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

| **Syllabus reference** | **Syllabus details and associated Learning Objectives** | *Aeroplane* | | *Helicopter* | | | *IR* |
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| | | 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** | | | | | | |
| LO | Describe the following structural design philosophy:<br>— safe life;<br>— fail-safe (multiple load paths);<br>— damage-tolerant. | x | x | x | x | x | |
| LO | Describe the following system design philosophy:<br>— redundancy. | x | x | x | x | x | |
| **021 01 01 02** | **Level of certification** | | | | | | |
| LO | Explain and state the safety objectives associated with failure conditions (AMC 25.1309, Fig. 2). | x | | | | | |
| LO | Explain the relationship between the probability of a failure and the severity of the failure effects. | x | | x | x | | |
| LO | Explain why some systems are duplicated or triplicated. | x | | x | x | | |

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| **021 01 02 00** | **Loads and stresses** | | | | | | |
| LO | Explain the following terms:<br>— stress,<br>— strain,<br>— tension,<br>— compression,<br>— buckling,<br>— bending,<br>— torsion,<br>— static loads,<br>— dynamic loads,<br>— cyclic loads,<br>— elastic and plastic deformation. | x | x | x | x | x | |
| | *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.* | | | | | | |
| LO | Describe the relationship between stress and strain for a metal. | x | x | x | x | x | |
| **021 01 03 00** | **Fatigue** | | | | | | |
| LO | Describe the phenomenon of fatigue. | x | x | x | x | x | |
| LO | 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 | |
| LO | Explain the implication of stress-concentration factor. | x | x | x | x | x | |
| **021 01 04 00** | **Corrosion** | | | | | | |
| LO | Describe the following types of corrosion:<br>— oxidation,<br>— electrolytic. | x | x | x | x | x | |
| LO | Describe the interaction between fatigue and corrosion (stress corrosion). | x | x | x | x | x | |
| **021 01 05 00** | **Maintenance** | | | | | | |
| **021 01 05 01** | **Maintenance methods: hard time and on condition** | | | | | | |

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| LO | Explain the following terms:<br>— hard-time maintenance;<br>— on-condition maintenance. | x | x | x | x | x | |
| **021 02 00 00** | **AIRFRAME** | | | | | | |
| **021 02 01 00** | **Construction and attachment methods** | | | | | | |
| LO | Describe the principles of the following construction methods:<br>— monocoque;<br>— semi-monocoque;<br>— cantilever;<br>— sandwich, including honey comb;<br>— truss. | x | x | x | x | x | |
| LO | Describe the following attachment methods:<br>— riveting,<br>— welding,<br>— bolting,<br>— pinning,<br>— adhesives (bonding). | x | x | x | x | x | |
| LO | State that sandwich structural parts need additional provisions to carry concentrated loads. | x | x | x | x | x | |
| **021 02 02 00** | **Materials** | | | | | | |
| LO | Explain the following material properties:<br>— elasticity,<br>— plasticity,<br>— stiffness,<br>— strength,<br>— strength-to-density ratio. | x | x | x | x | x | |
| LO | Compare the above properties as they apply to aluminium alloys, magnesium alloys, titanium alloys, steel and composites. | x | x | x | x | x | |
| LO | Explain the need to use alloys rather than pure metals. | x | x | x | x | x | |
| LO | Explain the principle of a composite material. | x | x | x | x | x | |
| LO | Describe the function of the following components:<br>— matrix, resin or filler;<br>— fibres. | x | x | x | x | x | |

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| LO | State the advantages and disadvantages of composite materials compared with metal alloys by considering the following:<br>— strength-to-weight ratio;<br>— capability to tailor the strength to the direction of the load;<br>— stiffness;<br>— electrical conductivity (lightning);<br>— resistance to fatigue;<br>— resistance to corrosion and cost. | x | x | x | x | x | |
| LO | State that the following are composite-fibre materials:<br>— carbon,<br>— glass,<br>— aramid (Kevlar). | x | x | x | x | x | |
| **021 02 03 00** | **Aeroplane: wings, tail surfaces and control surfaces** | | | | | | |
| **021 02 03 01** | **Design and construction** | | | | | | |
| LO | Describe the following types of construction:<br>— cantilever,<br>— non-cantilever (braced). | x | x | | | | |
| **021 02 03 02** | **Structural components** | | | | | | |
| LO | Describe the function of the following structural components:<br>— spar and its components (web and girder or cap),<br>— rib,<br>— stringer,<br>— skin,<br>— torsion box. | x | x | | | | |
| **021 02 03 03** | **Loads, stresses and aeroelastic vibrations ('flutter')** | | | | | | |
| LO | Describe the vertical and horizontal loads on the ground. | x | x | | | | |
| LO | Describe the loads in flight for symmetrical and asymmetrical conditions, considering both vertical and horizontal loads and loads due to engine failure. | x | x | | | | |
| LO | Describe the principle of flutter, flutter damping and resonance for the wing and control surfaces. | x | x | | | | |

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| LO | Explain the significance on stress relief and flutter of the following:<br>— chord-wise and span-wise position of masses (e.g. engines, fuel and balance masses, control balance masses);<br>— torsional stiffness;<br>— bending flexibility. | x | x | | | | |
| LO | Describe the following design configurations:<br>— conventional (low or mid set) tailplane;<br>— T-tail. | x | x | | | | |
| **021 02 04 00** | **Fuselage, landing gear, doors, floor, windscreen and windows** | | | | | | |
| LO | Describe the following types of fuselage construction:<br>— monocoque,<br>— semi-monocoque. | x | x | x | x | x | |
| LO | Describe the construction and the function of the following structural components of a fuselage:<br>— frames;<br>— bulkhead;<br>— stiffeners, stringers, longerons;<br>— skin, doublers;<br>— floor suspension (crossbeams);<br>— floor panels;<br>— firewall. | x | x | x | x | x | |
| LO | Describe the loads on the fuselage due to pressurisation. | x | x | | | | |
| LO | Describe the following loads on a main landing gear:<br>— touch-down loads (vertical and horizontal)<br>— taxi loads on bogie gear (turns). | x | x | | | | |
| LO | Describe the structural danger of a nose-wheel landing with respect to:<br>— fuselage loads;<br>— nose-wheel strut loads. | x | x | | | | |
| LO | Describe the structural danger of a tail strike with respect to:<br>— fuselage and aft bulkhead damage (pressurisation). | x | x | | | | |

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| LO | Describe the door and hatch construction for pressurised and unpressurised aeroplanes including:<br>— door and frame (plug type);<br>— hinge location;<br>— locking mechanism. | x | x | | | | |
| LO | Explain the advantages and disadvantages of the following fuselage cross sections:<br>— circular;<br>— double bubble (two types);<br>— oval;<br>— rectangular. | x | x | | | | |
| LO | State that flight-deck windows are constructed with different layers. | x | x | | | | |
| LO | Explain the function of window heating for structural purposes. | x | x | | | | |
| LO | Explain the implication of a direct-vision window (see CS 25.773(b)(3)). | x | x | | | | |
| LO | State the need for an eye-reference position. | x | x | | | | |
| LO | Explain the function of floor venting (blow-out panels). | x | x | | | | |
| LO | 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** | | | | | | |
| LO | List the functions of flight controls. | | | x | x | x | |
| LO | Describe and explain the different flight control design concepts for conventional, tandem, coaxial, side by side, NOTAR and Fenestron-equipped helicopters. | | | x | x | x | |
| LO | Explain the advantages, disadvantages and limitations of the respective designs above. | | | x | x | x | |
| LO | Explain the function of the synchronised elevator. | | | x | x | x | |
| LO | Describe the construction methods and alignment of vertical and horizontal stabilisers. | | | x | x | x | |

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| **021 02 05 02** | **Structural components and materials** | | | | | | |
| LO | Name the main components of flight and control surfaces. | | | x | x | x | |
| LO | Describe the fatigue life and methods of checking for serviceability of flight and control surface components and materials. | | | x | x | x | |
| **021 02 05 03** | **Loads, stresses and aeroelastic vibrations** | | | | | | |
| LO | Describe and explain where the main stresses are applied to components. | | | x | x | x | |
| LO | Describe the dangers and stresses regarding safety and serviceability in flight when the manufacturer's design envelope is exceeded. | | | x | x | x | |
| LO | Explain the procedure for:<br>— static chord-wise balancing;<br>— static span-wise balancing;<br>— blade alignment;<br>— dynamic chord-wise balancing;<br>— dynamic span-wise balancing. | | | x | x | x | |
| LO | Explain the process of blade tracking including:<br>— the pre-track method of blade tracking;<br>— the use of delta incidence numbers;<br>— aircraft configuration whilst carrying out tracking;<br>— factors affecting blade-flying profile;<br>— ground tracking and in-flight trend analysis;<br>— use of pitch-link and blade-trim tab adjustments;<br>— tracking techniques, including stroboscopic and electronic. | | | x | x | x | |
| LO | 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 | |

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| LO | Explain how a vibration harmonic can be set up in other components which can lead to their early failure. | | | x | x | x | |
| LO | Describe the three planes of vibration measurement, i.e. vertical, lateral, fore and aft. | | | x | x | x | |
| **021 02 06 00** | **Structural limitations** | | | | | | |
| LO | Define and explain the following maximum structural masses:<br>— maximum ramp mass;<br>— maximum take-off mass;<br>— maximum zero-fuel mass;<br>— maximum landing mass.<br>*Remark: These limitations may also be found in the relevant part of subjects 031, 032 and 034.* | x | x | | | | |
| LO | Explain that airframe life is limited by fatigue, created by alternating stress and the number of load cycles. | x | x | | | | |
| LO | Explain the maximum structural masses:<br>— maximum take-off mass. | | | x | x | x | |
| LO | 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** | | | | | | |
| LO | Explain the concept and basic principles of hydromechanics including:<br>— hydrostatic pressure;<br>— Pascal's law;<br>— the relationship between pressure, force and area;<br>— 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** | | | | | | |

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| LO | List and explain the desirable properties of a hydraulic fluid:<br>— thermal stability;<br>— corrosiveness;<br>— flashpoint and flammability;<br>— volatility;<br>— viscosity. | x | x | x | x | x | |
| LO | State that hydraulic fluids are irritating for skin and eyes. | x | x | x | x | x | |
| LO | List the two different types of hydraulic fluids:<br>— synthetic,<br>— mineral. | x | x | x | x | x | |
| LO | State that different types of hydraulic fluids cannot be mixed. | x | x | x | x | x | |
| LO | State that at the pressures being considered, hydraulic fluid is considered incompressible. | x | x | x | x | x | |
| **021 03 02 02** | **System components: design, operation, degraded modes of operation, indications and warnings** | | | | | | |
| LO | Explain the working principle of a hydraulic system. | x | x | x | x | x | |
| LO | 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 | |
| LO | 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 | |
| LO | List the main advantages and disadvantages of system actuation by hydraulic or purely mechanical means with respect to:<br>— weight,<br>— size,<br>— force. | x | x | x | x | x | |
| LO | List the main users of hydraulic systems. | x | x | x | x | x | |

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| LO | 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 | |
| LO | State that the normal hydraulic pressure of most large transport aircraft is 3 000 psi. | x | x | x | x | x | |
| LO | Explain the working principle of a low-pressure (0–2000 psi) open centred system using an off loading valve and an RPM dependent pump. | x | x | x | x | x | |
| LO | Explain the advantages and disadvantages of a high pressure system over a low - pressure system. | x | x | x | x | x | |
| LO | Describe the working principle and functions of pressure pumps including:<br>— constant pressure pump (swash plate or cam plate);<br>— pressure pump whose output is dependent on pump RPM (gear type). | x | x | x | x | x | |
| LO | State that for an aeroplane, the power sources of a hydraulic pressure pump can be:<br>— manual;<br>— engine gearbox;<br>— electrical;<br>— air (pneumatic and ram-air turbine);<br>— hydraulic (power transfer unit) or reversible motor pumps. | x | x | | | | |
| LO | State that for a helicopter, the power sources of a hydraulic pressure pump can be:<br>— manual,<br>— engine,<br>— gearbox,<br>— electrical. | | | x | x | x | |

