C. SUBJECT 022 — INSTRUMENTATION

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
020 00 00 00	**AIRCRAFT GENERAL KNOWLEDGE**						
022 00 00 00	**AIRCRAFT GENERAL KNOWLEDGE — INSTRUMENTATION**						
022 01 00 00	**SENSORS AND INSTRUMENTS**						
022 01 01 00	**Pressure gauge**						
LO	Define 'pressure', 'absolute pressure' and 'differential pressure'.	x	x	x	x	x	
LO	List the following units used for pressure: — Pascal, — bar, — inches of mercury (in Hg), — pounds per square inch (PSI).	x	x	x	x	x	
LO	State the relationship between the different units.	x	x	x	x	x	
LO	List and describe the following different types of sensors used according to the pressure to be measured: — aneroid capsules, — bellows, — diaphragms, — bourdon tube.	x	x	x	x	x	
LO	Solid-state sensors (to be introduced at a later date)	x	x	x	x	x	
LO	For each type of sensor identify applications such as: — liquid-pressure measurement (fuel, oil, hydraulic); — air-pressure measurement (bleed-air systems, air-conditioning systems); — Manifold Absolute Pressure (MAP) gauge.	x	x	x	x	x	
LO	Pressure probes for Engine Pressure Ratio (EPR).	x	x				
LO	Give examples of display for each of the applications above.	x	x	x	x	x	

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the need for remote-indicating systems.	x	x	x	x	x	
022 01 02 00	**Temperature sensing**						
LO	Explain temperature.	x	x	x	x	x	
LO	List the following units that can be used for temperature measurement: — Kelvin, — Celsius, — Fahrenheit.	x	x	x	x	x	
LO	State the relationship between these different units.	x	x	x	x	x	
LO	Describe and explain the operating principles of the following types of sensors: — expansion type (bimetallic strip), — electrical type (resistance, thermocouple).	x	x	x	x	x	
LO	State the relationship for a thermocouple between the electromotive force and the temperature to be measured.	x	x	x	x	x	
LO	For each type, identify applications such as: — gas-temperature measurement (ambient air, bleed-air systems, air-conditioning systems, air inlet, exhaust gas, gas turbine outlets); — liquid-temperature measurement (fuel, oil, hydraulic).	x	x	x	x	x	
LO	Give examples of display for each of the applications above.	x	x	x	x	x	
022 01 03 00	**Fuel gauge**						
LO	State that the quantity of fuel can be measured by volume or mass.	x	x	x	x	x	
LO	List the following units used for fuel quantity when measured by mass: — kilogramme; — pound.	x	x	x	x	x	
LO	State the relationship between these different units.	x	x	x	x	x	

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define ‘capacitance’ and ‘permittivity’, and state their relationship with density.	x	x	x	x	x	
LO	List and explain the parameters that can affect the measurement of the volume and/or mass of the fuel in a wing fuel tank: — temperature; — aircraft accelerations and attitudes, and explain how the fuel-gauge system design compensates for these changes.	X	X	X	X	X	
LO	Describe and explain the operating principles of the following types of fuel gauges: — float system; — capacitance type fuel-gauge system; — ultrasound type of fuel gauge: to be introduced at a later date.	x	x	x	x	x	
022 01 04 00	**Fuel flowmeters**						
LO	Define ‘fuel flow’ and where it is measured.	x	x	x	x	x	
LO	State that fuel flow may be measured by volume or mass per unit of time.	x	x	x	x	x	
LO	List the following units used for fuel flow when measured by mass per hour: — kilogrammes/hour, — pounds/hour.	x	x	x	x	x	
LO	List the following units used for fuel flow when measured by volume per hour: — litres/hour, — US gallons/hour.	x	x	x	x	x	
LO	List and describe the following different types of fuel flowmeter: — mechanical, — electrical (analogue), — electronic (digital), and explain how the signal can be corrected to measure mass flow.	x	x	x	x	x	
LO	Explain how total fuel consumption is obtained.	x	x	x	x	x	
022 01 05 00	**Tachometer**						

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	List the following types of tachometers: — mechanical (rotating magnet); — electrical (three-phase tacho-generator); — electronic (impulse measurement with speed probe and phonic wheel); — and describe the operating principle of each type.	x	x	x	x	x	
LO	For each type, identify applications such as engine-speed measurement (crankshaft speed for piston engines, spool speed for gas turbine engines), wheel-speed measurement for anti-skid systems (anti-skid systems for aeroplane only), and give examples of display.	x	x	x	x	x	
LO	State that engine speed is most commonly displayed as a percentage.	x	x	x	x	x	
022 01 06 00	**Thrust measurement**						
LO	List and describe the following two parameters used to represent thrust: N1, EPR.	x	x				
LO	Explain the operating principle of the EPR gauge and the consequences for the pilot in case of a malfunction including blockage and leakage.	x	x				
LO	Give examples of display for N1 and EPR.	x	x				
022 01 07 00	**Engine torquemeter**						
LO	Define ‘torque’.	x	x	x	x	x	
LO	Explain the relationship between power, torque and RPM.	x	x	x	x	x	
LO	List the following units used for torque: — Newton meters, — inch or foot pounds.	x	x	x	x	x	
LO	State that engine torque can be displayed as a percentage.	x	x	x	x	x	

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	List and describe the following different types of torquemeters: — mechanical, — electronic, and explain their operating principles.	x	x	x	x	x	
LO	Compare the two systems with regard to design and weight.	x	x	x	x	x	
LO	Give examples of display.	x	x	x	x	x	
022 01 08 00	**Synchroscope**						
LO	State the purpose of a synchroscope.	x	x				
LO	Explain the operating principle of a synchroscope.	x	x				
LO	Give examples of display.	x	x				
022 01 09 00	**Engine-vibration monitoring**						
LO	State the purpose of a vibration-monitoring system for a jet engine.	x	x				
LO	Describe the operating principle of a vibration-monitoring system using the following two types of sensors: — piezoelectric crystal, — magnet.	x	x				
LO	State that no specific unit is displayed for a vibration-monitoring system.	x	x				
LO	Give examples of display.	x	x				
022 01 10 00	**Time measurement**						
LO	Explain the use of time/date measurement and recording for engines and system maintenance.	x	x	x	x	x	
022 02 00 00	**MEASUREMENT OF AIR-DATA PARAMETERS**						
022 02 01 00	**Pressure measurement**						
022 02 01 01	**Definitions**						
LO	Define ‘static, total and dynamic pressures’ and state the relationship between them.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define 'impact pressure' as total pressure minus static pressure and discuss the conditions when dynamic pressure equals impact pressure.	x	x	x	x	x	x
022 02 01 02	**Pitot/static system: design and errors**						
LO	Describe the design and the operating principle of a: — static source, — pitot tube, — combined pitot/static probe.	x	x	x	x	x	x
LO	For each of these indicate the various locations, and describe the following associated errors: — position errors; — instrument errors; — errors due to a non-longitudinal axial flow (including manoeuvre-induced errors); and the means of correction and/or compensation.	x	x	x	x	x	x
LO	Describe a typical pitot/static system and list the possible outputs.	x	x	x	x	x	x
LO	Explain the redundancy and the interconnections of typical pitot/static systems.	x	x	x	x	x	x
LO	Explain the purpose of heating and interpret the effect of heating on sensed pressure.	x	x	x	x	x	x
LO	List the affected instruments and explain the consequences for the pilot in case of a malfunction including blockage and leakage.	x	x	x	x	x	x
LO	Describe alternate static sources and their effects when used.	x	x	x	x	x	x
LO	Solid-state sensors (to be introduced at a later date).	x	x	x	x	x	x
022 02 02 00	**Temperature measurement**						

