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INTRODUCTION

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 00 00 00	**AIRCRAFT GENERAL KNOWLEDGE – INSTRUMENTATION**						
022 01 00 00	**SENSORS AND INSTRUMENTS**						
022 01 01 00	**Characteristics and General Definitions, Ergonomy, Signal transmission and Indicators.**						
Statement	*In these Learning Objectives an instrument (or instrument system) is considered to consist of the following composing parts: sensor, processor and indicator/actuator. The composing parts are not necesssarily in one housing/casing!*						
	Except where specified, the content of this topic refers to all aircraft systems and not only to the engine. For example, pressure gauges must be described not only for the engine oil system but also for other aircraft systems such as the IDG, the hydraulic system, the pneumatic system including the flight instruments!						
022 01 01 01	Characteristics and General Definitions						
LO	measuring range. sensitivity/resolution. accuracy: relative- and absolute error, systematic- and random error, tolerance. reliability: Failure rate, MTBF, MTBO. Instrument error.						
022 01 01 02	Ergonomy						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Location: • Basic-6/Basic-T, instrument panels. • Avionics bay (E&E bay). Readability: • Eye reference point, parralax, analogue vs digital indicators, circular vs straight scales, linear vs logarithmic scales. Inside-out/outside-in presentation. Coloured arcs: • Green: normal operating (range). • Yellow/amber: caution (range). • Red: (warning). Colour standardisation: • white: status. • Blue: temporary situation. • green: normal, safe. • yellow/amber: caution. • Red: warning. JAR colour code rules JAR-25.						
022 01 01 03	Signal transmission						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Mechanical, pneumatical, hydraulical. Electr(on)ical: • Torque synchro system, synchro-servo system. Digital: • ARINC-429, ARINC-629.						
022 01 01 04	Indicators						
LO	Mechanical: • Gears, levers, rods, axes, pointers etc. Electrical: • Moving coil meter, Ratiometer, Synchro's, Servo driven indicators. Electronical: • 7-segment display, 5x7 display, CRT, LCD.						
022 01 02 00	**Pressure measurement**						
022 01 02 01	Different types, design, operation, characteristics, accuracy						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application) • P = F/A. • Units: inches Mercury (in or “Hg), hecto Pascal (hPa), pounds per square inch (psi), bar, units. • Interrelation between units. • Aircraft (system) and Engine condition- and performance monitoring and control. • Temperature compensation. • Absolute pressure sensor (aneroid), differential pressure sensor. • Low, medium and/or high pressures. • Aircraft (system) pressures: pitot, static, cabin, bleed-air, anti-ice, hydraulic and instrument air. • Engine pressures: MAP, EPR, oil and fuel. Sensors (construction, operating principle, characteristics & error behavior): • Diaphragm, Capsule: deflection, corrugations, stack, elasticity (hysteresis and lag). • Bellows: deflection. • Bourdon tube: deflection. • Quartz crystal: change in electrical resistance (piezo-resistive).	x	x	x	x	x	
022 01 02 02	Manifold Absolute Pressure (MAP)						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Manifold absolute pressure is the absolute pressure in the inlet manifold of a piston engine. • Measure MAP to monitor engine performance. • State MAP is an absolute pressure measurement. Design (construction, operation & characteristics): • MAP supplied capsule or belows that measures against aneroid, ventilated instrument casing, mechanical processing, mechanical indication. Indication & Control: • Mechanicallly driven analogue display calibrated in inches Mercury (“Hg). Error behavior & Cross checks: • Shows QFE when on ground and engines out. • Relation between MAP and engine power: fuel flow and rpm. • Relation between MAP and altitude. • Relation between MAP and turbo-boosted piston engines.						
022 01 02 03	Engine Pressure Ratio (EPR)						