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| LO | Describe the working principle and functions of the following hydraulic-system components:<br>— reservoir (pressurised and unpressurised);<br>— accumulators;<br>— case drain lines and fluid cooler return lines;<br>— piston actuators (single and double acting);<br>— hydraulic motors;<br>— filters;<br>— non-return (check) valves;<br>— relief valves;<br>— restrictor valves;<br>— elector valves (linear and basic rotary selectors, two and four ports);<br>— bypass valves;<br>— shuttle valves;<br>— fire shut-off valves;<br>— priority valves;<br>— fuse valves;<br>— pressure and return pipes. | x | x | x | x | x | |
| LO | Explain why many transport aeroplanes have ‘demand’ hydraulic pumps. | x | x | | | | |
| LO | Explain how redundancy is obtained by giving examples. | x | x | x | x | x | |
| LO | Interpret the hydraulic system schematic appended to these LOs (to be introduced at a later date). | x | x | x | x | x | |
| LO | Explain the implication of a high system demand. | x | x | x | x | x | |
| LO | Explain the implication of a system internal leakage including hydraulic lock of piston actuators. | x | x | x | x | x | |
| LO | List and describe the instruments and alerts for monitoring a hydraulic system. | x | x | x | x | x | |
| LO | State the indications and explain the implications of the following malfunctions:<br>— system leak or low level;<br>— low pressure;<br>— high temperature. | x | x | x | x | x | |

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| **021 04 00 00** | **LANDING GEAR, WHEELS, TYRES, BRAKES** | | | | | | |
| **021 04 01 00** | **Landing gear** | | | | | | |
| **021 04 01 01** | **Types** | | | | | | |
| LO | Name, for an aeroplane, the following different landing-gear configurations:<br>— nose wheel,<br>— tail wheel. | x | x | | | | |
| LO | Name, for a helicopter, the following different landing-gear configurations:<br>— nose wheel,<br>— tail wheel,<br>— skids. | | | x | x | x | |
| **021 04 01 02** | **System components, design, operation, indications and warnings, on-ground/in-flight protections, emergency extension systems** | | | | | | |
| LO | Explain the function of the following components of a landing gear:<br>— oleo leg/shock strut;<br>— axles;<br>— bogies and bogie beam;<br>— drag struts;<br>— side stays/struts;<br>— torsion links;<br>— locks (over centre);<br>— gear doors and retraction mechanisms (normal and emergency operation). | x | x | | | | |
| LO | Explain the function of the following components of a landing gear:<br>— oleo leg/shock strut;<br>— axles;<br>— drag struts;<br>— side stays/struts;<br>— torsion links;<br>— locks (over centre);<br>— gear doors and retraction mechanisms (normal and emergency operation). | | | x | x | x | |
| LO | Name the different components of a landing gear, using the diagram appended to these LOs. | x | x | | | | |

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| LO | Describe the sequence of events of the landing gear during normal operation. | x | x | x | x | x | |
| LO | State how landing-gear position indication and alerting is implemented. | x | x | x | x | x | |
| LO | Describe the various protection devices to avoid inadvertent gear retraction on the ground:<br>— ground lock (pins);<br>— protection devices in the gear-retraction mechanism. | x | x | x | x | x | |
| LO | Explain the speed limitations for gear operation (VLO and VLE). | x | x | | | | |
| LO | Describe the sequence for emergency gear extension:<br>— unlocking;<br>— operating;<br>— down-locking. | x | x | x | x | x | |
| | Describe some methods for emergency gear extension including:<br>— gravity/free fall;<br>— air or nitrogen pressure;<br>— manually/mechanically. | x | x | x | x | x | |
| **021 04 02 00** | **Nose-wheel steering: design, operation** | | | | | | |
| LO | Explain the operating principle of nose-wheel steering. | x | x | x | x | x | |
| LO | Explain, for a helicopter, the functioning of differential braking with free-castoring nose wheel. | | | x | x | x | |
| LO | Describe, for an aeroplane, the functioning of the following systems:<br>— differential braking with free-castoring nose wheel;<br>— tiller or hand wheel steering;<br>— rudder pedal nose-wheel steering. | x | x | | | | |
| LO | Explain the centring mechanism of the nose wheel. | x | x | | | | |
| LO | Define the term ‘shimmy’ and the possible consequences for the nose and the main-wheel system. | x | x | x | x | x | |

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| LO | Explain the purpose of main-wheel (body) steering. | x | x | | | | |

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| **021 04 03 00** | **Brakes** | | | | | | |
| **021 04 03 01** | **Types and materials** | | | | | | |
| LO | Describe the basic operating principle of a disk brake. | x | x | x | x | x | |
| LO | State the different materials used in a disc brake (steel, carbon). | x | x | x | x | x | |
| LO | Describe their characteristics, advantages and disadvantages such as:<br>— weight;<br>— temperature limits;<br>— internal-friction coefficient;<br>— wear. | x | x | x | x | x | |
| **021 04 03 02** | **System components, design, operation, indications and warnings** | | | | | | |
| LO | State the limitation of brake energy and describe the operational consequences. | x | x | | | | |
| LO | Explain how brakes are actuated. | x | x | x | x | x | |
| LO | Identify the task of an auto-retract or in-flight brake system. | x | x | | | | |
| LO | State that brakes can be torque-limited. | x | x | | | | |
| LO | Describe the function of a brake accumulator. | x | x | x | x | x | |
| LO | Describe the function of the parking brake. | x | x | x | x | x | |
| LO | Explain the function of wear indicators. | x | x | | | | |
| LO | Explain the reason for the brake-temperature indicator. | x | x | | | | |
| LO | State that the main power source for brakes in normal operation and for alternate operation for large transport aeroplanes is hydraulic. | x | x | | | | |
| **021 04 03 03** | **Anti-skid** | | | | | | |
| LO | Describe the operating principle of an anti-skid system where the brake performance is based on maintaining the optimum wheel-slip value. | x | x | | | | |

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| LO | Explain the purpose of the wheel-speed signal (tachometer) and of the aeroplane reference speed signal to the anti-skid computer, considering:<br>— slip ratio for maximum braking performance;<br>— locked-wheel prevention (protection against deep skid on one wheel);<br>— touchdown protection (protection against brake-pressure application during touchdown);<br>— hydroplane protection. | x | x | | | | |
| LO | Give examples of the impact of an anti-skid system on performance. | x | x | | | | |
| **021 04 03 04** | **Autobrake** | | | | | | |
| LO | Describe the operating principle of an autobrake system. | x | x | | | | |
| LO | State that the anti-skid system must be available when using autobrakes. | x | x | | | | |
| LO | Explain the difference between the three possible levels of operation of an autobrake system:<br>— OFF (system off or reset);<br>— Arm/Disarm (arm: the system is ready to operate under certain conditions);<br>— Operative/Inoperative or Activated/ Deactivated (application of pressure on brakes). | x | x | | | | |
| **021 04 04 00** | **Wheels, rims and tyres** | | | | | | |
| **021 04 04 01** | **Types, structural components and materials, operational limitations, thermal plugs** | | | | | | |
| LO | Describe the different types of tyres such as:<br>— tubeless;<br>— diagonal (cross ply);<br>— radial (circumferential bias). | x | x | x | x | x | |
| LO | Define the following terms:<br>— ply rating;<br>— tyre tread;<br>— tyre creep;<br>— retread (cover). | x | x | x | x | x | |

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| LO | Explain the function of thermal/fusible plugs. | x | x | | | | |
| LO | Explain the implications of tread separation and tyre burst. | x | x | | | | |
| LO | State that the ground speed of tyres is limited. | x | x | | | | |
| LO | Describe material and basic construction of the rim of an aeroplane wheel. | x | x | | | | |
| **021 04 05 00** | **Helicopter equipment** | | | | | | |
| LO | Explain flotation devices and how they are operated. | | | x | x | x | |
| LO | Explain the IAS limitations before, during and after flotation-device deployment. | | | 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.* | | | | | | |
| LO | Define a 'primary flight control'. | x | x | | | | |
| LO | List the following primary flight control surfaces:<br>— elevator;<br>— aileron, roll spoilers;<br>— rudder. | x | x | | | | |
| LO | List the various means of control surface actuation including:<br>— manual;<br>— fully powered (irreversible);<br>— partially powered (reversible). | x | x | | | | |
| **021 05 01 01** | **Manual controls** | | | | | | |
| LO | Explain the basic principle of a fully manual control system. | x | x | | | | |

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| **021 05 01 02** | **Fully powered controls (irreversible)** | | | | | | |
| LO | Explain the basic principle of a fully powered control system. | x | | | | | |
| LO | Explain the concept of irreversibility in a flight control system. | x | | | | | |
| LO | Explain the need for a 'feel system' in a fully powered control system. | x | | | | | |
| LO | Explain the operating principle of a stabiliser trim system in a fully powered control system. | x | | | | | |
| LO | Explain the operating principle of rudder and aileron trim in a fully powered control system. | x | | | | | |
| **021 05 01 03** | **Partially powered controls (reversible)** | | | | | | |
| LO | Explain the basic principle of a partially powered control system. | x | x | | | | |
| LO | Explain why a 'feel system' is not necessary in a partially powered control system. | x | x | | | | |
| **021 05 01 04** | **System components, design, operation, indications and warnings, degraded modes of operation, jamming** | | | | | | |
| LO | List and describe the function of the following components of a flight control system:<br>— actuators;<br>— control valves;<br>— cables or electrical wiring;<br>— control surface position sensors. | x | x | | | | |
| LO | Explain how redundancy is obtained in primary flight control systems of large transport aeroplanes. | x | x | | | | |
| LO | Explain the danger of control jamming and the means of retaining sufficient control capability. | x | x | | | | |
| LO | Explain the methods of locking the controls on the ground and describe 'gust or control lock' warnings. | x | x | | | | |

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| LO | 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 operation, indications and warnings** | | | | | | |
| LO | Define a 'secondary flight control'. | x | x | | | | |
| | List the following secondary flight control surfaces:<br>— lift-augmentation devices (flaps and slats);<br>— speed brakes;<br>— flight and ground spoilers;<br>— trimming devices such as trim tabs, trimmable horizontal stabiliser. | x | x | | | | |
| LO | Describe secondary flight control actuation methods and sources of actuating power. | x | x | | | | |
| LO | Explain the function of a mechanical lock when using hydraulic motors driving a screw jack. | x | x | | | | |
| LO | Describe the requirement for limiting speeds for the various secondary flight control surfaces. | x | x | | | | |
| LO | For lift-augmentation devices, explain the load-limiting (relief) protection devices and the functioning of an autoretraction system. | x | x | | | | |
| LO | Explain how a flap/slat asymmetry protection device functions. | x | x | | | | |
| LO | Describe the function of an autoslat system. | x | x | | | | |
| LO | Explain the concept of control surface blow-back (aerodynamic forces overruling hydraulic forces). | x | x | | | | |
| **021 05 03 00** | **Helicopter: flight controls** | | | | | | |
| LO | Explain the methods of locking the controls on the ground. | | | x | x | x | |