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
022 02 02 01	**Definitions**						
LO	Define 'OAT', 'SAT', 'TAT' and 'measured temperature'.	x	x	x	x	x	x
LO	Define 'ram rise' and 'recovery factor'.	x					
LO	State the relationship between the different temperatures according to Mach number.	x					
022 02 02 02	**Design and operation**						
LO	Describe the following types of air-temperature probes and their features: — expansion type: bimetallic strip, direct reading; — electrical type wire resistance, remote reading.	x	x	x	x	x	x
LO	For each of these indicate the various locations, and describe the following associated errors: — position errors, — instrument errors, and the means of correction and/or compensation.	x	x	x	x	x	x
LO	Explain the purpose of heating and interpret the effect of heating on sensed temperature.	x	x	x	x	x	x
022 02 03 00	**Angle-of-attack measurement**						
LO	Describe the following two types of angle-of-attack sensors: — null-seeking (slotted) probe, — vane detector.	x	x				
LO	For each type, explain the operating principles.	x	x				
LO	Explain how both types are protected against ice.	x	x				

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Give examples of systems that use the angle of attack as an input, such as: — air-data computer; — Stall Warning Systems; — flight-envelope protection systems.	x	x				
LO	Give examples of different types of angle-of-attack (AoA) displays.	x	x				
022 02 04 00	**Altimeter**						
LO	Define 'ISA'.	x	x	x	x	x	x
LO	List the following two units used for altimeters: — feet, — metres, and state the relationship between them.	x	x	x	x	x	x
LO	Define the following terms: — height, altitude; — indicated altitude, true altitude; — pressure altitude, density altitude.	x	x	x	x	x	x
LO	Define the following barometric references: 'QNH', 'QFE', '1013,25'.	x	x	x	x	x	x
LO	Explain the operating principles of an altimeter.	x	x	x	x	x	x
LO	Describe and compare the following three types of altimeters: — simple altimeter (single capsule); — sensitive altimeter (multi-capsule); — servoassisted altimeter.	x	x	x	x	x	x
LO	Give examples of associated displays: pointer, multi-pointer, drum, vertical straight scale.	x	x	x	x	x	x
LO	Describe the following errors: — pitot/static system errors; — temperature error (air column not at ISA conditions); — time lag (altimeter response to change of height); and the means of correction.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Give examples of altimeter corrections table from an Aircraft Operating Handbook (AOH).	x	x	x	x	x	x
LO	Describe the effects of a blockage or a leakage on the static pressure line.	x	x	x	x	x	x
022 02 05 00	**Vertical Speed Indicator (VSI)**						
LO	List the two units used for VSI: — metres per second, — feet per minute, and state the relationship between them.	x	x	x	x	x	x
LO	Explain the operating principles of a VSI.	x	x	x	x	x	x
LO	Describe and compare the following two types of vertical speed indicators: — barometric type, — inertial type (inertial information provided by an inertial reference unit).	x	x	x	x	x	x
LO	Describe the following VSI errors: — pitot/static system errors, — time lag, and the means of correction.	x	x	x	x	x	x
LO	Describe the effects on a VSI of a blockage or a leakage on the static pressure line.	x	x	x	x	x	x
LO	Give examples of a VSI display.	x	x	x	x	x	x
022 02 06 00	**Airspeed Indicator (ASI)**						
LO	List the following three units used for airspeed: — nautical miles/hour (knots), — statute miles/hour, — kilometres/hour, and state the relationship between them.	x	x	x	x	x	x
LO	Define 'IAS', 'CAS', 'EAS', 'TAS' and state and explain the relationship between these speeds.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe the following ASI errors and state when they must be considered: — pitot/static system errors, — compressibility error, — density error.	x	x	x	x	x	x
LO	Explain the operating principles of an ASI (as appropriate to aeroplanes or helicopters).	x	x	x	x	x	x
LO	Give examples of an ASI display: pointer, vertical straight scale.	x	x	x	x	x	x
LO	Interpret ASI corrections tables as used in an Aircraft Operating Handbook (AOH).	x	x	x	x	x	x
LO	Define and explain the following colour codes that can be used on an ASI: — white arc (flap operating speed range); — green arc (normal operating speed range); — yellow arc (caution speed range); — red line (VNE); — blue line (best rate of climb speed, one-engine-out for multi-engine piston light aeroplanes).	x	x				
LO	Describe the effects on an ASI of a blockage or a leakage in the static and/or total pressure line(s).	x	x	x	x	x	x
022 02 07 00	**Machmeter**						
LO	Define 'Mach number' and 'Local Speed of Sound' (LSS), and perform simple calculations that include these terms.	x					
LO	Describe the operating principle of a Machmeter.	x					
LO	Explain why a Machmeter suffers only from pitot/static system errors.	x					
LO	Give examples of a Machmeter display: pointer, drum, vertical straight scale, digital.	x					

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe the effects on a Machmeter of a blockage or a leakage in the static and/or total pressure line(s).	x					
LO	State the relationship between Mach number, CAS and TAS, and interpret their variations according to FL and temperature changes.	x					
LO	State the existence of MMO.	x					
022 02 08 00	**Air-Data Computer (ADC)**						
LO	Explain the operating principle of an ADC.	x		x	x		
LO	List the following possible input data: — TAT, — static pressure, — total pressure, — measured temperature, — angle of attack, — flaps and landing gear position, — stored aircraft data.	x		x	x		
LO	List the following possible output data: — IAS, — TAS, — SAT, — TAT, — Mach number, — angle of attack, — altitude, — vertical speed, — VMO/MMO pointer.	x		x	x		
LO	For each output, list the datum/data sensed and explain the principle of calculation.	x		x	x		
LO	Explain how position, instrument, compressibility and density errors can be compensated/corrected to achieve a TAS calculation.	x		x	x		
LO	Explain why accuracy is improved for each output datum when compared to raw data.	x		x	x		
LO	Give examples of instruments and/or systems which may use ADC output data.	x		x	x		

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that an ADC can be a stand-alone system or integrated with the Inertial Reference Unit (ADIRU).	x		x	x		
LO	Explain the ADC architecture for air-data measurement including sensors, processing units and displays, as opposed to stand-alone air-data measurement instruments.	x		x	x		
LO	Explain the advantage of an ADC for air-data information management compared to raw data.	x		x	x		
022 03 00 00	**MAGNETISM — DIRECT-READING COMPASS AND FLUX VALVE**						
022 03 01 00	**Earth's magnetic field**						
LO	Describe the magnetic field of the Earth.	x	x	x	x	x	x
LO	Explain the properties of a magnet.	x	x	x	x	x	x
LO	Define the following terms: — magnetic variation, — magnetic dip (inclination).	x	x	x	x	x	x
022 03 02 00	**Aircraft magnetic field**						
LO	Define and explain the following terms: — magnetic and non-magnetic material; — hard and soft iron; — permanent magnetism and electromagnetism.	x	x	x	x	x	x
LO	Explain the principles and the reasons for: — compass swinging (determination of initial deviations); — compass compensation (correction of deviations found); — compass calibration (determination of residual deviations).	x	x	x	x	x	x
LO	List the causes of the aircraft's magnetic field and explain how it affects the accuracy of the compass indications.	x	x	x	x	x	x
LO	Describe the purpose and the use of a deviation correction card.	x	x	x	x	x	x
022 03 03 00	**Direct-reading magnetic compass**						