Mise en forme : Puces et numéros

Mise en forme : Puces et numéros

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Syllabus reference	Syllabus details and Learning Objectives	*Aeroplane* ATPL	*Aeroplane* CPL	*Helicopter* ATPL/IR	*Helicopter* ATPL	*Helicopter* CPL	*IR*
LO	General (definition, purpose & application): • Engine Pressure Ratio (EPR) is the ratio between the outlet pressure and the inlet pressure of a jet-engine. • Distinct between the EPR of a fan-jet and the EPR of a straight jet. • Measure EPR for engine performance monitoring and engine control. • Applied in aeroplanes with a gasturbine engine that is EPR controlled. Design (construction, operation & characteristics): • The engine outlet pressure is admitted to a differential pressure sensor which is surrounded by engine inlet pressure. The output of the differential pressure sensor is divided by the output of an absolute pressure sensor that measures engine outlet pressure: (Pt7 – Pt2)/Pt2. • State engine inlet pressure can be measured at the compressor inlet or by the Pitot tube. • State engine outlet pressure can be measured halfway the turbine section, behind the turbine section or behind the fan. • State construction with capsules and (electro)mechanical processor. • State construction with solid state sensors and digital processor (FADEC). • Moving coil meter, servo-driven indicator or electronic display. Indication & Control: • Digital and/or analogue display calibrated in units starting at '1'. • Mention the use of the adjustable EPR setting pointer. Error behavior & Cross checks: • Shows '1' when engine is off.						
022 01 02 04	Oil pressure						

Mise en forme : Puces et numéros

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Syllabus reference	Syllabus details and Learning Objectives	Aeroplane		Helicopter			IR
		ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Measure oil pressure for engine condition monitoring. Design (construction, operation & characteristics): • State construction with bourdon tube and (electro)mechanical processor. • State construction with solid state sensor and digital processor (FADEC). • State construction with pressure switch (diaphragm operated electric contact). • Moving coil meter, servo-driven indicator or electronic display. Indication & Control: • Digital and/or analogue display calibrated in psi. • Electronic engine display system. • Low oil pressure alert. Error behavior & Cross checks: • Low oil pressure may be caused by low oil quantity, failure of oil pump or oil leak. • Low oil pressure may cause damage to engine. • During engine start increasing oil pressure has to be monitored.						
022 01 02 05	Fuel pressure						

Mise en forme : Puces et numéros

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Measure fuel pressure to monitor fuel pump. Design (construction, operation & characteristics): • State construction with bourdon tube and (electro)mechanical processor. • State construction with solid state sensor and digital processor (FADEC). • Moving coil meter, servo-driven indicator or electronic display • State construction with pressure switch (diaphragm operated electric contact). Indication & Control: • (Electro)mechanicallly driven, analogue pointer that shows engine fuel pressure on a vertical or circular scale with green, yellow and red band and graduated in psi. • Electronic engine display system. • Low fuel pressure alert. Error behavior & Cross checks: • Low fuel pressure may be caused by low fuel quantity, failure of fuel pump failure or fuel leak. • Low fuel pressure may cause engine flame out.						
022 01 03 00	**Temperature measurement**						
022 01 03 01	Different types, design, operation, characteristics, accuracy	x	x	x	x	x	

Mise en forme : Puces et numéros

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Temperature change causes alteration of energy state. • Units: Degrees Celsius, degrees Fahrenheit, Kelvin and units. • Interrelation between units. • Aircraft (system) and Engine condition- and performance monitoring and control. • Aircraft (system) temperatures: compartment, component, OAT, SAT, TAT and tank. • Engine temperatures: CHT, Carburetor, EGT, ITT, TIT, TGT, fuel and oil. Sensors (construction, operating principle, characteristics & error behavior): • Vapor-pressure thermometer: relation between temperature and pressure for a fixed Volume. • Bi-metallic thermometer: expansion/contraction, spiral wound or contact. • Thermistor/Semiconductor: change of electrical resistance (NTC/PTC). • Thermocouple: thermo-electric effect (Seebeck effect) causes a potential difference (voltage), cold junction compensation. • Infrared sensor: heat radiation.						
022 01 03 02	Cylinder Head Temperature (CHT)	x	x	x	x	x	