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| LO | Describe main-rotor droop stops and how static rotor flapping is restricted. | | | x | x | x | |
| LO | Describe the need for linear and rotary control input/output. | | | x | x | x | |
| LO | Explain the principle of phase lag and advance angle. | | | x | x | x | |
| LO | Describe the following four axes of control operation, their operating principle and their associated cockpit controls:<br>— collective control;<br>— cyclic fore and aft (pitch axis);<br>— cyclic lateral (roll axis);<br>— yaw. | | | x | x | x | |
| LO | Describe the swash plate or azimuth star control system including the following:<br>— swash plate inputs;<br>— the function of the non-rotating swash plate;<br>— the function of the rotating swash plate;<br>— how swash plate tilt is achieved;<br>— swash plate pitch axis;<br>— swash plate roll axis;<br>— balancing of pitch/roll/collective inputs to the swash plate to equalise torsional loads on the blades. | | | x | x | x | |
| LO | Describe the main-rotor spider control system including the following:<br>— the collective beam;<br>— pitch/roll/collective inputs to the collective beam;<br>— spider drive. | | | x | x | x | |
| LO | Describe the need for control system interlinks, in particular:<br>— collective/yaw;<br>— collective/throttle;<br>— cyclic/stabilator;<br>— interaction between cyclic controls and horizontal/stabilator. | | | x | x | x | |
| LO | State the need for ‘feel systems’ in the hydraulic actuated flight control system. | | | x | x | x | |
| LO | Describe the purpose of a trim system. | | | x | x | x | |

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| LO | 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 | |
| LO | List and describe the different types of trim systems. | | | x | x | x | |
| LO | Explain the basic components of a trim system, in particular:<br>— force-trim switch;<br>— force gradient;<br>— parallel trim actuator;<br>— cyclic 4-way trim switch;<br>— interaction of trim system with an SAS/SCAS/ASS stability system;<br>— trim-motor indicators. | | | x | x | x | |
| LO | Describe the different types of control runs. | | | x | x | x | |
| LO | Explain the use of control stops. | | | x | x | x | |
| **021 05 04 00** | **Aeroplane: Fly-by-Wire (FBW) control systems** | | | | | | |
| LO | Explain that a FBW flight control system is composed of the following:<br>— pilot's input command (control stick/column);<br>— electrical signalling, including:<br>• pilot input to computer;<br>• computer to flight control surfaces;<br>• feedback from aircraft response to computer;<br>— flight control computers;<br>— actuators;<br>— control surfaces. | x | x | | | | |
| LO | State the advantages and disadvantages of a FBW system in comparison with a conventional flight control system including:<br>— weight;<br>— pilot workload;<br>— flight-envelope protection. | x | x | | | | |
| LO | Explain why a FBW system is always irreversible. | x | x | | | | |
| LO | State the existence of degraded modes of operation. | x | x | | | | |

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| **021 05 05 00** | **Helicopter: Fly-by-Wire (FBW) control systems** | | | | | | |
| LO | 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** | | | | | | |
| LO | State the method of supplying air for the pneumatic systems for piston engine aircraft. | x | x | x | x | x | |
| LO | State that air supply is required for the following systems:<br>— instrumentation,<br>— heating,<br>— de-icing. | x | x | x | x | x | |
| **021 06 01 02** | **Gas turbine engine: bleed air supply** | | | | | | |
| LO | State that the possible bleed air sources for gas turbine engine aircraft are the following:<br>— engine,<br>— APU,<br>— ground supply. | x | x | x | x | x | |
| LO | State that for an aeroplane a bleed air supply can be used for the following systems or components:<br>— anti-icing;<br>— engine air starter;<br>— pressurisation of a hydraulic reservoir;<br>— air-driven hydraulic pumps;<br>— pressurisation and air conditioning. | x | x | | | | |
| LO | State that for a helicopter a bleed air supply can be used for the following systems or components:<br>— anti-icing;<br>— engine air starter;<br>— pressurisation of a hydraulic reservoir. | | | x | x | x | |

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| LO | State that the bleed air supply system can comprise the following:<br>— pneumatic ducts;<br>— isolation valve;<br>— pressure-regulating valve;<br>— engine bleed valve (HP/IP valves);<br>— fan-air pre-cooler;<br>— temperature and pressure sensors. | x | x | x | x | x | |
| LO | Interpret the pneumatic system schematic appended to these LOs (to be introduced at a later date). | x | x | x | x | x | |
| LO | Describe the cockpit indications for bleed air systems. | x | x | x | x | x | |
| LO | State how the bleed air supply system is controlled and monitored. | x | x | x | x | x | |
| LO | List the following air bleed malfunctions:<br>— over-temperature;<br>— over-pressure;<br>— low pressure;<br>— overheat/duct leak. | x | x | x | x | x | |
| **021 06 02 00** | **Helicopter: air-conditioning systems** | | | | | | |
| **021 06 02 01** | **Types, system components, design, operation, degraded modes of operation, indications and warnings** | | | | | | |
| LO | Describe the purpose of an air-conditioning system. | | | x | x | x | |
| LO | Explain how an air-conditioning system is controlled. | | | x | x | x | |
| LO | Describe the vapour cycle air-conditioning system including system components, design, operation, degraded modes of operation and system malfunction indications. | | | x | x | x | |

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| LO | Identify the following components from a diagram of an air-conditioning system and describe the operating principle and function:<br>— air-cycle machine (pack, bootstrap system);<br>— pack-cooling fan;<br>— water separator;<br>— mixing valves;<br>— flow-control valves;<br>— isolation valves;<br>— recirculation fans;<br>— filters for recirculation;<br>— temperature sensors. | | | x | x | x | |
| LO | List and describe the controls, indications and warnings related to an air-conditioning system. | | | x | x | x | |
| **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** | | | | | | |
| LO | State that a pressurisation and an air-conditioning system of an aeroplane controls:<br>— ventilation,<br>— temperature,<br>— pressure. | x | x | | | | |
| LO | State that in general humidity is not controlled. | x | x | | | | |
| LO | Explain that the following components constitute a pressurisation system:<br>— pneumatic system as the power source;<br>— outflow valve;<br>— outflow valve actuator;<br>— pressure controller;<br>— excessive differential pressure-relief valve;<br>— negative differential pressure-relief valve. | x | x | | | | |

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| LO | Explain that the following components constitute an air-conditioning system and describe their operating principles and function:<br>— air-cycle machine (pack, bootstrap system);<br>— pack-cooling fan;<br>— water separator;<br>— mixing valves;<br>— flow-control valves (outflow valve);<br>— isolation valves;<br>— ram-air valve;<br>— recirculation fans;<br>— filters for recirculated air;<br>— temperature sensors.<br>*Remark: The bootstrap system is the only air-conditioning system considered for Part-FCL aeroplane examinations.* | x | x | | | | |
| LO | Describe the use of hot trim air. | x | x | | | | |
| LO | Define the following terms:<br>— cabin altitude;<br>— cabin vertical speed;<br>— differential pressure;<br>— ground pressurisation. | x | x | | | | |
| LO | Describe the operating principle of a pressurisation system. | x | x | | | | |
| LO | Describe the emergency operation by manual setting of the outflow valve position. | x | x | | | | |
| LO | Describe the working principle of an electronic cabin-pressure controller. | x | x | | | | |
| LO | State how the maximum operating altitude is determined. | x | x | | | | |
| LO | State:<br>— the maximum allowed value of cabin altitude;<br>— a typical value of maximum differential pressure for large transport aeroplanes (8 to 9 psi);<br>— the relation between cabin altitude, the maximum differential pressure and maximum aeroplane operating altitude. | x | x | | | | |

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| LO | Identify the aural warning when cabin altitude exceeds 10 000 ft. | x | x | | | | |
| LO | List the indications of the pressurisation system. | x | x | | | | |
| **021 07 00 00** | **ANTI-ICING AND DE-ICING SYSTEMS** | | | | | | |
| **021 07 01 00** | **Types, design, operation, indications and warnings, operational limitations** | | | | | | |
| LO | Explain the concepts of de-icing and anti-icing. | x | x | x | x | x | |
| LO | Name the components of an aircraft which can be protected from ice accretion. | x | x | x | x | x | |
| LO | State that on some aeroplanes the tail does not have an ice-protection system. | x | x | | | | |
| LO | State the different types of anti-icing/de-icing systems (hot air, electrical, fluid). | x | x | x | x | x | |
| LO | Describe the operating principle of these systems. | x | x | x | x | x | |
| LO | Describe the operating principle of the inflatable boot de-icing system. | x | x | | | | |
| **021 07 02 00** | **Ice-warning systems: types, operation, and indications** | | | | | | |
| LO | Describe the different operating principles of the following ice detectors:<br>— mechanical systems using air pressure;<br>— electromechanical systems using resonance frequencies. | x | x | | | | |
| LO | Describe the principle of operation of ice-warning systems. | x | x | | | | |
| **021 07 03 00** | **Helicopter blade-heating systems** | | | | | | |
| LO | 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** | | | | | | |

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| LO | State the types of fuel used by piston engine (diesel, AVGAS, MOGAS) and their associated limitations. | x | x | x | x | x | |
| LO | 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** | | | | | | |
| LO | State the tasks of the fuel system. | x | x | x | x | x | |
| LO | Name the following main components of a fuel system, and state their location and their function.<br>— lines;<br>— boost pump;<br>— pressure valves;<br>— filter, strainer;<br>— tanks (wing, tip, fuselage);<br>— vent system;<br>— sump;<br>— drain;<br>— fuel-quantity sensor;<br>— temperature sensor. | x | x | x | x | x | |
| LO | Describe a gravity fuel feed system and a pressure feed fuel system. | x | x | x | x | x | |
| LO | Describe the construction of the different types of fuel tanks and state their advantages and disadvantages:<br>— drum tank,<br>— bladder tank,<br>— integral tank. | x | x | x | x | x | |
| LO | Explain the function of cross-feed. | x | x | x | x | x | |
| LO | Define the term ‘unusable fuel’. | x | x | x | x | x | |
| LO | List the following parameters that are monitored for the fuel system:<br>— fuel quantity (low-level warning);<br>— fuel temperature. | x | x | x | x | x | |
| **021 08 02 00** | **Turbine engine** | | | | | | |
| **021 08 02 01** | **Fuel: types, characteristics, limitations** | | | | | | |
| LO | State the types of fuel used by gas turbine engine (JET-A, JET-A1, JET-B). | x | x | x | x | x | |

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| LO | State the main characteristics of these fuels and give typical values regarding their flash points, freezing points and density. | x | x | x | x | x | |
| LO | State the existence of additives for freezing. | x | x | x | x | x | |
| **021 08 02 02** | **Design, operation, system components, indications** | | | | | | |
| LO | State the tasks of the fuel system. | x | x | x | x | x | |
| LO | Name the main components of a fuel system, and state their location and their function:<br>— lines;<br>— centrifugal boost pump;<br>— pressure valves;<br>— fuel shut-off valve;<br>— filter, strainer;<br>— tanks (wing, tip, fuselage, tail);<br>— bafflers;<br>— sump;<br>— vent system;<br>— drain;<br>— fuel-quantity sensor;<br>— temperature sensor;<br>— refuelling/defuelling system;<br>— fuel dump/jettison system. | x | x | x | x | x | |
| LO | Interpret the fuel-system schematic appended to these LOs. | x | x | | | | |
| LO | Explain the limitations in the event of loss of booster pump fuel pressure. | x | x | x | x | x | |
| LO | Describe the construction of the different types of fuel tanks and state their advantages and disadvantages:<br>— drum tank,<br>— bladder tank,<br>— integral tank. | x | x | x | x | x | |
| LO | Explain the function of cross-feed and transfer. | x | x | x | x | x | |
| LO | Define the term ‘unusable fuel’. | x | x | x | x | x | |
| LO | Describe the use and purpose of drip sticks (manual magnetic indicators). | x | x | x | x | x | |
| LO | Explain the considerations for fitting a fuel dump/jettison system. | x | x | x | x | x | |