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define the role of a direct-reading magnetic compass.	x	x	x	x	x	x
LO	Describe and explain the design of a vertical card-type compass.	x	x	x	x	x	x
LO	Describe the deviation compensation.	x	x	x	x	x	x
LO	Describe and interpret the effects of the following errors: — acceleration, — turning, — attitude, — deviation.	x	x	x	x	x	x
LO	Explain how to use and interpret the direct-reading compass indications during a turn.	x	x	x	x	x	x
022 03 04 00	**Flux valve**						
LO	Explain the purpose of a flux valve.	x	x	x	x	x	x
LO	Explain its operating principle.	x	x	x	x	x	x
LO	Indicate various locations and precautions needed.	x	x	x	x	x	x
LO	Give the remote-reading compass system as example of application.	x	x	x	x	x	x
LO	State that because of the electromagnetic deviation correction, the flux-valve output itself does not have a deviation correction card.	x	x	x	x	x	x
LO	Describe and interpret the effects of the following errors: — acceleration, — turning, — attitude, — deviation.	x	x	x	x	x	x
022 04 00 00	**GYROSCOPIC INSTRUMENTS**						
022 04 01 00	**Gyroscope: basic principles**						
LO	Define a ‘gyro’.	x	x	x	x	x	x
LO	Explain the fundamentals of the theory of gyroscopic forces.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define the 'degrees of freedom' of a gyro. *Remark: As a convention, the degrees of freedom of a gyroscope do not include its own axis of rotation (the spin axis).*	x	x	x	x	x	x
LO	Explain the following terms: — rigidity, — precession, — wander (drift/topple).	x	x	x	x	x	x
LO	Distinguish between: — real wander and apparent wander; — apparent wander due to the rotation of the Earth and transport wander.	x	x	x	x	x	x
LO	Describe a free (space) gyro and a tied gyro.	x	x	x	x	x	x
LO	Describe and compare electrically and pneumatically-driven gyroscopes.	x	x	x	x	x	x
LO	Explain the construction and operating principles of a: — rate gyro, — rate-integrating gyro.	x	x	x	x	x	x
022 04 02 00	**Rate-of-turn indicator — Turn coordinator — Balance (slip) indicator**						
LO	Explain the purpose of a rate-of-turn and balance (slip) indicator.	x	x	x	x	x	x
LO	Define a 'rate-one turn'.	x	x	x	x	x	x
LO	Describe the construction and principles of operation of a rate-of-turn indicator.	x	x	x	x	x	x
LO	State the degrees of freedom of a rate-of-turn indicator.	x	x	x	x	x	x
LO	Explain the relation between bank angle, rate of turn and TAS.	x	x	x	x	x	x
LO	Explain why the indication of a rate-of-turn indicator is only correct for one TAS and when turn is coordinated.	x	x	x	x	x	x
LO	Describe the construction and principles of operation of a balance (slip) indicator.	X	X	X	X	X	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain the purpose of a balance (slip) indicator.	x	x	x	x	x	x
LO	Describe the indications of a rate-of-turn and balance (slip) indicator during a balanced, slip or skid turn.	x	x	x	x	x	x
LO	Describe the construction and principles of operation of a turn coordinator (or turn-and-bank indicator).	x	x	x	x	x	x
LO	Compare the rate-of-turn indicator and the turn coordinator.	x	x	x	x	x	x
022 04 03 00	**Attitude indicator (artificial horizon)**						
LO	Explain the purpose of the attitude indicator.	x	x	x	x	x	x
LO	Describe the different designs and principles of operation of attitude indicators (air-driven, electric).	x	x	x	x	x	x
LO	State the degrees of freedom.	x	x	x	x	x	x
LO	Describe the gimbal system.	x	x	x	x	x	x
LO	Describe the effects of the aircraft's acceleration and turns on instrument indications.	x	x	x	x	x	x
LO	Describe the attitude display and instrument markings.	x	x	x	x	x	x
LO	Explain the purpose of a vertical gyro unit.	x	x	x	x	x	x
LO	List and describe the following components of a vertical gyro unit: — inputs: pitch and roll sensors; — transmission and amplification (synchros and amplifiers); — outputs: display units such as Attitude Direction Indicator (ADI), auto-flight control systems.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State the advantages and disadvantages of a vertical gyro unit compared to an attitude indicator with regard to: — design (power source, weight and volume); — accuracy of the information displayed; — availability of the information for several systems (ADI, AFCS).	x	x	x	x	x	x
022 04 04 00	**Directional gyroscope**						
LO	Explain the purpose of the directional gyroscope.	x	x	x	x	x	x
LO	Describe the following two types of directional gyroscopes: — air-driven directional gyro; — electric directional gyro.	x	x	x	x	x	x
LO	State the degrees of freedom.	x	x	x	x	x	x
LO	Describe the gimbal system.	x	x	x	x	x	x
LO	Define the following different errors: — design and manufacturing imperfections (random wander); — apparent wander (rotation of the Earth); — transport wander (movement relative to the Earth's surface); and explain their effects.	x	x	x	x	x	x
LO	Calculate the apparent wander (apparent drift rate in degrees per hour) of an uncompensated gyro according to latitude.	x	x	x	x	x	x
022 04 05 00	**Remote-reading compass systems**						
LO	Describe the principles of operation of a remote-reading compass system.	x	x	x	x	x	x

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LO	Using a block diagram, list and explain the function of the following components of a remote-reading compass system: — flux detection unit; — gyro unit; — transducers, precession amplifiers, annunciator; — display unit (compass card, synchronising and set-heading knob, DG/compass switch).	x	x	x	x	x	x
LO	State the advantages and disadvantages of a remote-reading compass system compared to a direct-reading magnetic compass with regard to: — design (power source, weight and volume); — deviation due to aircraft magnetism; — turning and acceleration errors; — attitude errors; — accuracy and stability of the information displayed; — availability of the information for several systems (compass card, RMI, AFCS).	x	x	x	x	x	x
022 04 06 00	**Solid-state systems — AHRS (the following paragraph is to be introduced at a later date)**	x	x	x	x	x	x
LO	State that the Micro-Electromechanical Sensors (MEMS) technology can be used to make: — solid-state accelerometers; — solid-state rate sensor gyroscopes; — solid-state magnetometers (measurement of the Earth's magnetic field).	x	x	x	x	x	x
LO	Describe the basic principle of a solid-state Attitude and Heading Reference System (AHRS) using a solid-state 3-axis rate sensor, 3-axis accelerometer and a 3-axis magnetometer.	x	x	x	x	x	x

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Compare the solid-state AHRS with the mechanical gyroscope and flux-gate system with regard to: — size and weight, — accuracy, — reliability, — cost.	x	x	x	x	x	x
022 05 00 00	**INERTIAL NAVIGATION AND REFERENCE SYSTEMS (INS AND IRS)**						
022 05 01 00	**Inertial Navigation Systems (INS) (stabilised inertial platform)**						
022 05 01 01	**Basic principles**						
LO	Explain the basic principles of inertial navigation.	x		x	x		
022 05 01 02	**Design**						
LO	List and describe the main components of a stabilised inertial platform.	x		x	x		
LO	Explain the different corrections made to stabilise the platform.	x		x	x		
LO	List the following two effects that must be compensated for: — Coriolis, — centrifugal.	x		x	x		
LO	Explain the alignment of the system, the different phases associated and the conditions required.	x		x	x		
LO	Explain the Schuler condition and give the value of the Schuler period.	x		x	x		
022 05 01 03	**Errors, accuracy**						
LO	State that there are three different types of errors: — bounded errors, — unbounded errors, — other errors.	x		x	x		
LO	Give average values for bounded and unbounded errors according to time.	x		x	x		

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		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	State that an average value for the position error of the INS according to time is 1,5 NM/hour or more.	x		x	x		
022 05 01 04	**Operation**						
LO	Give examples of INS control and display panels.	x		x	x		
LO	Give an average value of alignment time at midlatitudes.	x		x	x		
LO	List the outputs given by an INS.	x		x	x		
LO	Describe and explain the consequences concerning the loss of alignment by an INS in flight.	x		x	x		
022 05 02 00	**Inertial Reference Systems (IRS) (strapped-down)**						
022 05 02 01	**Basic principles**						
LO	Describe the operating principle of a strapped-down IRS.	x		x	x		
LO	State the differences between a strapped-down inertial system (IRS) and a stabilised inertial platform (INS).	x		x	x		
022 05 02 02	**Design**						
LO	List and describe the following main components of an IRS: — rate sensors (laser gyros), — inertial accelerometers, — high-performance processors, — display unit.	x		x	x		
LO	Explain the construction and operating principles of a Ring Laser Gyroscope (RLG).	x		x	x		
LO	Explain the different computations and corrections to be made to achieve data processing.	x		x	x		
LO	Explain the alignment of the system, the different phases associated and the conditions required.	x		x	x		