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Cylinder head temperature is the temperature of the cylinder head of a piston engine. • Measure and show the CHT for engine condition monitoring. • Application in air-cooled piston-engine driven aircraft. • Usually measured at one (hottest) cylinder: cylinder that receives the least cooling. Design (construction, operation & characteristics): • Thermocouple sensor on hottest cylinder. • Electrical processing. • Moving coil meter type indicator. Indication & Control: • (Electro)mechanicallly driven, analogue pointer that shows CHT along scale graduated in degrees C or F. Error behavior & Cross checks: • Do not use engine power when CHT is too low. • Too high CHT may be an indication of engine cooling problems. • Too high CHT may cause mechanical damage to engine. • Relation between power and CHT.						
022 01 03 03	Exhaust Gas Temperature (EGT) piston engine						

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • EGT is the temperature of the gases that leave the exhaust of a piston or gasturbine engine. • Measure and show the EGT for engine condition monitoring. • To allow fuel/air mixture control in order to safe fuel flow. • Application in piston engine driven aircraft. Design (construction, operation & characteristics): • Thermocouple in exhaust. • Electrical processing. • Moving coil meter type indicator. Indication & Control: • (Electro)mechanicallly driven, analogue pointer that shows EGT on scale graduated in markings with a maximum EGT marking in the form of an asterisk. • Control via the mixture lever. Error behavior & Cross checks: • State the relation between fuel/air mixture and EGT. • State the relation between power and EGT						
022 01 03 04	Carburetor temperature						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Carburetor temperature is the temperature of the carburetor of a piston engine. • Measure and show whether the carburetor tenmperature is in the icing range or not. • To allow the pilot to select the carburetor heating on when the carburetor temperature is in the icing range. • Application in piston engine driven aircraft with a carburetor. Design (construction, operation & characteristics): • Thermistor on carberetor. • Electrical processing. • Moving coil meter type indicator. Indication & Control: • Analogue display calibrated in degrees C or F. • Control via carburetor heating switch/lever. Error behavior & Cross checks: • State the consequence of carburetor ice.						
022 01 03 05	Gas temperatures (EGT, ITT, TIT and TGT) gasturbine engine						

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • EGT is the exhaust gas temperature: the temperature of the gases at the exhaust of piston and gasturbine engine. • ITT is the inter-turbine temperature: the temperature of the gases between the HP and LP turbine. • TIT is the turbine inlet temperature: the temperature of the gases that enter the turbine. • TGT is the total gas temperature: the total temperature of the gases that leave the engine. • EGT, ITT, TIT or TGT is a measure for engine condition monitoring and control. Design (construction, operation & characteristics): • Ring of parallel thermocouples, electr(on)ical processing, moving coil meter or servo driven indicator. • Infrared sensor, digital processing and electronic display. Indication & Control: • Digital and/or analogue display with scale calibrated in degrees Celsius. • Maximum EGT pointer (trailing pointer). • Overheat alert. Error behavior & Cross checks: • A too high EGT may cause mechanical damage to the engine . • State the relation between egine power and EGT. • State some engines are limited by EGT pressure may cause damage to engine.						
022 01 03 06	Fuel temperature						

Mise en forme : Puces et numéros

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Syllabus reference	Syllabus details and Learning Objectives	*Aeroplane* ATPL	*Aeroplane* CPL	*Helicopter* ATPL/IR	*Helicopter* ATPL	*Helicopter* CPL	*IR*
LO	Definition, purpose & application: • Temperature of fuel in the tank and/or in the fuel line. • To allow detection of possible icing. • Wing type fuel tanks of aeroplanes that fly in the upper parts of the troposphere. Design, construction, operation, characteristics: • Thermistors, electr(on)ical processing, moving coil meter, ratiometer or alert light. Indication, control: • Discrete or analogue display with scale graduated in degrees C or F. • Discrete low fuel temperature alert. Error behavior, accuracy, cross checks: • Low fuel temperature may cause any water to freeze which in turn may cause fuel starvation. • Prolonged flights at high altitudes may cause low fuel temperatures.						
022 01 03 07	Oil temperature						