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| LO | List the following parameters that are monitored for the fuel system:<br>— fuel quantity (low-level warning);<br>— fuel temperature. | x | x | x | x | x | |
| **021 09 00 00** | **ELECTRICS** | | | | | | |
| **021 09 01 00** | **General, definitions, basic applications: circuit breakers, logic circuits.** | | | | | | |
| **021 09 01 01** | **Static electricity** | | | | | | |
| LO | Explain static electricity. | x | x | x | x | x | |
| LO | Describe a static discharger and explain its purpose. | x | x | x | x | x | |
| LO | Explain why an aircraft must first be grounded before refuelling/defuelling. | x | x | x | x | x | |
| LO | Explain the reason for electrical bonding. | x | x | x | x | x | |
| **021 09 01 02** | **Direct current** | | | | | | |
| LO | State that a current can only flow in a closed circuit. | x | x | x | x | x | |
| LO | Explain the basic principles of conductivity and give examples of conductors, semiconductors and insulators. | x | x | x | x | x | |
| LO | State the operating principle of mechanical (toggle, rocker, push and pull), thermo, time and proximity switches. | x | x | x | x | x | |
| LO | Define ‘voltage’, ‘current and resistance’, and state their unit of measurement. | x | x | x | x | x | |
| LO | Explain Ohm’s law in qualitative terms. | x | x | x | x | x | |
| LO | Explain the effect on total resistance when resistors are connected in series or in parallel. | x | x | x | x | x | |
| LO | State that resistances can have a positive or a negative temperature coefficient (PTC/ NTC) and state their use. | x | x | x | x | x | |
| LO | Define ‘electrical work and power’ in qualitative terms and state the unit of measurement. | x | x | x | x | x | |

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| LO | 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 | |
| LO | 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** | | | | | | |
| LO | Explain the term 'alternating current' (AC). | x | x | x | x | x | |
| LO | Define the term 'phase'. | x | x | x | x | x | |
| LO | Explain the principle of single-phase and three-phase AC and state its use in the aircraft. | x | x | x | x | x | |
| LO | Define 'frequency' in qualitative terms and state the unit of measurement. | x | x | x | x | x | |
| LO | Explain the use of a particular frequency in aircraft. | x | x | x | x | x | |
| LO | Define 'phase shift' in qualitative terms. | x | x | x | x | x | |
| **021 09 01 04** | **Resistors, capacitors, inductance coil** | | | | | | |
| LO | Describe the relation between voltage and current of an ohmic resistor in an AC/DC circuit. | x | x | x | x | x | |
| LO | Describe the relation between voltage and current of a capacitor in an AC/DC circuit. | x | x | x | x | x | |
| LO | Describe the relation between voltage and current of a coil in an AC/DC circuit. | x | x | x | x | x | |
| **021 09 01 05** | **Permanent magnets** | | | | | | |
| LO | Explain the term 'magnetic flux'. | x | x | x | x | x | |
| LO | State the pattern and direction of the magnetic flux outside the magnetic poles and inside the magnet. | x | x | x | x | x | |
| **021 09 01 06** | **Electromagnetism** | | | | | | |
| LO | State that an electrical current produces a magnetic field and define the direction of that field. | x | x | x | x | x | |

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| LO | Describe how the strength of the magnetic field changes if supported by a ferromagnetic core. | x | x | x | x | x | |
| LO | Explain the purpose and the working principle of a solenoid. | x | x | x | x | x | |
| LO | Explain the purpose and the working principle of a relay. | x | x | x | x | x | |
| LO | Explain the principle of electromagnetic induction. | x | x | x | x | x | |
| LO | List the parameters affecting the inductance of a coil. | x | x | x | x | x | |
| LO | List the parameters affecting the induced voltage in a coil. | x | x | x | x | x | |
| **021 09 01 07** | **Circuit breakers** | | | | | | |
| LO | Explain the operating principle of a fuse and a circuit breaker. | x | x | x | x | x | |
| LO | Explain how a fuse is rated. | x | x | x | x | x | |
| LO | State the difference between a 'trip-free' and 'non-trip-free' circuit breaker. | x | x | x | x | x | |
| LO | List the following different types of circuit breakers:<br>— thermal circuit breaker;<br>— magnetic circuit breaker. | x | x | x | x | x | |
| **021 09 01 08** | **Semiconductors and logic circuits** | | | | | | |
| LO | State the differences between semiconductor materials and conductors and explain how the conductivity of semiconductors can be altered. | x | x | x | x | x | |
| LO | State the principal function of diodes, such as rectification and voltage limiting. | x | x | x | x | x | |
| LO | State the principal function of transistors, such as switching and amplification. | x | x | x | x | x | |
| LO | Explain the following five basic functions: AND, OR, NOT, NOR and NAND. | x | x | x | x | x | |
| LO | Describe their associated symbols. | x | x | x | x | x | |
| LO | Interpret logic diagrams using a combination of these functions. | x | x | x | x | x | |

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| **021 09 02 00** | **Batteries** | | | | | | |
| **021 09 02 01** | **Types, characteristics and limitations** | | | | | | |
| LO | State the function of an aircraft battery. | | | | | | |
| LO | Name the types of rechargeable batteries used in aircraft. | x | x | x | x | x | |
| LO | Compare lead-acid and nickel-cadmium (Ni-Cd) batteries with respect to weight, voltage, load behaviour, self-discharge, charging characteristics, thermal runaway and storage life. | x | x | x | x | x | |
| LO | Explain the term ‘cell voltage’. | x | x | x | x | x | |
| LO | State that a battery is composed of several cells. | x | x | x | x | x | |
| LO | Explain the difference between battery voltage and charging voltage. | x | x | x | x | x | |
| LO | State the charging voltage that corresponds with different battery voltages. | x | x | x | x | x | |
| LO | Define the term ‘capacity of batteries’ and state the unit of measurement used. | x | x | x | x | x | |
| LO | State the effect of temperature on battery capacity. | x | x | x | x | x | |
| LO | State the relationship between voltage and capacity when batteries are connected in series or in parallel. | x | x | x | x | x | |
| LO | 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 | |
| **021 09 03 00** | **Generation** | | | | | | |

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| | *Remark: For standardisation purposes, the following standard expressions are used:*<br>— *DC generator: produces DC output;*<br>— *DC alternator: produces internal AC, rectified by integrated rectifying unit, the output is DC;*<br>— *AC generator: produces AC output;*<br>— *starter generator: integrated combination of a DC generator with DC output and a starter motor using battery DC;*<br>— *permanent magnet alternator/ generator: produces AC output without field excitation using a permanent magnet.* | x | x | x | x | x | |
| **021 09 03 01** | **DC generation** | | | | | | |
| LO | Describe the working principle of a simple DC alternator and name its main components. | x | x | x | x | x | |
| LO | State in qualitative terms how voltage depends on the number of windings, field strength, RPM and load. | x | x | x | x | x | |
| LO | 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 | |
| LO | Explain the principle of voltage control. | x | x | x | x | x | |
| LO | Explain why reverse current flow from the battery to the generator must be prevented. | x | x | x | x | x | |
| LO | Describe the operating principle of a starter generator and state its purpose. | x | x | x | x | x | |
| **021 09 03 02** | **AC generation** | | | | | | |
| LO | Describe the components of a three-phase AC generator and the operating principle. | x | x | x | x | x | |
| LO | State that the generator field current is used to control voltage. | x | x | x | x | x | |
| LO | State in qualitative terms the relation between frequency, number of pole pairs and RPM of a three-phase generator. | x | x | x | x | x | |

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| LO | Explain the term 'wild-frequency generator'. | x | x | x | x | x | |
| LO | Describe how a three-phase AC generator can be connected to the electrical system. | x | x | x | x | x | |
| LO | Describe the purpose and the working principle of a permanent magnet alternator/generator. | x | x | x | x | x | |
| LO | List the following different power sources that can be used for an aeroplane to drive an AC generator:<br>— engine,<br>— APU,<br>— RAT,<br>— hydraulic. | x | x | | | | |
| LO | List the following different power sources that can be used for a helicopter to drive an AC generator:<br>— engine,<br>— APU,<br>— gearbox. | | | x | x | x | |
| **021 09 03 03** | **Constant Speed Drive (CSD) and Integrated Drive Generator (IDG) systems.** | | | | | | |
| LO | Describe the function and the working principle of a CSD. | x | x | | | | |
| LO | Explain the parameters of a CSD that are monitored. | x | x | | | | |
| LO | Describe the function and the working principle of an IDG. | x | x | | | | |
| LO | 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, static inverters** | | | | | | |
| LO | State the function of a transformer and its operating principle. | x | x | x | x | x | |
| LO | State the function of a Transformer Rectifier Unit (TRU), its operating principle and the voltage output. | x | x | x | x | x | |

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| LO | State the function of static inverters, their operating principle and the voltage output. | x | x | x | x | x | |
| **021 09 04 00** | **Distribution** | | | | | | |
| **021 09 04 01** | **General** | | | | | | |
| LO | Explain the function of a bus (bus bar). | x | x | x | x | x | |
| LO | Describe the function of the following buses:<br>— main bus,<br>— tie bus,<br>— essential bus,<br>— emergency bus,<br>— ground bus,<br>— battery bus,<br>— hot (battery) bus. | x | x | x | x | x | |
| LO | 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 | |
| LO | Explain the function of external power. | x | x | x | x | x | |
| LO | State that a priority sequence exists between the different sources of electrical power on ground and in flight. | x | x | x | x | x | |
| LO | Introduce the term ‘load sharing’. | x | x | x | x | x | |
| LO | Explain that load sharing is always achieved during parallel operations. | x | x | x | x | x | |
| LO | Introduce the term ‘load shedding’. | x | x | x | x | x | |
| LO | Explain that an AC load can be shed in case of generator overload. | x | x | x | x | x | |
| LO | Interpret an electrical-system schematic (appended to these LOs).<br>*Remark: The system described is a split system.* | x | x | x | x | x | |
| **021 09 04 02** | **DC distribution** | | | | | | |
| LO | Describe a simple DC electrical system of a single-engine aircraft. | x | x | x | x | x | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LO | 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 | |
| LO | 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 | |
| LO | Give examples of DC consumers. | x | x | x | x | x | |
| **021 09 04 03** | **AC distribution** | | | | | | |
| LO | Describe the AC electrical system of a transport aircraft for split and parallel operation. | x | x | x | x | x | |
| LO | Describe the distribution consequences of:<br>— APU electrical supply and external power priority switching;<br>— loss of (all) generator(s);<br>— bus failure. | x | x | x | x | x | |
| LO | Give examples of AC consumers. | x | x | x | x | x | |
| LO | Explain the conditions to be met for paralleling AC generators. | x | x | x | x | x | |
| LO | Explain the terms ‘real and reactive loads’. | x | x | x | x | x | |
| LO | State that real/reactive loads are compensated in the case of paralleled AC generators. | x | x | x | x | x | |
| **021 09 04 04** | **Electrical load management and monitoring systems: automatic generators and bus switching during normal and failure operation, indications and warnings** | | | | | | |
| LO | Give examples of system control, monitoring and annunciators. | x | x | x | x | x | |
| LO | Describe, for normal (on ground/in flight) and degraded modes of operation, the following functions of an electrical load management system:<br>— distribution,<br>— monitoring,<br>— protection (overloading, over/under voltage, incorrect frequency). | x | x | x | x | x | |