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain why the Schuler condition is still required.	x		x	x		
LO	Describe the 'lock-in' (laser lock) phenomena and the means to overcome it.	x		x	x		
LO	State that an IRS can be a stand-alone system or integrated with an ADC (ADIRU).	x		x	x		
022 05 02 03	**Errors, accuracy**						
LO	Compare IRS and INS for errors and accuracy.	x		x	x		
022 05 02 04	**Operation**						
LO	Compare IRS and INS, and give recent examples of control panels.	x		x	x		
LO	List the outputs given by an IRS.	x		x	x		
LO	Give the advantages and disadvantages of an IRS compared to an INS.	x		x	x		
022 06 00 00	**AEROPLANE: AUTOMATIC FLIGHT CONTROL SYSTEMS**						
022 06 01 00	**General: Definitions and control loops**						
LO	State the following purposes of an Automatic Flight Control System (AFCS): — enhancement of flight controls; — reduction of pilot workload.	x	x				
LO	Define and explain the following two functions of an AFCS: — aircraft control: control of the aeroplane's movement about its centre of gravity (CG); — aircraft guidance: guidance of the aeroplane's CG (flight path).	x	x				
LO	Define and explain 'closed loop' and open loop.	x	x				
LO	Explain that the inner loop is for aircraft control and outer loop is for aircraft guidance.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	List the following different elements of a closed-loop control system and explain their function: — input signal; — error detector; — signal processing (computation of output signal according to control laws); — output signal; — control element; — feedback signal.	x	x				
022 06 02 00	**Autopilot system: design and operation**						
LO	Define the three basic control channels.	x	x				
LO	List the following different types of autopilot systems: 1-axis, 2-axis and 3-axis.	x	x				
LO	List and describe the main components of an autopilot system.	x	x				
LO	Explain and describe the following lateral modes: roll, heading, VOR/LOC, NAV or LNAV.	x	x				
LO	Describe the purpose of control laws for pitch and roll modes.	x	x				
LO	Explain and describe the following longitudinal (or vertical) modes: pitch, vertical speed, level change, altitude hold (ALT), profile or VNAV, G/S.	x	x				
LO	Give basic examples for pitch and roll channels of inner loops and outer loops with the help of a diagram.	x	x				
LO	Explain the influence of gain variation on precision and stability.	x	x				
LO	Explain gain adaptation with regard to speed, configuration or flight phase.	x	x				

Syllabus reference	**Syllabus details and associated Learning Objectives**	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Explain and describe the following common (or mixed) modes: take-off, go-around and approach. *Remark: The landing sequence is studied in 022 06 04 00.*	x	x				
LO	List the different types of actuation configuration and compare their advantages/disadvantages.	x	x				
LO	List the inputs and outputs of a 3-axis autopilot system.	x	x				
LO	Describe and explain the synchronisation function.	x	x				
LO	Give examples of engagement and disengagement systems and conditions.	x	x				
LO	Define the 'Control Wheel Steering' (CWS) mode according to CS-25 (see AMC 25.1329, paragraph 4.3).	x	x				
LO	Describe the CWS mode operation.	x	x				
LO	Describe with the help of a control panel of an autopilot system and a flight mode annunciator/indicator the actions and the checks performed by a pilot through a complete sequence: — from Heading (HDG) selection to VOR/LOC guidance (arm/capture/ track); — from Altitude selection (LVL change) to Altitude (ALT) hold (arm/intercept/ hold).	x	x				
LO	Describe and explain the different phases and the associated annunciations/ indications from level change to altitude capture and from heading mode to VOR/ LOC capture.	x	x				

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Describe and explain the existence of operational limits for lateral modes (LOC capture) with regard to speed/angle of interception/distance to threshold, and for longitudinal modes (ALT or G/S capture) with regard to V/S.	x	x				
022 06 03 00	**Flight Director: design and operation**						
LO	State the purpose of a Flight Director (FD) system.	x	x				
LO	List and describe the main components of an FD system.	x	x				
LO	List the different types of display.	x	x				
LO	Explain the differences between an FD system and an Autopilot (AP) system.	x	x				
LO	Explain how an FD and an AP can be used together, separately (AP with no FD, or FD with no AP), or none of them.	x	x				
LO	Give examples of different situations with the respective indications of the command bars.	x	x				
022 06 04 00	**Aeroplane: Flight Mode Annunciator (FMA)**						
LO	Explain the purpose and the importance of the FMA.	x	x				
LO	State that the FMA provides: — AFCS lateral and vertical modes; — auto-throttle modes; — FD selection, AP engagement and automatic landing capacity; — failure and alert messages.	x	x				
022 06 05 00	**Autoland: design and operation**						
LO	Explain the purpose of an autoland system.	x					
LO	List and describe the main components of an autoland system.	x					

Syllabus reference	Syllabus details and associated Learning Objectives	*Aeroplane*		*Helicopter*			*IR*
		ATPL	CPL	ATPL/ IR	ATPL	CPL	
LO	Define the following terms: — ‘fail passive system’; — ‘fail operational’ (fail active) system; — alert height; according to CS-AWO.	x					
LO	Describe and explain the autoland sequence and the associated annunciations/indications from initial approach to roll-out (AP disengagement) or go-around.	x					
LO	List and explain the operational limitations to perform an autoland.	x					
022 07 00 00	**HELICOPTER: AUTOMATIC FLIGHT CONTROL SYSTEMS**						
022 07 01 00	**General principles**						
022 07 01 01	**Stabilisation**						
LO	Explain the similarities and differences between SAS and AFCS (the latter can actually fly the helicopter to perform certain functions selected by the pilot). Some AFCSs just have altitude and heading hold whilst others include a vertical speed or IAS hold mode, where a constant rate of climb/decent or IAS is maintained by the AFCS.			x	x	x	
022 07 01 02	**Reduction of pilot workload**						
LO	Appreciate how effective the AFCS is in reducing pilot workload by improving basic aircraft control harmony and decreasing disturbances.			x	x	x	

022 07 01 03	**Enhancement of helicopter capability**						
LO	Explain how an AFCS improves helicopter flight safety during: — search and rescue because of increased capabilities; — flight by sole reference to instruments; — underslung load operations; — white-out conditions in snow-covered landscapes; — an approach to land with lack of visual cues.			x	x	x	
LO	Explain that the Search and Rescue (SAR) modes of AFCS include the following functions: — ability to autohover; — automatically transition down from cruise to a predetermined point or over-flown point; — ability for the rear crew to move the helicopter around in the hover; — the ability to automatically transition back from the hover to cruise flight; — the ability to fly various search patterns.			x	x	x	
LO	Explain that the earlier autohover systems use Doppler velocity sensors and the later systems use inertial sensors plus GPS, and normally include a two-dimensional hover-velocity indicator for the pilots.			x	x	x	
LO	Explain why some SAR helicopters have both radio-altimeter height hold and barometric altitude hold.			x	x	x	
022 07 01 04	**Failures**						
LO	Explain the various redundancies and independent systems that are built into the AFCSs.			x	x	x	
LO	Appreciate that the pilot can override the system in the event of a failure.			x	x	x	
LO	Explain a series actuator 'hard over' which equals aircraft attitude runaway.			x	x	x	

