — accurate recording of flight exceedances; — ~~cockpit voice recorder~~ CVR/FDR ~~flight data recorder~~ allows accurate accident /incident investigation and~~&~~ HOMP; — maintenance cost savings.								
(04)		State the benefits of IHUMS and HOMP.			X	X				
022 14 03 03		***Aeroplane c~~C~~ondition m~~M~~onitoring s~~S~~ystem (ACMS): general, design, operation***								
(01)		State the purpose of an ACMS.	X							
(02)		Describe the structure of an ACMS including: — inputs: aircraft systems (such as air conditioning, autoflight, flight controls, fuel, landing gear, navigation, pneumatic, APU, engine), MCDU; — data management unit; — recording unit: digital recorder; — outputs: printer, ACARS or ATSU.	X							
(03)		State that maintenance messages sent by an ACMS can be transmitted without crew notification.	X							

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(04) New		Explain that data from the ACMS can be used as part of an FDM and safety programme.	X							New LO
(05) New		Explain that the FDM programme is collecting data anonymously; however, grave exceedance of parameters may warrant a further investigation of the event by the operator.	X							New LO
(06) New		Explain the purpose of FDM as a system for identifying adverse safety trends and tailoring training programmes in order to enhance the overall safety of the operation.	X							New LO
022 15 00 00		**DIGITAL CIRCUITS AND COMPUTERS**								
022 15 01 00		**Digital circuits and computers: g~~G~~eneral, definitions and design**								
(01)		Define a 'computer' as a machine for manipulating data according to a list of instructions.	X		X	X		X	X	
~~LO (02)~~		~~List the following main components of a stored programme ('Von Neumann architecture') on a basic computer:~~ — ~~Central Processing Unit (CPU) including the Arithmetic Logic Unit (ALU) and the control unit;~~ — ~~memory;~~ — ~~input and output devices (peripherals);~~	~~X~~		~~X~~	~~X~~				No practical use

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		~~and state their functions.~~								
(03)		~~State the existence of the different buses and their function.~~ Explain the term 'bus' being used as a term for a facility (wiring, optical fibre, etc.) transferring data between different parts of a computer, both internal and external.	X		X	X		X	X	Reworded
(04)		Define the terms 'hardware' and 'software'.	X		X	X		X	X	
(05)	X	Define and explain the terms 'multitasking' and 'multiprocessing'.	X		X	X		X	X	
(06)	X	With the help of the relevant 022 references, give examples of airborne computers, such as ADC, FMS, GPWS, etc., and list the possible peripheral equipment for each system.	X		X	X		X	X	
~~LO (07)~~		~~Describe the principle of the following technologies used for memories:~~ — ~~chip circuit,~~ — ~~magnetic disk,~~ — ~~optical disk.~~	~~X~~		~~X~~	~~X~~				No practical use
(08)		Explain the difference in practical use between the following types of memor~~y~~ies: — volatile memory, requiring electrical power to retain	X		X	X		X	X	

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		the information, — non-volatile memory, not requiring electrical power to retain the information~~;~~.								
~~**022 15 02 00**~~		~~**Software: General, definitions and certification specifications**~~								No practical use
~~LO (01)~~		~~State the difference between assembly languages, high-level languages and scripting languages.~~	~~X~~		~~X~~	~~X~~				
~~LO (02)~~		~~Define the term 'Operating System' (OS) and give different examples including airborne systems such as FMS or ATSU (for aeroplanes only).~~	~~X~~		~~X~~	~~X~~				
~~LO (03)~~		~~State the existence of 'Software Considerations in Airborne Systems and Equipment Certification' (see document referenced RTCA/DO-178B or EUROCAE ED-12B).~~	~~X~~		~~X~~	~~X~~				
~~LO (04)~~		~~List the specific levels of safety criticality according to the EUROCAE ED-12B document.~~	~~X~~		~~X~~	~~X~~				

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