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|---|---|---|---|---|---|---|---|
| LO | State which parameters are used to monitor an electrical system for parallel and split system operation. | x | x | x | x | x | |
| LO | Describe how batteries are monitored. | x | x | x | x | x | |
| LO | State that Ni-Cd batteries are monitored to avoid damage resulting from excessive temperature increase (thermal runaway). | x | x | x | x | x | |
| LO | 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** | | | | | | |
| LO | State that the purpose of an electric motor is to convert electrical energy into mechanical energy. | x | x | x | x | x | |
| **021 09 05 02** | **Operating principle** | | | | | | |
| LO | 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. | x | x | x | x | x | |
| LO | State that electrical motors can be AC or DC type. | x | x | x | x | x | |
| **021 09 05 03** | **Components** | | | | | | |
| LO | Name the following components of an electric motor and explain their function:<br>— rotor (rotating part of an electric motor);<br>— stator (stationary part of an electric motor). | x | x | x | x | x | |
| **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** | | | | | | |

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|---|---|---|---|---|---|---|---|
| LO | Define the following terms and expressions:<br>— RPM;<br>— torque;<br>— Manifold Absolute Pressure (MAP);<br>— power output;<br>— specific fuel consumption;<br>— mechanical efficiency, thermal efficiency, volumetric efficiency;<br>— compression ratio, clearance volume, swept (displaced) volume, total volume. | x | x | x | x | x | |
| LO | Describe the influence of compression ratio on thermal efficiency. | x | x | x | x | x | |

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|---|---|---|---|---|---|---|---|
| **021 10 01 02** | **Engine: design, operation, components and materials** | | | | | | |
| LO | Describe the following main engine components and state their function.<br>— crankcase,<br>— crankshaft,<br>— connecting rod,<br>— piston,<br>— piston pin,<br>— piston rings,<br>— cylinder,<br>— cylinder head,<br>— valves,<br>— valve springs,<br>— push rod,<br>— camshaft,<br>— rocker arm,<br>— camshaft gear,<br>— bearings. | x | x | x | x | x | |
| LO | State the materials used for the following engine components:<br>— crankcase,<br>— crankshaft,<br>— connecting rod,<br>— piston,<br>— piston pin,<br>— cylinder,<br>— cylinder head,<br>— valves,<br>— camshaft. | x | x | x | x | x | |
| LO | Name and identify the various types of engine design with regard to cylinder arrangement, such as:<br>— horizontal opposed,<br>— in line,<br>— radial,<br>— and working cycle (four stroke: petrol and diesel). | x | x | x | x | x | |
| LO | 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 | |
| LO | Explain the main differences between the theoretical (Otto cycle) and the practical four-stroke piston-engine cycles. | x | x | x | x | x | |

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|---|---|---|---|---|---|---|---|
| LO | Describe the differences between petrol engines and diesel engines with respect to:<br>— means of ignition;<br>— maximum compression ratio;<br>— air or mixture supply to the cylinder;<br>— specific power output (kW/kg);<br>— thermal efficiency;<br>— pollution from the exhaust. | x | x | x | x | x | |
| **021 10 02 00** | **Fuel** | | | | | | |
| **021 10 02 01** | **Types, grades, characteristics, limitations** | | | | | | |
| LO | Name the type of fuel used for petrol engines including its colour (AVGAS). | x | x | x | x | x | |
| LO | Name the types of fuel used for diesel engines (kerosene or diesel). | x | x | x | x | x | |
| LO | Define the term ‘octane rating’. | x | x | x | x | x | |
| LO | Describe the combustion process in a piston-engine cylinder for both petrol and diesel engines. | x | x | x | x | x | |
| LO | Define the term ‘flame front velocity’ and describe its variations depending on the fuel-air mixture for petrol engines. | x | x | x | x | x | |
| LO | Define the term ‘detonation’ and describe the causes and effects of detonation for both petrol and diesel engines. | x | x | x | x | x | |
| LO | 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 | |
| LO | Identify the conditions and power settings that promote detonation for petrol engines. | x | x | x | x | x | |
| LO | Describe how detonation in petrol engines is recognised. | x | x | x | x | x | |
| LO | Name the anti-detonation petrol fuel additive (tetraethyl lead). | x | x | x | x | x | |
| LO | Describe the method and occasions for checking the fuel for water content. | x | x | x | x | x | |
| LO | State the typical value of fuel density for aviation gasoline and diesel fuel. | x | x | x | x | x | |

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|---|---|---|---|---|---|---|---|
| LO | Explain volatility, viscosity and vapour locking for petrol and diesel fuels. | x | x | x | x | x | |
| **021 10 03 00** | **Engine fuel pumps** | | | | | | |
| LO | Describe the need for a separate engine-driven fuel pump. | x | x | x | x | x | |
| LO | List the different types of engine-driven fuel pumps:<br>— gear type,<br>— vane type. | x | x | x | x | X | |
| **021 10 04 00** | **Carburettor/injection system** | | | | | | |
| **021 10 04 01** | **Carburettor: design, operation, degraded modes of operation, indications and warnings** | | | | | | |
| LO | State the purpose of a carburettor. | x | x | x | x | x | |
| LO | Describe the operating principle of the simple float chamber carburettor. | x | x | x | x | x | |
| LO | Describe the method of achieving reliable idle operation. | x | x | x | x | x | |
| LO | Describe the methods of obtaining mixture control over the whole operating engine power setting range (compensation jet, diffuser). | x | x | x | x | x | |
| LO | Describe the methods of obtaining mixture control over the whole operating altitude range. | x | x | x | x | x | |
| LO | Explain the purpose and the operating principle of an accelerator pump. | x | x | x | x | x | |
| LO | Explain the purpose of power enrichment. | x | x | x | x | x | |
| LO | Describe the function of the carburettor heat system. | x | x | x | x | x | |
| LO | Explain the effect of carburettor heat on mixture ratio and power output. | x | x | x | x | x | |
| LO | Explain the purpose and the operating principle of a primer pump. | x | x | x | x | x | |
| LO | Discuss other methods for priming an engine (acceleration pumps). | x | x | x | x | x | |

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| LO | 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 | 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 | |
| LO | Explain the advantages of an injection system compared with a carburettor system. | x | x | x | x | x | |
| LO | Explain the requirement for two different pumps in the fuel injection system and describe their operation. | x | x | x | x | x | |
| LO | 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 | |
| LO | 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 | |
| LO | Describe the injection system of a diesel engine and explain the function of the following components:<br>— high-pressure fuel injection pump;<br>— common-rail principle;<br>— fuel lines;<br>— fuel injectors. | x | x | x | x | x | |
| **021 10 04 03** | **Icing** | | | | | | |
| LO | Describe the causes and effects of carburettor icing and the action to be taken if carburettor icing is suspected. | x | x | x | x | x | |
| LO | Name the meteorological conditions under which carburettor icing may occur. | x | x | x | x | x | |
| LO | Describe the indications of the presence of carburettor icing with both a fixed pitch and a constant speed propeller. | x | x | | | | |

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|---|---|---|---|---|---|---|---|
| LO | Describe the indications of the presence of carburettor icing with a helicopter. | | | x | x | x | |
| LO | Describe the indications that will occur upon selection of carburettor heat depending on whether ice is present or not. | x | x | x | x | x | |
| LO | Explain the reason for the use of alternate air on fuel injection systems and describe its operating principle. | x | x | x | x | x | |
| LO | 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** | | | | | | |
| LO | Specify the reasons for cooling a piston engine. | x | x | x | x | x | |
| LO | Describe the design features to enhance cylinder air cooling for aeroplanes. | x | x | | | | |
| LO | Describe the design features to enhance cylinder air cooling for helicopters (e.g. engine-driven impeller and scroll assembly, baffles). | | | x | x | x | |
| LO | Compare the advantages of liquid and air-cooling systems. | x | x | x | x | x | |
| LO | Identify the cylinder head temperature indication to monitor engine cooling. | x | x | x | x | x | |
| LO | Describe the function and the operation of cowl flaps. | x | x | | | | |
| **021 10 06 00** | **Lubrication systems** | | | | | | |
| **021 10 06 01** | **Lubricants: characteristics, limitations** | | | | | | |
| LO | Describe the term ‘viscosity’ including the effect of temperature. | x | x | x | x | x | |
| LO | Describe the viscosity grade numbering system used in aviation. | x | x | x | x | x | |
| **021 10 06 02** | **Design, operation, indications and warnings** | | | | | | |

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|---|---|---|---|---|---|---|---|
| LO | State the functions of a piston-engine lubrication system. | x | x | x | x | x | |
| LO | Describe the working principle of a dry-sump lubrication system and describe the functions of the following components:<br>— oil tank (reservoir) and its internal components: hot well, de-aerator, vent, expansion space;<br>— check valve (non-return valve);<br>— pressure pump and pressure-relief valve;<br>— scavenge pump;<br>— filters (suction, pressure and scavenge);<br>— oil cooler;<br>— oil cooler bypass valve (anti-surge and thermostatic);<br>— pressure and temperature sensors;<br>— lines. | x | x | x | x | x | |
| LO | Describe a wet-sump lubrication system. | x | x | x | x | x | |
| LO | State the differences between a wet and a dry-sump lubrication system. | x | x | x | x | x | |
| LO | State the advantages/disadvantages of each system. | x | x | x | x | x | |
| LO | List the following factors that influence oil consumption:<br>— oil grade,<br>— cylinder and piston wear,<br>— condition of piston rings. | x | x | x | x | x | |
| LO | Describe the interaction between oil pressure, oil temperature and oil quantity. | x | x | x | x | x | |
| **021 10 07 00** | **Ignition circuits** | | | | | | |
| **021 10 07 01** | **Design, operation** | | | | | | |

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|---|---|---|---|---|---|---|---|
| LO | Describe the working principle of a magneto-ignition system and the functions of the following components:<br>— magneto,<br>— contact-breaker points,<br>— capacitor (condenser),<br>— coils or windings,<br>— ignition switches,<br>— distributor,<br>— spark plug,<br>— high-tension (HT) cable. | x | x | x | x | x | |
| LO | State why piston engines are equipped with two electrically independent ignition systems. | x | x | x | x | x | |
| LO | State the function and operating principle of the following methods of spark augmentation:<br>— starter vibrator (booster coil),<br>— impulse-start coupling. | x | x | | | | |
| LO | State the function and operating principle of the following methods of spark augmentation:<br>— starter vibrator (booster coil),<br>— both magnetos live. | | | x | x | x | |
| LO | Explain the function of the magneto check. | x | x | x | x | x | |
| LO | State the reasons for using the correct temperature grade for a spark plug. | x | x | x | x | x | |
| LO | Explain the function of ignition timing advance or retard. | x | x | x | x | x | |
| LO | 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** | | | | | | |

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|---|---|---|---|---|---|---|---|
| LO | Define the following terms:<br>— mixture,<br>— chemically correct ratio (stoichiometric),<br>— best power ratio,<br>— lean (weak) mixture (lean or rich side of the EGT top),<br>— rich mixture. | x | x | x | x | x | |
| LO | State the typical fuel-to-air ratio values or range of values for the above mixtures. | x | x | x | x | x | |
| LO | Describe the advantages and disadvantages of weak and rich mixtures. | x | x | x | x | x | |
| LO | Describe the relation between engine-specific fuel consumption and mixture ratio. | x | x | x | x | x | |
| LO | Describe the use of the exhaust gas temperature as an aid to mixture-setting. | x | x | x | x | x | |
| LO | Explain the relation between mixture ratio, cylinder head temperature, detonation and pre-ignition. | x | x | x | x | x | |
| LO | 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 subject 081, topic 07 (Propellers) but need to be appreciated for this subject as well.* | x | x | | | | |
| **021 10 09 02** | **Constant-speed propeller: design, operation, system components** | | | | | | |
| LO | Describe the operating principle of a constant-speed propeller system under normal flight operations with the aid of a schematic. | x | x | | | | |
| LO | Explain the need for a Manifold Absolute Pressure (MAP) indicator to control the power setting with a constant-speed propeller. | x | x | | | | |
| LO | State the purpose of a torque-meter. | x | x | | | | |