LO	Explain the consequences of a saturation of the series actuators.			x	x	x	
022 07 02 00	**Components: Operation**						
022 07 02 01	**Basic sensors**						
LO	Explain the basic sensors in the system and their functions.			x	x	x	
LO	Explain that the number of sensors will be dependent on the number of couple modes of the system.			x	x	x	
022 07 02 02	**Specific sensors**						
LO	Explain the function of the microswitches and strain gauges in the system which sense pilot input to prevent excessive feedback forces from the system.			x	x	x	
022 07 02 03	**Actuators**						
LO	Explain the principles of operation of the series and parallel actuators, spring-box clutches and the autotrim system.			x	x	x	
LO	Explain the principle of operation of the electronic hydraulic actuators in the system.			x	x	x	
022 07 02 04	**Pilot/system interface: control panels, system indication, warnings**						
LO	Describe the typical layout of the AFCS control panel.			x	x	x	
LO	Describe the system indications and warnings.			x	x	x	
022 07 02 05	**Operation**						
LO	Explain the functions of the redundant sensors' simplex and duplex channels (single/dual channel).			x	x	x	
022 07 03 00	**Stability Augmentation System (SAS)**						
022 07 03 01	**General principles and operation**						

LO	Explain the general principles and operation of an SAS with regard to: — rate damping; — short-term attitude hold; — effect on static stability; — effect on dynamic stability; — aerodynamic cross-coupling; — effect on manoeuvrability; — control response; — engagement/disengagement; — authority.			x	x	x	
LO	Explain and describe the general working principles and primary use of SAS by damping pitch, roll and yaw motions.			x	x	x	
LO	Describe a simple SAS with forced trim system which uses magnetic clutch and springs to hold cyclic control in the position where it was last released.			x	x	x	
LO	Explain the interaction of trim with SAS/Stability and Control Augmentation System (SCAS).			x	x	x	
LO	Appreciate that the system can be overridden by the pilot and individual channels deselected.			x	x	x	
LO	Describe the operational limits of the system.			x	x	x	
LO	Explain why the system should be turned off in severe turbulence or when extreme flight attitudes are reached.			x	x	x	
LO	Explain the safety design features built into some SASs to limit the authority of the actuators to 10–20 % of the full-control throw in order to allow the pilot to override if actuators demand an unsafe control input.			x	x	x	
LO	Explain how cross-coupling produces an adverse effect on roll to yaw coupling, when the helicopter is subject to gusts.			x	x	x	
LO	Explain the collective-to-pitch coupling, side-slip-to-pitch coupling and inter-axis coupling.			x	x	x	

022 07 04 00	**Autopilot — Automatic stability equipment**						
022 07 04 01	**General principles**						
LO	Explain the general autopilot principles with regard to: — long-term attitude hold; — fly-through; — changing the reference (beep trim, trim release).			x	x	x	
022 07 04 02	**Basic modes (3/4 axes)**						
LO	Explain the AFCS operation on cyclic axes (pitch/roll), yaw axis, and on collective (fourth axis).			x	x	x	
022 07 04 03	**Automatic guidance (upper modes of AFCS)**						
LO	Explain the function of the attitude-hold system in an AFCS.			x	x	x	
LO	Explain the function of the heading-hold system in an AFCS.			x	x	x	
LO	Explain the function of the vertical-speed hold system in an AFCS.			x	x	x	
LO	Explain the function of the navigation-coupling system in an AFCS.			x	x	x	
LO	Explain the function of the VOR/ILS-coupling system in an AFCS.			x	x	x	
LO	Explain the function of the hover-mode system in an AFCS (including Doppler and radio altimeter systems).			x	x	x	
LO	Explain the function of the SAR mode (automatic transition to hover and back to cruise) in an AFCS.			x	x	x	
022 07 04 04	**Flight Director: design and operation**						
LO	Explain the purpose of a Flight Director (FD) system.			x	x	x	
LO	List the different types of display.			x	x	x	

LO	State the difference between the FD system and the autopilot system. Explain how each can be used independently.			x	x	x	
LO	List and describe the main components of an FD system.			x	x	x	
LO	Give examples of different situations with the respective indications of the command bars.			x	x	x	
LO	Explain the architecture of the different FDs fitted to helicopters and the importance to monitor other instruments as well as the FD, because on some helicopter types which have the collective setting on the FD, there is no protection against a collective transmission overtorque.			x	x	x	
LO	Describe the collective setting and yaw depiction on FD for some helicopters.			x	x	x	
022 07 04 05	**Automatic Flight Control Panel (AFCP)**						
LO	Explain the purpose and the importance of the AFCP.			x	x	x	
LO	State that the AFCP provides: — AFCS basic and upper modes; — FD selection, SAS and AP engagement; — failure and alert messages.			x	x	x	
022 08 00 00	**TRIMS — YAW DAMPER — FLIGHT-ENVELOPE PROTECTION**						
022 08 01 00	**Trim systems: design and operation**						
LO	Explain the purpose of the trim system.	x	x				
LO	State the existence of a trim system for each of the three axes.	x	x				
LO	Give examples of trim indicators and their function.	x	x				
LO	Describe and explain an automatic pitch-trim system for a conventional aeroplane.	x	x				
LO	Describe and explain an automatic pitch-trim system for a fly-by-wire aeroplane.	x					

LO	State that for a fly-by-wire aeroplane the automatic pitch-trim system operates also during manual flight.	x					
LO	Describe the consequences of manual operation on the trim wheel when the automatic pitch-trim system is engaged.	x	x				
LO	Describe and explain the engagement and disengagement conditions of the autopilot according to trim controls.	x	x				
LO	Define 'Mach trim' and state that the Mach-trim system can be independent.	x	x				
LO	State that for a fly-by-wire aeroplane an autotrim system can be available for each of the three axes. *Remark: For the fly-by-wire LOs, please refer to reference 21.5.4.0.*	x	x				
022 08 02 00	**Yaw damper: design and operation**						
LO	Explain the purpose of the yaw-damper system.	x	x				
LO	List and describe the main components of a yaw-damper system.	x	x				
LO	Explain the purpose of the Dutch-roll filter (filtering of the yaw input signal).	x	x				
LO	Explain the operation of a yaw-damper system and state the difference between a yaw-damper system and a 3-axis autopilot operation on the rudder channel.	x	x				
022 08 03 00	**Flight-Envelope Protection (FEP)**						
LO	Explain the purpose of the FEP.	x					
LO	List the input parameters of the FEP.	x					
LO	Explain the following functions of the FEP: — stall protection, — overspeed protection.	x					

LO	State that the stall protection function and the overspeed protection function apply to both mechanical/conventional and fly-by-wire control systems, but other functions (e.g. pitch or bank limitation) can only apply to fly-by-wire control systems.	x					

022 09 00 00	**AUTO-THROTTLE — AUTOMATIC THRUST CONTROL SYSTEM**						
LO	State the purpose of the auto-throttle (AT) system.	x					
LO	Explain the operation of an AT system with regard to the following modes: — take-off/go-around; — climb or Maximum Continuous Thrust (MCT): N1 or EPR targeted; — speed; — idle thrust; — landing ('flare' or 'retard').	x					
LO	Describe the control loop of an AT system with regard to: — inputs: mode selection unit and switches (disengagement and engagement: TO-GA switches), radio altitude, air–ground logic switches; — error detection: comparison between reference values (N1 or EPR, speed) and actual values; — signal processing (control laws of the thrust-lever displacement according to error signal); — outputs: AT servo-actuator; — feedback: Thrust Lever Angle (TLA), data from ADC (TAS, Mach number), engine parameters (N1 or EPR).	x					
LO	State the existence of AT systems where thrust modes are determined by the lever position (no thrust mode panel or thrust rating panel, no TOGA switches).	x					
LO	Explain the limitations of an AT system in case of turbulence.	x					
022 10 00 00	**COMMUNICATION SYSTEMS**						
022 10 01 00	**Voice communication, data link transmission**						
022 10 01 01	**Definitions and transmission modes**						
LO	State the purpose of a data link transmission system.	x					
LO	Compare voice communication versus data link transmission systems.	x					