Mise en forme : Puces et numéros

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		Aeroplane		Helicopter			IR
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • Temperature of the oil in the oil tank. • Engine (oil system) condition monitoring. • All engine driven aircraft. Construction, operation, characteristics: • Thermistor, electr(on)ical processing and -indicator. • Bi-metallic switch, electrical processing, discrete alert. Indication & Control: • Analogue display calibrated in degrees C. • High oil temperature alert. Error behavior, accuracy & cross checks: • High oil temperature may be caused by failure of the oil cooling system. • Low oil temperature will decrease performance of oil cooling and lubrication system. • In many engine use is made of a fuel cooled oil cooler. Fuel is heated by cooling engine oil. A failure of the oil cooler affects the fuel heater.						
022 01 04 00	**Quantity measurement**						
022 01 04 01	Different types, design, operation, characteristics, accuracy						

Mise en forme : Puces et numéros

Supprimé : Fuel gauge

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (Definition, Purpose & Application): • Quantity measurement based on measurement of level (height). • Level converted into volume units (small aeroplanes) or mass units (large aeroplanes). • Volume is height times surface area (V = h.A). • Mass is volume times density (m = ρ.V). • Units: Liter (l), Gallon (gal), kilogram (kg), pound (lb) and units. (quart, pint) • Interrelation between units. • Determination of operational status of aircraft. • Liquid level depends on temperature, aircraft attitude and on accelerations. • Aircraft system quantities: fuel (individual and total), hydraulic and water. • Engine system quantities: engine oil, IDG oil, water/methanol system. Sensors (Construction, operating principle, characteristics & error behavior): • Inspection window: visual. • D(r)ipstick: measurement of height/level with help of cohesion forces. • Float: float operated potentiometer or reed switches. • Capacitor: change of electrical capacity (C = .A/d). • Ultrasonic probe: measurement of frequency.						
022 01 04 02	Fuel quantity indicating system	x	x	x	x	x	

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Syllabus reference	Syllabus details and Learning Objectives	Aeroplane ATPL	Aeroplane CPL	Helicopter ATPL/IR	Helicopter ATPL	Helicopter CPL	IR
LO	General (definition, purpose & application): • Fuel quantity is the amount of fuel in the tanks of the aircraft. • Fuel quantity for aircraft performance monitoring. • Since volume depends on temperature, mass is a better parameter for amount of energy. Design (construction, operation & characteristics): • D(r)ipsticks: Several sticks per tank, access, calibration in volume units, mass units or just units. • Float: One float per tank, electrical processing, moving coil meter/ratiometer. • Capacitors: Several capacitors per tank, reference capacitor, temperature compensation, densitometer, electronic processing, servo-driven indicator. • Ultrasonic probes: Several probes per tank, electronic processing, electronic indication. Indication & Control: • Digital and/or analogue display of individual and/or total fuel quantity calibrated in liters, gallons, pounds or kilograms. • Total fuel quantity is also transferred to the FMS. Error behavior & Cross checks: • Consequence of water in the tank. • Consequence of different fuel densities (stratification) + solution (mixers) • Effect of aircraft attitude changes + solution (baffle plates). • Effect of aircraft accelerations. • Initial fuel quantity minus FMS calculated fuel burn should reflect total fuel quantity.						
022 01 04 03	Engine oil quantity						

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Measure oil quantity for engine condition monitoring. • Measure of oil cooling and lubrication system Design (construction, operation & characteristics): • Dipstick + visual inspection. • Float and reed switches and electr(on)ical processor and electr(on)ical indicator. Indication & Control: • Digital and/or analogue display calibrated in units, liters, gallons, quarts or pints. Error behavior & Cross checks: • Low oil quantity may cause engine cooling and lubrication problems and subsequent engine damage. • Low oil quantity may be caused by oil leak or high oil consumption of engine. • Oil quantity has to be checked before engine start.						
022 01 05 00	**Flow measurement**						
022 01 05 01	Different types, design, operation, characteristics, accuracy						