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|---|---|---|---|---|---|---|---|
| LO | State the purpose and describe the operation of a low-pitch stop (centrifugal latch). | x | x | | | | |
| LO | Describe the operating principle of a single-acting and a double-acting variable pitch propeller for single and multi-engine aeroplanes. | x | x | | | | |
| LO | Describe the function and the basic operating principle of synchronising and synchro-phasing systems. | x | x | | | | |
| LO | Explain the purpose and the basic operating principle of an auto-feathering system including un-feathering. | x | x | | | | |
| **021 10 09 03** | **Reduction gearing: design** | | | | | | |
| LO | State the purpose of reduction gearing. | x | x | | | | |
| LO | Explain the principles of design for reduction gearing. | x | x | | | | |
| **021 10 09 04** | **Propeller handling: associated control levers, degraded modes of operation, indications and warnings** | | | | | | |
| LO | Describe the checks to be carried out on a constant-speed propeller system after engine start. | x | x | | | | |
| LO | Describe the operation of a constant-speed propeller system during flight at different true airspeeds and RPM including an overspeeding propeller. | x | x | | | | |
| LO | Describe the operating principle of a variable pitch propeller when feathering and unfeathering, including the operation of cockpit controls. | x | x | | | | |
| LO | Describe the operating principle of a variable pitch propeller when reverse pitch is selected, including the operation of cockpit controls. | x | x | | | | |
| LO | Describe the operation of the propeller levers during different phases of flight. | x | x | | | | |
| **021 10 10 00** | **Performance and engine handling** | | | | | | |

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| **021 10 10 01** | **Performance** | | | | | | |
| LO | Engine performance: define 'pressure altitude' and 'density altitude'. | x | x | x | x | x | |
| LO | Describe the effect on power output of a petrol and diesel engine taking into consideration the following parameters:<br>— ambient pressure, exhaust back pressure;<br>— temperature;<br>— density altitude;<br>— humidity. | x | x | x | x | x | |
| LO | Explain the term 'normally aspirated engine'. | x | x | x | x | x | |
| LO | Power-augmentation devices: explain the requirement for power augmentation (turbocharging) of a piston engine. | x | x | x | x | x | |
| LO | Describe the function and the principle of operation of the following main components of a turbocharger:<br>— turbine,<br>— compressor,<br>— waste gate,<br>— waste-gate actuator,<br>— absolute-pressure controller,<br>— density controller,<br>— differential-pressure controller. | x | x | x | x | x | |
| LO | Explain the difference between an altitude-boosted turbocharger and a ground-boosted turbocharger. | x | x | x | x | x | |
| LO | Explain turbo lag. | x | x | x | x | x | |
| LO | Define the term 'critical altitude'. | x | x | x | x | x | |
| LO | Explain the function of an intercooler. | x | x | x | x | x | |
| LO | Define the terms 'full-throttle height' and 'rated altitude'. | x | x | x | x | x | |
| **021 10 10 02** | **Engine handling** | | | | | | |
| LO | State the correct procedures for setting the engine controls when increasing or decreasing power. | x | x | x | x | x | |

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| LO | Define the following terms:<br>— take-off power;<br>— maximum continuous power. | x | x | x | x | x | |
| LO | Describe the term 'hydraulicing' and the precautions to be taken prior to engine start. | x | x | x | x | x | |
| LO | Describe the start problems associated with extreme cold weather. | x | x | x | x | x | |
| LO | FADEC for a piston engine: To be introduced at a later date. | x | x | x | x | x | |
| **021 11 00 00** | **TURBINE ENGINES** | | | | | | |
| **021 11 01 00** | **Basic principles** | | | | | | |
| **021 11 01 01** | **Basic generation of thrust and the thrust formula** | | | | | | |
| LO | Describe how thrust is produced by a basic gas turbine engine. | x | x | | | | |
| LO | Describe the simple form of the thrust formula for a basic, straight turbojet and perform simple calculations (including pressure thrust). | x | x | | | | |
| LO | 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 of turbine engines, components** | | | | | | |
| LO | List the main components of a basic gas turbine engine.<br>— inlet,<br>— compressor,<br>— combustion chamber,<br>— turbine,<br>— outlet. | x | x | x | x | x | |
| LO | Describe the system of station numbering in a gas turbine engine. | x | x | x | x | x | |
| LO | 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 | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LO | Describe the differences between absolute, circumferential (tangential) and axial velocity. | x | x | x | x | x | |
| LO | List the different types of gas turbine engines:<br>— straight jet,<br>— turbo fan,<br>— turbo prop. | x | x | | | | |
| LO | State that a gas turbine engine can have one or more spools. | x | x | x | x | x | |
| LO | Describe how thrust is produced by turbojet and turbofan engines. | x | x | | | | |
| LO | Describe how power is produced by turboprop engines. | x | x | | | | |
| LO | Describe the term 'equivalent horsepower' (= thrust horsepower + shaft horsepower). | x | x | | | | |
| LO | Explain the principle of a free turbine or free-power turbine. | x | x | x | x | x | |
| LO | Define the term 'bypass ratio' and perform simple calculations to determine bypass ratio. | x | x | | | | |
| LO | Define the terms 'propulsive power', 'propulsive efficiency', 'thermal efficiency' and 'total efficiency'. | x | x | | | | |
| LO | Describe the influence of compressor-pressure ratio on thermal efficiency. | x | x | x | x | x | |
| LO | Explain the variations of propulsive efficiency with forward speed for turbojet, turbofan and turboprop engines. | x | x | | | | |
| LO | Define the term 'specific fuel consumption' for turbojets and turboprops. | x | x | | | | |
| **021 11 01 03** | **Coupled turbine engine: design, operation, components and materials** | | | | | | |
| LO | Name the main assembly parts of a coupled turbine engine and explain the operation of the engine. | | | x | x | x | |

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| LO | Explain the limitations of the materials used with regard to maximum turbine temperature, engine and drive train torque limits. | | | x | x | x | |
| LO | Describe the possible effects on engine components when limits are exceeded. | | | x | x | x | |
| LO | 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** | | | | | | |
| LO | Describe the design methods to keep the engine's size small for installation in helicopters. | | | x | x | x | |
| LO | List the main components of a free turbine engine. | | | x | x | x | |
| LO | Describe how the power is developed by a turboshaft/free turbine engine. | | | x | x | x | |
| LO | Explain how the exhaust gas temperature is used to monitor turbine stress. | | | x | x | x | |
| **021 11 02 00** | **Main-engine components** | | | | | | |
| **021 11 02 01** | **Aeroplane: air intake** | | | | | | |
| LO | State the functions of the engine air inlet/air intake. | x | x | | | | |
| LO | Describe the geometry of a subsonic (pitot-type) air inlet. | x | x | | | | |
| LO | Explain the gas-parameter changes in a subsonic air inlet at different flight speeds. | x | x | | | | |
| LO | Describe the reasons for, and the dangers of, the following operational problems concerning the engine air inlet:<br>— airflow separation,<br>— inlet icing,<br>— inlet damage,<br>— Foreign Object Damage (FOD),<br>— heavy in-flight turbulence. | x | x | | | | |
| **021 11 02 02** | **Compressor and diffuser** | | | | | | |
| LO | State the purpose of the compressor. | x | x | x | x | x | |

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| LO | Describe the working principle of a centrifugal and an axial flow compressor. | x | x | x | x | x | |
| LO | Name the following main components of a single stage and describe their function for a centrifugal compressor:<br>— impeller,<br>— diffuser. | x | x | x | x | x | |
| LO | Name the following main components of a single stage and describe their function for an axial compressor:<br>— rotor vanes,<br>— stator vanes. | x | x | x | x | x | |
| LO | Describe the gas-parameter changes in a compressor stage. | x | x | x | x | x | |
| LO | 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 | |
| LO | State the advantages and disadvantages of increasing the number of stages in a centrifugal compressor. | x | x | x | x | x | |
| LO | 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 | |
| LO | Explain the convergent air annulus through an axial flow compressor. | x | x | x | x | x | |
| LO | Describe the reason for twisting the compressor blades. | x | x | x | x | x | |
| LO | State the tasks of inlet guide vanes (IGVs). | x | x | x | x | x | |
| LO | State the reason for the clicking noise whilst the compressor slowly rotates on the ground. | x | x | x | x | x | |
| LO | State the advantages of increasing the number of spools. | x | x | x | x | x | |
| LO | Explain the implications of tip losses and describe the design features to minimise the problem. | x | x | x | x | x | |

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| LO | Explain the problems of blade bending and flapping and describe the design features to minimise the problem. | x | x | x | x | x | |
| LO | Explain the following terms:<br>— compressor stall,<br>— engine surge. | x | x | x | x | x | |
| LO | State the conditions that are possible causes of stall and surge. | x | x | x | x | x | |
| LO | Describe the indications of stall and surge. | x | x | x | x | x | |
| LO | Describe the design features used to minimise the occurrence of stall and surge. | x | x | x | x | x | |
| LO | Describe a compressor map (surge envelope) with RPM lines, stall limit, steady state line and acceleration line. | x | x | x | x | x | |
| LO | Describe the function of the diffuser. | x | x | x | x | x | |
| **021 11 02 03** | **Combustion chamber** | | | | | | |
| LO | Define the purpose of the combustion chamber. | x | x | x | x | x | |
| LO | List the requirements for combustion. | x | x | x | x | x | |
| LO | Describe the working principle of a combustion chamber. | x | x | x | x | x | |
| LO | Explain the reason for reducing the airflow axial velocity at the combustion chamber inlet (snout). | x | x | x | x | x | |
| LO | State the function of the swirl vanes (swirler). | x | x | x | x | x | |
| LO | State the function of the drain valves. | x | x | x | x | x | |
| LO | Define the terms ‘primary airflow’ and ‘secondary airflow’ and explain their purpose. | x | x | x | x | x | |
| LO | Explain the following two mixture ratios:<br>— primary airflow to fuel,<br>— total airflow (within the combustion chamber) to fuel. | x | x | x | x | x | |
| LO | Describe the gas-parameter changes in the combustion chamber. | x | x | x | x | x | |

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| LO | State a typical maximum value of the outlet temperature of the combustion chamber. | x | x | x | x | x | |
| LO | Describe the following types of combustion chamber and state the differences between them:<br>— can type;<br>— can-annular, cannular or tubo-annular;<br>— annular;<br>— reverse-flow annular. | x | x | x | x | x | |
| LO | Describe the principle of operation of a simplex and a duplex fuel spray nozzle (atomiser). | x | x | x | x | x | |
| **021 11 02 04** | **Turbine** | | | | | | |
| LO | Explain the purpose of a turbine in different types of gas turbine engines. | x | x | x | x | x | |
| LO | Describe the principles of operation of impulse, reaction and impulse-reaction axial flow turbines. | x | x | x | x | x | |
| LO | Name the main components of a turbine stage and their function. | x | x | x | x | x | |
| LO | Describe the working principle of a turbine. | x | x | x | x | x | |
| LO | Describe the gas-parameter changes in a turbine stage. | x | x | x | x | x | |
| LO | Describe the function and the working principle of active clearance control. | x | x | x | x | x | |
| LO | Describe the implications of tip losses and the means to minimise them. | x | x | x | x | x | |
| LO | Explain why the available engine thrust is limited by the turbine inlet temperature. | x | x | x | x | x | |
| LO | Explain the divergent gas-flow annulus through an axial-flow turbine. | x | x | x | x | x | |
| LO | Describe turbine-blade convection, impingement and film cooling. | x | x | x | x | x | |
| LO | Explain the high mechanical-thermal stress in the turbine blades and wheels. | x | x | x | x | x | |
| LO | Explain the term ‘creep’. | x | x | x | x | x | |