LO	State that VHF, HF and SATCOM devices can be used for voice communication and data link transmission.	x					
LO	State the advantages and disadvantages of each transmission mode with regard to: — range; — line-of-sight limitations; — quality of the signal received; — interference due to ionospheric conditions; — data transmission speed.	x					
LO	State that the satellite communication networks do not cover extreme polar regions.	x					
LO	Define ‘downlink and uplink communications’.	x					
LO	State that a D-ATIS is an ATIS message received by data link.	x					
022 10 01 02	**Systems: Architecture, design and operation**						
LO	Name the two following data link service providers: — SITA, — ARINC, and state their function.	x					
LO	Describe the ACARS network.	x					
LO	Describe the two following systems using the VHF/HF/SATCOM data link transmission: — Aircraft Communication Addressing and Reporting System (ACARS); — Air Traffic Service Unit (ATSU).	x					

LO	List and describe the following possible onboard components of an ATSU: — communications management unit (VHF/HF/SATCOM); — Data Communication Display Unit (DCDU); — Multi-Control Display Unit (MCDU) for AOC, ATC and messages from the crew (downlink communication); — ATC message visual warning; — printer.	x					
LO	Give examples of Airline Operations Communications (AOC) data link messages such as: — Out of the gate, Off the ground, On the ground, Into the gate (OOOI); — load sheet; — passenger information (connecting flights); — weather reports (METAR, TAF); — maintenance reports (engine exceedances); — free-text messages.	x					
LO	Give examples of Air Traffic Communications (ATC) data link messages such as: — departure clearance, — oceanic clearance.	x					
022 10 02 00	**Future Air Navigation Systems (FANS)**						
LO	State the existence of the ICAO Communication, Navigation, Surveillance/ Air Traffic Management (CNS/ATM) concept.	x					
LO	Define and explain the 'FANS concept' (including FANS A and FANS B).	x					
LO	State that FANS A uses the ACARS network.	x					
LO	List and explain the following FANS A applications: — ATS Facility Notification (AFN); — Automatic Dependent Surveillance (ADS); — Controller–Pilot Data Link Communications (CPDLC).	x					

LO	Compare the ADS application with the secondary surveillance radar function, and the CPDLC application with VHF communication systems.	x					
LO	State that an ATC centre can use the ADS application only, or the CPDLC application only, or both of them (not including AFN).	x					
LO	Describe a notification phase (LOG ON) and state its purpose.	x					
LO	List the different types of messages of the CPDLC function and give examples of CPDLC data link messages.	x					
LO	List the different types of ADS contracts: — periodic, — on demand, — on event, — emergency mode.	x					
LO	State that the controller can modify the 'periodic', 'on demand' and 'on event' contracts or the parameters of these contracts (optional data groups), and that these modifications do not require crew notification.	x					
LO	Describe the 'emergency mode'.	x					
022 11 00 00	**FLIGHT MANAGEMENT SYSTEM (FMS)**						
LO	*Remark: The use of an FMS as a navigation system is detailed in Radio Navigation (062), reference 062 05 04 00.*						
022 11 01 00	**Design**						
LO	State the purpose of an FMS.	x		x	x		
LO	Describe a typical dual FMS architecture.	x		x	x		
LO	Describe the different possible configurations of this architecture during degraded modes of operation.	x		x	x		

LO	List the possible inputs and outputs of an FMS. *Remark: No standard of FMS can be given because the FMS is type specific for aircraft manufacturers and the FMS standard is defined by the airline customer.*	x		x	x		
LO	Describe the interfaces of the FMS with AFCS.	x		x	x		
LO	Describe the interfaces of the FMS with the AT system.	x					
022 11 02 00	**Navigation database, aircraft database**						
LO	Describe the contents and the main features of the navigation database and of the aircraft database: read-only information, updating cycle.	x		x	x		
LO	Define and explain the 'performance factor'.	x		x	x		
022 11 03 00	**Operations, limitations**						
LO	List and describe data computation and functions including position computations (multisensors), flight management, lateral/vertical navigation and guidance.	x		x	x		
LO	State the difference between computations based on measured data (use of sensors) and computations based on database information and give examples.	x		x	x		
LO	Define and explain the 'Cost Index' (CI).	x					
LO	Describe navigation accuracy computations and approach capability, degraded modes of operation: back-up navigation, use of raw data to confirm position/RAIM function for RNAV procedures.	x		x	x		
LO	Describe fuel computations with standard and non-standard configurations including one engine out, landing gear down, flaps, spoilers, use of the anti-icing system, increase of consumption due to an MEL/CDL item, etc.	x		x	x		

LO	Describe automatic radio navigation and tuning (COMM, NAV).	x		x	x		
022 11 04 00	**Man–machine interface (Multifunction Control Display Unit (MCDU))**						
LO	Give examples and describe the basic functions of the man–machine interface (MCDU).	x		x	x		
022 12 00 00	**ALERTING SYSTEMS, PROXIMITY SYSTEMS**						
022 12 01 00	**General**						
LO	State definitions, category, criteria and characteristics of alerting systems according to CS 25/AMJ 25.1322 for aeroplanes and CS-29 for helicopters as appropriate.	x	x	x	x	x	
022 12 02 00	**Flight Warning Systems (FWS)**						
LO	State the purpose of an FWS and list the typical sources (abnormal situations) of a warning and/or an alert.	x		x	x	x	
LO	List the main components of an FWS.	x		x	x	x	
022 12 03 00	**Stall Warning Systems (SWS)**						
LO	State the function of an SWS.	x	x				
LO	State the characteristics of an SWS according to CS 25.207(c).	x	x				
LO	List the different types of stall warning systems.	x	x				
LO	List the main components of an SWS.	x	x				
LO	List the inputs and outputs of an SWS.	x	x				
022 12 04 00	**Stall protection**						
LO	State the function of a stall protection system.	x					
LO	List the different types of stall protection systems including the difference between mechanical and fly-by-wire controls.	x					
LO	List the main components of a stall protection system.	x					

LO	List the inputs and outputs of a stall protection system.	x					
LO	Explain the difference between a stall warning system and a stall protection system.	x					
022 12 05 00	**Overspeed warning**						
LO	Explain the purpose of an overspeed warning system (VMO/MMO pointer).	x	x				
LO	Explain the design of a mechanical VMO/ MMO pointer.	x	x				
LO	State that for large aeroplanes, an aural warning must be associated to the overspeed warning if an electronic display is used (see AMC 25.11, paragraph 10.b(2), p. 2-GEN-22).	x	x				
LO	Give examples of VMO/MMO pointer: barber pole pointer, barber pole vertical scale.	x	x				
022 12 06 00	**Take-off warning**						
LO	State the purpose of a take-off warning system and list the typical abnormal situations which generate a warning (see AMC 25.703, paragraphs 4 and 5).	x					
022 12 07 00	**Altitude alert system**						
LO	State the function and describe an altitude alert system.	x	x	x	x	x	x
LO	List and describe the different types of displays and possible alerts.	x	x	x	x	x	x
022 12 08 00	**Radio altimeter**						
LO	State the function of a low-altitude radio altimeter.	x	x	x	x	x	x
LO	Describe the principle of the distance (height) measurement.	x	x	x	x	x	x
LO	State the bandwidth and frequency range used.	x	x	x	x	x	x