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| LO | Explain the consequences of creep on the turbine. | x | x | x | x | x | |
| LO | Explain the terms ‘low-cycle fatigue’ and ‘high-cycle fatigue’. | x | x | x | x | x | |
| **021 11 02 05** | **Aeroplane: exhaust** | | | | | | |
| LO | Name the following main components of the exhaust unit and their function:<br>— jet pipe,<br>— propelling nozzle,<br>— exhaust cone. | x | x | | | | |
| LO | Describe the working principle of the exhaust unit. | x | x | | | | |
| LO | Describe the gas-parameter changes in the exhaust unit. | x | x | | | | |
| LO | Define the term ‘choked exhaust nozzle’ (not applicable to turboprops). | x | | | | | |
| LO | Explain how jet exhaust noise can be reduced. | x | x | | | | |
| **021 11 02 06** | **Helicopter: air intake** | | | | | | |
| LO | Name and explain the main task of the engine air intake. | | | x | x | x | |
| LO | Describe the use of a convergent air-intake ducting on helicopters. | | | x | x | x | |
| LO | Describe the reasons for and the dangers of the following operational problems concerning engine air intake:<br>— airflow separations,<br>— intake icing,<br>— intake damage,<br>— foreign object damage,<br>— heavy in-flight turbulence. | | | x | x | x | |
| LO | Describe the conditions and circumstances during ground operations when foreign object damage is most likely to occur. | | | x | x | x | |
| LO | 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 | |

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| LO | Describe the function of the heated pads on some helicopter air intakes. | | | x | x | x | |
| **021 11 02 07** | **Helicopter: exhaust** | | | | | | |
| LO | Name the following main components of the exhaust unit and their function.<br>— jet pipe,<br>— exhaust cone. | | | x | x | x | |
| LO | Describe the working principle of the exhaust unit. | | | x | x | x | |
| LO | 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** | | | | | | |
| LO | Name the main components of the engine fuel system and state their function. | x | x | x | x | x | |
| LO | Name the two types of engine-driven high-pressure pumps, such as:<br>— gear-type,<br>— swash plate-type. | x | x | x | x | x | |
| LO | State the tasks of the fuel control unit. | x | x | x | x | x | |
| LO | 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** | | | | | | |
| LO | State the tasks of the engine control system. | x | x | x | x | x | |

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| LO | 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:<br>— hydro mechanical (Main Engine Control (MEC));<br>— hydro mechanical with a limited authority electronic supervisor (Power Management System/Control (PMS/PMC));<br>— single channel full-authority engine control with hydro-mechanical backup;<br>— dual channel full-authority electronic engine control system with no backup or any other combination (FADEC). | x | x | x | x | x | |
| LO | 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 TLA (see also AMC to CS-E-50), and an EGT protection function and engine overspeed. | x | | x | x | | |
| LO | Explain how redundancy is achieved by using more than one channel in a FADEC system. | x | | x | x | | |
| LO | State the consequences of a FADEC single input data failure. | x | | x | x | | |
| LO | State that all input and output data are checked by both channels. | x | | x | x | | |
| LO | State that a FADEC system uses its own sensors and that in some cases also data from aircraft systems is used. | x | | x | x | | |
| LO | State that a FADEC must have its own source of electrical power. | x | | x | x | | |
| **021 11 03 03** | **Engine lubrication** | | | | | | |
| LO | State the tasks of an engine lubrication system. | x | x | | | | |

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| LO | Name the following main components of a lubrication system and state their function:<br>— oil tank and centrifugal breather,<br>— oil pumps (pressure and scavenge pumps),<br>— oil filters (including the bypass),<br>— oil sumps,<br>— chip detectors,<br>— coolers. | x | x | | | | |
| LO | Explain that each spool is fitted with at least one ball bearing two or more roller bearings. | x | x | | | | |
| LO | Explain the use of compressor air in oil-sealing systems (e.g. labyrinth seals). | x | x | | | | |
| **021 11 03 04** | **Engine auxiliary gearbox** | | | | | | |
| LO | State the tasks of the auxiliary gearbox. | x | x | | | | |
| LO | Describe how the gearbox is driven and lubricated. | x | x | | | | |
| **021 11 03 05** | **Engine ignition** | | | | | | |
| LO | State the task of the ignition system. | x | x | | | | |
| LO | Name the following main components of the ignition system and state their function.<br>— power sources,<br>— trembler mechanism (vibrator),<br>— transformer,<br>— diodes,<br>— capacitors,<br>— discharge gap (high-tension tube),<br>— igniters. | x | x | | | | |
| LO | State why jet turbine engines are equipped with two electrically independent ignition systems. | x | x | | | | |
| LO | Explain the different modes of operation of the ignition system. | x | x | | | | |
| **021 11 03 06** | **Engine starter** | | | | | | |
| LO | Name the main components of the starting system and state their function. | x | x | | | | |
| LO | Explain the principle of a turbine engine start. | x | x | | | | |

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| LO | Describe the following two types of starters:<br>— electric,<br>— pneumatic. | x | x | | | | |
| LO | Describe a typical start sequence (on ground/in flight) for a turbofan. | x | x | | | | |
| LO | Define 'self-sustaining RPM'. | x | x | | | | |
| **021 11 03 07** | **Reverse thrust** | | | | | | |
| LO | Name the following main components of a reverse-thrust system and state their function:<br>— reverse-thrust select lever,<br>— power source (pneumatic or hydraulic),<br>— actuators,<br>— doors,<br>— annunciations. | x | x | | | | |
| LO | Explain the principle of a reverse-thrust system. | x | x | | | | |
| LO | Identify the advantages and disadvantages of using reverse thrust. | x | x | | | | |
| LO | Describe and explain the following different types of thrust-reverser systems:<br>— hot-stream reverser,<br>— clamshell or bucket-door system,<br>— cold-stream reverser (only turbofan engines),<br>— blocker doors,<br>— cascade vanes. | x | x | | | | |
| LO | Explain the implications of reversing the cold stream (fan reverser) only on a high bypass ratio engine. | x | x | | | | |
| LO | Describe the protection features against inadvertent thrust-reverse deployment in flight as present on most transport aeroplanes. | x | x | | | | |
| LO | Describe the controls and indications provided for the thrust-reverser system. | x | x | | | | |

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| **021 11 03 08** | **Helicopter specifics on design, operation and components for: Additional components and systems such as lubrication system, ignition circuit, starter, accessory gearbox** | | | | | | |
| LO | State the task of the lubrication system. | | | x | x | x | |
| LO | List and describe the common helicopter lubrication systems. | | | x | x | x | |
| LO | Name the following main components of a helicopter lubrication system:<br>— reservoir;<br>— pump assembly;<br>— external oil filter;<br>— magnetic chip detectors, electronic chip detectors;<br>— thermostatic oil coolers;<br>— breather. | | | x | x | x | |
| LO | Identify and name the components of a helicopter lubrication system from a diagram. | | | x | x | x | |
| LO | Identify the indications used to monitor a lubrication system including warning systems. | | | x | x | x | |
| LO | Explain the differences and appropriate use of straight oil and compound oil, and describe the oil numbering system for aviation use. | | | x | x | x | |
| LO | 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 | |
| LO | 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 | |
| LO | 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** | | | | | | |

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| LO | Explain the following aeroplane engine limitations:<br>— take-off,<br>— go-around,<br>— maximum continuous thrust/power,<br>— maximum climb thrust/power. | x | x | | | | |
| LO | Explain spool-up time. | x | x | x | x | x | |
| LO | Explain the reason for the difference between ground and approach flight idle values (RPM). | x | x | | | | |
| LO | State the parameters that can be used for setting and monitoring the thrust/power. | x | x | x | x | x | |
| LO | Describe the terms 'alpha range', 'beta range' and 'reverse thrust' as applied to a turboprop power lever. | x | x | | | | |
| LO | Explain the dangers of inadvertent beta-range selection in flight for a turboprop. | x | x | | | | |
| LO | Explain the purpose of engine trending. | x | x | x | x | | |
| LO | Explain how the exhaust gas temperature is used to monitor turbine stress. | x | x | x | x | | |
| LO | Describe the effect of engine acceleration and deceleration on the EGT. | x | x | x | x | | |
| LO | Describe the possible effects on engine components when EGT limits are exceeded. | x | x | x | x | | |
| LO | Explain why engine-limit exceedances must be reported. | x | x | x | x | | |
| LO | Explain the limitations on the use of the thrust-reverser system at low forward speed. | x | x | | | | |
| LO | Explain the term 'engine seizure'. | x | x | x | x | | |
| LO | State the possible causes of engine seizure and explain their preventative measures. | x | x | x | x | | |
| LO | Explain the reason for the difference in the pressures of the fuel and oil in the heat exchanger. | x | x | x | x | | |
| LO | Explain oil-filter clogging (blockage) and the implications for the lubrication system. | x | x | x | x | | |

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| LO | Give examples of monitoring instruments of an engine. | x | x | x | x | | |
| **021 11 04 02** | **Starting malfunctions** | | | | | | |
| LO | Describe the indications and the possible causes of the following aeroplane starting malfunctions:<br>— false (dry or wet) start,<br>— tailpipe fire (torching),<br>— hot start,<br>— abortive (hung) start,<br>— no N1 rotation,<br>— no FADEC indications. | x | x | | | | |
| LO | Describe the indications and the possible causes of the following helicopter starting malfunctions:<br>— false (dry or wet) start,<br>— tailpipe fire (torching),<br>— hot start,<br>— abortive (hung) start,<br>— no N1 rotation,<br>— freewheel failure, | | | x | x | x | |
| LO | — no FADEC indications. | | | x | x | | |
| **021 11 04 03** | **Re-light envelope** | | | | | | |
| LO | Explain the re-light envelope. | x | x | | | | |
| **021 11 05 00** | **Performance aspects** | | | | | | |
| **021 11 05 01** | **Thrust, performance aspects, and limitations** | | | | | | |
| LO | Describe the variation of thrust and specific fuel consumption with altitude at constant TAS. | x | x | | | | |
| LO | Describe the variation of thrust and specific fuel consumption with TAS at constant altitude. | x | x | | | | |
| LO | Explain the term ‘flat-rated engine’ by describing the change of take-off thrust, turbine inlet temperature and engine RPM with OAT. | x | x | | | | |
| LO | Define the term ‘Engine Pressure Ratio’ (EPR). | x | x | | | | |

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| LO | 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 | | | | |
| LO | 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.** | | | | | | |
| LO | Describe engine rating torque limits for take-off, transient and maximum continuous. | | | x | x | x | |
| LO | Describe turbine outlet temperature (TOT) limits for take-off. | | | x | x | x | |
| LO | Explain why TOT is a limiting factor for helicopter performance. | | | x | x | x | |
| LO | 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 | |
| LO | Explain that hovering downwind on some helicopters will noticeably increase the engine TOT. | | | x | x | x | |
| LO | Explain the reason why the engine performance is less when aircraft accessories are switched on, i.e. anti-ice, heating, hoist, filters. | | | x | x | x | |
| LO | Describe the effects of use of bleed air on engine parameters. | | | x | x | x | |
| LO | Explain that on some helicopter exceeding the TOT limit may cause the main rotor to droop (slow down). | | | x | x | x | |
| **021 11 06 00** | **Auxiliary Power Unit (APU)** | | | | | | |
| **021 11 06 01** | **Design, operation, functions, operational limitations** | | | | | | |