LO	List the different components of a radio altimeter and describe the different types of displays.	x	x	x	x	x	x
LO	List the systems using radio-altimeter information.	x	x	x	x	x	x
LO	State the range and accuracy of a radio altimeter.	x	x	x	x	x	x
LO	Describe and explain the cable-length compensation.	x	x	x	x	x	x
022 12 09 00	**Ground-proximity warning systems (GPWS)**						
022 12 09 01	**GPWS: design, operation, indications**						
LO	State the purpose of a ground-proximity warning system (GPWS).	x		x	x		
LO	List the components of a GPWS.	x		x	x		
LO	List the inputs and outputs of a GPWS.	x		x	x		
LO	List and describe the different modes of operation of a GPWS.	x		x	x		
022 12 09 02	**Terrain-Avoidance Warning System (TAWS), other name: Enhanced GPWS (EGPWS)**						
LO	State the purpose of a TAWS for aeroplanes and HTAWS for helicopters and explain the difference from a GPWS.	x		x	x		
LO	List the components of a TAWS/ HTAWS.	x		x	x		
LO	List the inputs and outputs of a TAWS/ HTAWS.	x		x	x		
LO	Give examples of terrain displays and list the different possible alerts.	x		x	x		
LO	Give examples of time response left to the pilot according to look-ahead distance, speed and aircraft performances.	x		x	x		
LO	Explain why the TAWS/HTAWS must be coupled to a precise-position sensor.	x		x	x		
022 12 09 03	**Runway awareness and advisory system** (to be introduced at a later date)						

LO	Explain that a runway awareness and advisory system is a software upgrade of the existing TAWS (EGPWS) to reduce runway incursions.	x					
022 12 10 00	**ACAS/TCAS principles and operations**	x	x	x	x	x	x
LO	State that ACAS II is an ICAO standard for anti-collision purposes.	x	x	x	x	x	x
LO	State that TCAS II version 7 is compliant with the ACAS II standard.	x	x	x	x	x	x
LO	Explain that ACAS II is an anti-collision system and does not guarantee any specific separation.	x	x	x	x	x	x
LO	Describe the purpose of an ACAS II system as an anti-collision system.	x	x	x	x	x	x
LO	Define a ‘Resolution Advisory’ (RA) and a ‘Traffic Advisory’ (TA).	x	x	x	x	x	x
LO	State that RAs are calculated in the vertical plane only (climb or descent).	x	x	x	x	x	x
LO	Explain the difference between a corrective RA and a preventive RA (no modification of vertical speed).	x	x	x	x	x	x
LO	Explain that if two aircraft are fitted with ACAS II, the RA will be coordinated.	x	x	x	x	x	x
LO	State that ACAS II equipment can take into account several threats simultaneously.	x	x	x	x	x	x
LO	State that a detected aircraft without altitude-reporting can only generate a TA.	x	x	x	x	x	x
LO	Describe the TCAS II system in with regard to: — antenna used; — computer and links with radio altimeter, air-data computer and mode-S transponder.	x	x	x	x	x	x
LO	Identify the inputs and outputs of TCAS II.	x	x	x	x	x	x
LO	Explain the principle of TCAS II interrogations.	x	x	x	x	x	x
LO	State that the standard detection range is approximately 30 NM.	x	x	x	x	x	x

LO	State that the normal interrogation period is 1 second.	x	x	x	x	x	x
LO	Explain the principle of 'reduced surveillance'.	x	x	x	x	x	x
LO	Explain that in high-density traffic areas the period can be extended to 5 seconds and the transmission power reduction can reduce the range detection down to 5 NM.	x	x	x	x	x	x
LO	Identify the equipment which an intruder must be fitted with in order to be detected by TCAS II.	x	x	x	x	x	x
LO	Explain in the anti-collision process: — that the criteria used to trigger an alarm (TA or RA) are the time to reach the closest point of approach (called TAU) and the difference of altitude; — that an intruder will be classified as 'proximate' when being less than 6 NM and 1 200 ft from the TCAS-equipped aircraft; — that the time limit to CPA is different depending on aircraft altitude, is linked to a sensitivity level (SL), and state that the value to trigger an RA is from 15 to 35 seconds; — that, in case of an RA, the intended vertical separation varies from 300 to 600 ft (700 ft above FL420), depending on the SL; — that below 1 000 ft above ground, no RA can be generated; — that below 1 450 ft (radio-altimeter value) 'increase descent' RA is inhibited; — that, in high altitude, performances of the type of aircraft are taken into account to inhibit 'climb' and 'increase climb' RA.	x	x	x	x	x	x

LO	List and interpret the following information available from TCAS: — the different possible statuses of a detected aircraft: other, proximate, intruder; — the appropriate graphic symbols and their position on the horizontal display; — different aural warnings.	x	x	x	x	x	x
LO	Explain that an RA is presented as a possible vertical speed on a TCAS indicator or on the Primary Flight Display (PFD).	x	x	x	x	x	x
LO	Describe the possible presentation of an RA on a VSI or on a PFD.	x	x	x	x	x	x
LO	Explain that the pilot must not interpret the horizontal track of an intruder upon the display.	x	x	x	x	x	x
022 12 11 00	**Rotor/engine overspeed alert system**						
022 12 11 01	**Design, operation, displays, alarms**						
LO	Describe the basic design principles, operation, displays and warning/alarm systems fitted to different helicopters.			x	x	x	
022 13 00 00	**INTEGRATED INSTRUMENTS — ELECTRONIC DISPLAYS**						
022 13 01 00	**Electronic display units**						
022 13 01 01	**Design, limitations**						
LO	List the different technologies used, e.g. CRT and LCD, and the associated limitations: — cockpit temperature, — glare.	x	x	x	x	x	x
022 13 02 00	**Mechanical integrated instruments: Attitude and Director Indicator (ADI)/Horizontal Situation Indicator (HSI)**						
LO	Describe an ADI and an HSI.	x	x	x	x	x	x
LO	List all the information that can be displayed for either instruments.	x	x	x	x	x	x
022 13 03 00	**Electronic Flight Instrument Systems (EFIS)**						

	Remarks: *1 — The use of EFIS as navigation display system is also detailed in Radio Navigation (062), reference 062 05 05 02 (EFIS instruments).* *2 — Reference to AMC 25-1322 can be used for aeroplanes only.*						
022 13 03 01	**Design, operation**						
LO	List and describe the different components of an EFIS.	x	x	x	x	x	x
LO	List the following possible inputs and outputs of an EFIS: — control panel, — display units, — symbol generator, — remote-light sensor.	x	x	x	x	x	x
LO	Describe the function of the symbol generator unit.	x	x	x	x	x	x
022 13 03 02	**Primary Flight Display (PFD), Electronic Attitude Director Indicator (EADI)**						
LO	State that a PFD (or an EADI) presents a dynamic colour display of all the parameters necessary to control the aircraft.	x	x	x	x	x	x

LO	List and describe the following information that can be displayed on the PFD unit of an aircraft: — flight mode annunciation; — basic T: • attitude, • IAS, • altitude, • heading/track indications; — vertical speed; — maximum-airspeed warning; — selected airspeed; — speed-trend vector; — selected altitude; — current barometric reference; — steering indications (FD command bars); — selected heading; — flight path vector (FPV); — radio altitude; — decision height; — ILS indications; — ACAS (TCAS) indications; — failure flags and messages.	x	x	x	x	x	x
LO	List and describe the following information that can also be displayed on the PFD unit of an aeroplane: — take-off and landing reference speeds; — minimum airspeed; — lower selectable airspeed; — Mach number.	x					
022 13 03 03	**Navigation Display (ND), Electronic Horizontal Situation Indicator (EHSI)**						
LO	State that an ND (or an EHSI) provides a mode-selectable colour flight navigation display.	x	x	x	x	x	x
LO	List and describe the following four modes displayed on an ND unit: — MAP (or ARC), — VOR (or ROSE VOR), — APP (or ROSE LS), — PLAN.	x	x	x	x	x	x