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| LO | State that an APU is a gas turbine engine and list its tasks. | x | | x | x | | |
| LO | State the difference between the two types of APU inlets. | x | | x | x | | |
| LO | Define 'maximum operating and maximum starting altitude'. | x | | x | x | | |
| LO | Name the typical APU control and monitoring instruments. | x | | x | x | | |
| LO | Describe the APU's automatic shutdown protection. | x | | x | x | | |
| **021 12 00 00** | **PROTECTION AND DETECTION SYSTEMS** | | | | | | |
| **021 12 01 00** | **Smoke detection** | | | | | | |
| **021 12 01 01** | **Types, design, operation, indications and warnings** | | | | | | |
| LO | Explain the operating principle of the following types of smoke detection sensors:<br>— optical,<br>— ionising. | x | x | | | | |
| LO | 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)** | | | | | | |
| LO | Explain the operating principle of a built-in fire-extinguishing system and describe its components. | x | x | x | x | x | |
| LO | State that two discharges must be provided for each engine (see CS 25.1195(c)). | x | x | | | | |
| **021 12 02 02** | **Fire detection** | | | | | | |
| LO | Explain the following principles involved in fire detection:<br>— resistance and capacitance,<br>— gas pressure. | x | x | x | x | x | |
| LO | Explain fire-detection applications such as:<br>— bimetallic,<br>— continuous loop,<br>— gaseous loop (gas-filled detectors). | x | x | x | x | x | |

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| LO | Explain why generally double-loop systems are used. | x | x | x | x | x | |
| LO | 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** | | | | | | |
| LO | Explain the principle and method of operation of the following windshield rain-protecting systems for an aeroplane:<br>— wipers,<br>— liquids (rain repellent),<br>— coating. | x | x | | | | |
| LO | Explain the principle and method of operation of wipers for a helicopter. | | | x | x | x | |
| **021 13 00 00** | **OXYGEN SYSTEMS** | | | | | | |
| LO | Describe the basic operating principle of a cockpit oxygen system and describe the following different modes of operation:<br>— normal (diluter demand),<br>— 100 %,<br>— emergency. | x | x | | | | |
| LO | Describe the operating principle and the purposes of the following two portable oxygen systems:<br>— smoke hood,<br>— portable bottle. | x | x | | | | |
| LO | Describe the following two oxygen systems that can be used to supply oxygen to passengers:<br>— fixed system (chemical oxygen generator or gaseous);<br>— portable. | x | x | | | | |
| LO | Describe the actuation methods (automatic and manual) and the functioning of a passenger oxygen mask. | x | x | | | | |
| LO | Compare chemical oxygen generators to gaseous systems with respect to:<br>— capacity,<br>— flow regulation. | x | x | | | | |
| LO | State the dangers of grease or oil related to the use of oxygen systems. | x | x | | | | |

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| **021 14 00 00** | **HELICOPTER: MISCELLANEOUS SYSTEMS** | | | | | | |
| **021 14 01 00** | **Variable rotor speed** | | | | | | |
| LO | 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 | |
| LO | Explain the system for 'beeping' the $N_R$ to its upper limit to enable safer take-off. | | | x | x | x | |
| **021 14 02 00** | **Active vibration suppression** | | | | | | |
| LO | 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** | | | | | | |
| LO | 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** | | | | | | |
| LO | Describe the following rotor-head systems:<br>— teetering,<br>— articulated,<br>— hingeless,<br>— bearingless. | | | x | x | x | |
| LO | Describe the following configuration of rotor systems and their advantages and disadvantages:<br>— tandem,<br>— coaxial,<br>— side by side. | | | x | x | x | |
| LO | 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** | | | | | | |

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| LO | Identify from a diagram the main structural components of the main types of rotor-head system. | | | x | x | x | |
| LO | List and describe the methods used on how to detect damage and cracks. | | | x | x | x | |
| LO | 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 | |
| LO | Describe the various rotor-head lubrication methods. | | | x | x | x | |
| **021 15 01 03** | **Design and construction** | | | | | | |
| LO | Describe the material technology used in rotor-head design, including construction using the following materials or mixture of materials:<br>— composites,<br>— fibreglass,<br>— alloys,<br>— elastomers. | | | x | x | x | |
| **021 15 01 04** | **Adjustment** | | | | | | |
| LO | 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** | | | | | | |
| LO | Describe the following tail-rotor systems:<br>— delta 3 hinge;<br>— multi-bladed delta 3 effect;<br>— Fenestron or ducted fan tail rotor;<br>— No Tail Rotor (NOTAR) high-velocity air jet flows from adjustable nozzles (the Coandă effect). | | | x | x | x | |
| LO | Identify from a diagram the main structural components of the four main types of tail-rotor systems. | | | x | x | x | |
| LO | Explain and describe the methods to detect damage and cracks on the tail rotor and assembly. | | | x | x | x | |

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| LO | Explain and describe the structural limitations to the respective tail-rotor systems and possible limitations regarding the turning rate of the helicopter. | | | x | x | x | |
| LO | Explain and describe the following methods that helicopter designers use to minimise tail-rotor drift and roll:<br>— reducing the couple arm (tail rotor on a pylon);<br>— offsetting the rotor mast;<br>— use of 'bias' in cyclic control mechanism. | | | x | x | x | |
| LO | Explain pitch-input mechanisms. | | | x | x | x | |
| LO | Explain the relationship between tail-rotor thrust and engine power. | | | x | x | x | |
| LO | Describe how the vertical fin on some helicopters reduces the power demand of the Fenestron. | | | x | x | x | |
| **021 15 02 02** | **Design and construction** | | | | | | |
| LO | 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** | | | | | | |
| LO | Describe the rigging and adjustment of the tail-rotor system to obtain optimum position of the pilot's yaw pedals. | | | x | x | x | |

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| **021 16 00 00** | **HELICOPTER: TRANSMISSION** | | | | | | |
| **021 16 01 00** | **Main gearbox** | | | | | | |
| **021 16 01 01** | **Different types, design, operation, limitations** | | | | | | |
| LO | Describe the following main principles of helicopter transmission systems for single and twin-engine helicopters:<br>— drive for the main and tail rotor;<br>— accessory drive for the generator(s) alternator(s), hydraulic and oil pumps, oil cooler(s) and tachometers. | | | x | x | x | |
| LO | Describe the reason for limitations on multi-engine helicopter transmissions in various engine-out situations. | | | x | x | x | |
| LO | Describe how the passive vibration control works with gearbox mountings. | | | x | x | x | |
| **021 16 02 00** | **Rotor brake** | | | | | | |
| LO | Describe the main function of the disc type of rotor brake. | | | x | x | x | |
| LO | Describe both hydraulic and cable operated rotor-brake systems. | | | x | x | x | |
| LO | Describe the different options for the location of the rotor brake. | | | x | x | x | |
| LO | List the following operational considerations for the use of rotor brakes:<br>— rotor speed at engagement of rotor brake;<br>— risk of blade sailing in windy conditions;<br>— risk of rotor-brake overheating and possible fire when brake is applied above the maximum limit, particularly when spilled hydraulic fluid is present;<br>— avoid stopping blades over jet-pipe exhaust with engine running;<br>— cockpit annunciation of rotor-brake operation. | | | x | x | x | |
| **021 16 03 00** | **Auxiliary systems** | | | | | | |
| LO | Explain how the hoist/winch can be driven by an off-take from the auxiliary gearbox. | | | x | x | x | |

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|---|---|---|---|---|---|---|---|
| LO | 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** | | | | | | |
| LO | Describe how power is transmitted from the engine to the main rotor gearbox. | | | x | x | x | |
| LO | Describe the material and construction of the driveshaft. | | | x | x | x | |
| LO | Explain the need for alignment between the engine and the main rotor gearbox. | | | x | x | x | |
| LO | Identify how temporary misalignment occurs between driving and driven components. | | | x | x | x | |
| LO | Explain the use of:<br>— flexible couplings;<br>— Thomas couplings;<br>— flexible disc packs;<br>— driveshaft support bearings and temperature measurement;<br>— subcritical and supercritical driveshafts. | | | x | x | x | |
| LO | Explain the relationship between the driveshaft speed and torque. | | | x | x | x | |
| LO | Describe the methods with which power is delivered to the tail rotor. | | | x | x | x | |
| LO | Describe and identify the construction and materials of tail rotor/Fenestron driveshafts. | | | x | x | x | |
| **021 16 05 00** | **Intermediate and tail gearbox** | | | | | | |
| LO | Explain and describe the various arrangements when the drive changes direction and the need for an intermediate or tail gearbox. | | | x | x | x | |
| LO | Explain the lubrication requirements for intermediate and tail-rotor gearboxes and methods of checking levels. | | | x | x | x | |
| LO | 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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|---|---|---|---|---|---|---|---|
| LO | Explain the purpose of a clutch. | | | x | x | x | |
| | Describe and explain the operation of a:<br>— centrifugal clutch,<br>— actuated clutch. | | | x | x | x | |
| LO | List the typical components of the various clutches. | | | x | x | x | |
| LO | Identify the following methods by which clutch serviceability can be ascertained:<br>— brake-shoe dust;<br>— vibration;<br>— main-rotor run-down time;<br>— engine speed at time of main-rotor engagement;<br>— belt tensioning;<br>— start protection in a belt-drive clutch system. | | | x | x | x | |
| **021 16 07 00** | **Freewheels** | | | | | | |
| LO | Explain the purpose of a freewheel. | | | x | x | x | |
| LO | Describe and explain the operation of a:<br>— cam and roller type freewheel,<br>— sprag-clutch type freewheel. | | | x | x | x | |
| LO | List the typical components of the various freewheels. | | | x | x | x | |
| LO | Identify the various locations of freewheels in power plant and transmission systems. | | | x | x | x | |
| LO | 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 blade** | | | | | | |
| **021 17 01 01** | **Design, construction** | | | | | | |
| LO | Describe the different types of blade construction and the need for torsional stiffness. | | | x | x | x | |
| LO | Describe the principles of heating systems/pads on some blades for anti-icing/de-icing. | | | x | x | x | |
| **021 17 01 02** | **Structural components and materials** | | | | | | |
| LO | List the materials used in the construction of main-rotor blades. | | | x | x | x | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LO | List the main structural components of a main-rotor blade and their function. | | | x | x | x | |
| **021 17 01 03** | **Stresses** | | | | | | |
| LO | Describe main-rotor blade-loading on the ground and in flight. | | | x | x | x | |
| LO | Describe where the most common stress areas are on rotor blades. | | | x | x | x | |
| **021 17 01 04** | **Structural limitations** | | | | | | |
| LO | Explain the structural limitations in terms of bending and rotor RPM. | | | x | x | x | |
| **021 17 01 05** | **Adjustment** | | | | | | |
| LO | Explain the use of trim tabs. | | | x | x | x | |
| **021 17 01 06** | **Tip shape** | | | | | | |
| LO | Describe the various blade-tip shapes used by different manufacturers and compare their advantages and disadvantages. | | | x | x | x | |
| LO | 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 | |
| **021 17 02 00** | **Tail-rotor blade** | | | | | | |
| **021 17 02 01** | **Design, construction** | | | | | | |
| LO | 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 | |
| LO | 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 | |
| LO | Describe how anti-icing/de-icing systems are designed into the blade construction of some helicopters. | | | x | x | x | |
| **021 17 02 02** | **Structural components and materials** | | | | | | |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| LO | List the materials used in the construction of tail-rotor blades. | | | x | x | x | |
| LO | List the main structural components of a tail-rotor blade and their function. | | | x | x | x | |
| **021 17 02 03** | **Stresses** | | | | | | |
| LO | Describe the tail-rotor blade-loading on the ground and in flight. | | | x | x | x | |
| **021 17 02 04** | **Structural limitations** | | | | | | |
| LO | Describe the structural limitations of tail-rotor blades. | | | x | x | x | |
| LO | 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** | | | | | | |
| LO | Describe the adjustment of yaw pedals in the cockpit to obtain full control authority of the tail rotor. | | | x | x | x | |