LO	List and explain the following information that can be displayed with the MAP (or ARC) mode on an ND unit: — selected and current track; — selected and current heading (magnetic or true-north reference); — cross-track error; — origin and destination airport with runway selected; — bearings to or from the tuned and selected stations; — active and/or secondary flight plan; — range marks; — ground speed; — TAS and ground speed; — wind direction and speed; — next-waypoint distance and estimated time of arrival; — additional navigation facilities (STA), waypoint (WPT) and airports (ARPT); — weather radar information; — traffic information from the ACAS (TCAS); — terrain information from the TAWS or HTAWS (EGPWS); — failure flags and messages.	x	x	x	x	x	x
LO	List and explain the following information that can be displayed with the VOR/APP (or ROSE VOR/ROSE LS) mode on an ND unit: — selected and current track; — selected and current heading (magnetic or true-north reference) — VOR course or ILS localizer course — VOR (VOR or ROSE VOR mode) or LOC course deviation (APP or ROSE LS); — glide-slope pointer (APP or ROSE LS); — frequency or identifier of the tuned station; — ground speed; — TAS and ground speed; — wind direction and speed; — failure flags and messages.	x	x	x	x	x	x

LO	List and explain the following information that can be displayed with the PLAN mode on an ND unit: — selected and current track; — origin and destination airport with runway selected; — active and/or secondary flight plan; — range marks; — ground speed; — TAS and ground speed; — wind direction and speed; — next-waypoint distance and estimated time of arrival; — additional navigation facilities (STA), waypoint (WPT) and airports (ARPT); — failure flags and messages.	x	x				
LO	Give examples of possible transfers between units.	x	x	x	x	x	x
LO	Give examples of EFIS control panels.	x	x	x	x	x	x
022 13 04 00	**Engine parameters, crew warnings, aircraft systems, procedure and mission display systems**						
LO	State the purpose of the following systems: — engine instruments centralised display unit; — crew alerting system associated with an electronic checklist display unit; — that the aircraft systems display unit enables the display of normal and degraded modes of operation of the aircraft systems.	x		x	x		
LO	Describe the architecture of each system and give examples of display.	x		x	x		
LO	Give the following different names by which engine parameters, crew warnings, aircraft systems and procedures display systems are known: — Multifunction Display Unit (MFDU); — Engine Indication and Crew Alerting Systems (EICAS); — Engine and Warning Display (EWD); — Electronic Centralised Aircraft Monitor (ECAM).	x					

	LO	Give the names of the following different display systems and describe their main functions: — Vehicle Engine Monitoring Display (VEMD); — Integrated Instruments Display System (IIDS).			x	x		
	LO	State the purpose of a mission display unit.			x	x		
	LO	Describe the architecture of each system and give examples of display.			x	x		
022 13 05 00		**Engine first limit indicator**						
	LO	Describe the principles of design and operation, and compare the different indications and displays available.			x	x	x	
	LO	Describe what information can be displayed on the screen, when in the limited screen composite mode.			x	x	x	
022 13 06 00		**Electronic Flight Bag (EFB)** (to be introduced at a later date)						
022 14 00 00		**MAINTENANCE, MONITORING AND RECORDING SYSTEMS**						
	LO	State the basic technologies used for this equipment and its performances. *Remark: No knowledge of the applicable operational requirements is necessary.*	x	x	x	x	x	x
022 14 01 00		**Cockpit Voice Recorder (CVR)**						
	LO	State the purpose of a CVR.	x					
	LO	List the main components of a CVR: — a shock-resistant tape recorder associated with an underwater locating device; — an area microphone; — a control unit with the following controls: auto/on, test and erase, and a headset jack.	x					

LO	List the following main parameters recorded on the CVR: — voice communications transmitted from or received on the flight deck; — the aural environment of the flight deck; — voice communication of flight crew members using the aeroplane's interphone system; — voice or audio signals introduced into a headset or speaker; — voice communication of flight crew members using the public address system, when installed.	x					
022 14 02 00	**Flight Data Recorders (FDR)**						
LO	State the purpose of an FDR.	x					
LO	List the main components of an FDR: — a data interface and acquisition unit; — a recording system (digital flight data recorder); — two control units (start sequence, event mark setting).	x					
LO	List the following main parameters recorded on the FDR: — time or relative time count; — attitude (pitch and roll); — airspeed; — pressure altitude; — heading; — normal acceleration; — propulsive/thrust power on each engine and cockpit thrust/power lever position, if applicable; — flaps/slats configuration or cockpit selection; — ground spoilers and/or speed brake selection.	x					
LO	State that additional parameters can be recorded according to FDR capacity and the applicable operational requirements.	x					
022 14 03 00	**Maintenance and monitoring systems**						
022 14 03 01	**Helicopter Operations Monitoring Programme (HOMP): design, operation, performance**						

LO	Describe the HOMP as a helicopter version of the aeroplane Flight Data Monitoring (FDM) programmes.			x	x		
LO	State that the HOMP software consists of three integrated modules: — Flight Data Events (FDE); — Flight Data Measurements (FDM); — Flight Data Traces (FDT).			x	x		
LO	Describe and explain the information flow of HOMP.			x	x		
LO	Describe HOMP operation and management processes.			x	x		
022 14 03 02	**Integrated Health & Usage Monitoring System (IHUMS): design, operation, performance**						
LO	Describe the main features of IHUMS: — rotor system health; — cockpit voice recorder/flight data recorder; — gearbox system health; — engine health; — exceedance monitoring; — usage monitoring; — transparent operation; — ground station features; — exceedance monitoring; — monitoring; — gearbox health; — rotor track & balance; — engine performance trending; — usage monitoring; — quality controlled to level 2.			x	x		
LO	Describe the ground station features of IHUMS.			x	x		

LO	Summarise the benefits of IHUMS including: — reduced risk of catastrophic failure of rotor or gearbox; — improved rotor track & balance giving lower vibration levels; — accurate recording of flight exceedances; — cockpit voice recorder/flight data recorder allows accurate accident /incident investigation & HOMP; — maintenance cost savings.			x	x		
LO	State the benefits of IHUMS and HOMP.			x	x		
022 14 03 03	**Aeroplane Condition Monitoring System (ACMS): general, design, operation**						
LO	State the purpose of an ACMS.	x					
LO	Describe the structure of an ACMS including: — inputs: aircraft systems (such as air conditioning, autoflight, flight controls, fuel, landing gear, navigation, pneumatic, APU, engine), MCDU; — data management unit; — recording unit: digital recorder; — outputs: printer, ACARS or ATSU.	x					
LO	State that maintenance messages sent by an ACMS can be transmitted without crew notification.	x					
022 15 00 00	**DIGITAL CIRCUITS AND COMPUTERS**						
022 15 01 00	**Digital circuits and computers: General, definitions and design**						
LO	Define a ‘computer’ as a machine for manipulating data according to a list of instructions.	x		x	x		

LO	List the following main components of a stored-programme ('Von Neumann architecture') on a basic computer: — Central Processing Unit (CPU) including the Arithmetic Logic Unit (ALU) and the control unit; — memory; — input and output devices (peripherals); and state their functions.	x		x	x		
LO	State the existence of the different buses and their function.	x		x	x		
LO	Define the terms 'hardware' and 'software'.	x		x	x		
LO	Define and explain the terms 'multitasking' and 'multiprocessing'.	x		x	x		
LO	With the help of the relevant 022 references, give examples of airborne computers, such as ADC, FMS, GPWS, etc., and list the possible peripheral equipment for each system.	x		x	x		
LO	Describe the principle of the following technologies used for memories: — chip circuit, — magnetic disk, — optical disk.	x		x	x		
022 15 02 00	**Software: General, definitions and certification specifications**						
LO	State the difference between assembly languages, high-level languages and scripting languages.	x		x	x		
LO	Define the term 'Operating System' (OS) and give different examples including airborne systems such as FMS or ATSU (for aeroplanes only).	x		x	x		
LO	State the existence of 'Software Considerations in Airborne Systems and Equipment Certification' (see document referenced RTCA/DO-178B or EUROCAE ED-12B).	x		x	x		

LO	List the specific levels of safety criticality according to the EUROCAE ED-12B document.	x		x	x			