Mise en forme : Puces et numéros

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • a.k.a. consumption gauge. • Flow measurement based on differentiating a quantity over time. • Flow expressed in volume units (small aeroplanes) or mass units (large aeroplanes). • Units: liters per hour (l/h), gallons per hour (gal/h), kilograms per hour (kg/h) and pounds per hour (lb/h). • Interrelation between units. • Measurement of fuel flow per engine for engine condition and performance monitoring. • Calculation of total fuel used for aircraft performance calculation. Sensors (construction, operating principle, characteristics & error behavior): • Venturi: pressure differential (Bernoulli), volume flow measurement. • Dynamic vane: P = F/A, volume flow measurement. • Turbine: induction of EMF, volume flow measurement, with temperature compensation mass flow measurement. • Rotor torque: rotating impeller, measurement of angular momentum, mass flow measurement. • Stator torque: stationary impeller, measurement of angular momentum, mass flow measurement. • Motorless: measurement of angular momentum, mass flow measurement.						
022 01 05 02	Fuel flow	x	x	x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • Definition: Fuel flow is change of fuel quantity over time . • Purpose: Measurement of fuel flow per engine for engine condition and performance monitoring. • Application: in piston- and gasturbine engines driven aircraft. Design (construction, operation, characteristics): • Volume units: o Venturi: mechanical processor- and indicator. o Dynamic vane: (electro)mechanical processor- and indicator. o Turbine: electrical processor- and indicator. • Mass units: o Rotor torque: electr(on)ical processor- and indicator. o Stator torque: electr(on)ical processor- and indicator. o Motorless: electr(on)ical processor and indicator. Indication & Control: • Digital and/or analogue display calibrated in fuel units per hour. Error behavior & Cross checks: • Fuel flow integrated over time results in fuel used. • Fuel used used in FMS to determine aircraft weight. • Cross check fuel flow with total fuel quantity and with FMS calculation.						
022 01 06 00	**Position measurement**						
022 01 06 01	Different types, design, operation, characteristics, accuracy						

Mise en forme : Puces et numéros

Supprimé : transmitter

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	General (Definition, Purpose & Application): • Discrete position sensors and analogue position sensors. • Angular and linear displacement sensors • Units: degrees, millimeters or centimeters. • Measurement of position of aircraft- and engine systems for indication and control. • Aircraft and engine system position: doors, landing gear, flight controls, hydraulic and pneumatic valves, instrument, inlet guide vanes, thrust reverser. • Instrumentation: position of capsules, bellows, bordon tubes, shafts etc. • Effect of voltage, resistance, frequency, vibration, corrosion etc. Sensors (Construction, Operating principle, Characteristics & Error behavior): • Micro-switch: discrete position sensor; electric contact; fatique, corrosion, wear, arcing. • Proximity sensor: discrete position sensor; determination of impedance (Z). • Potentiometer: analogue position sensor for linear and angular displacements; changing electrical resistance, wear. • E-I pick-off: analogue position sensor for very small linear and angular displacements; inductive pick-off. • LVDT: analogue position sensor for small linear displacements; inductive pick-off. • RVDT: analogue position sensor for angular displacements; inductive pick-off. • Synchro: analogue position sensor for angular displacements; inductive pick-off.						
022 01 06 02	Discrete position sensors	x	x	x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • A discrete position sensor is a sensor used to pick-up only one discrete postion of a component. • Indication and control. • Pushbuttons, rotary switches, limit switches etc. Design (construction, operation, characteristics): • Micro switch: electrical processing and indication. • Proximity sensor: electronic processing and indication. Indication & Control: • Alert light/message. Error behavior & Cross checks: • Wrong adjustment causes false alerts.						
022 01 06 03	Analogue position sensors						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • An analogue sensor is a sensor used to pick up each position of a component ithin a given mesuring range. • Indication and control. • Measurement of position of: rotary selector knobs, mechanical pressure sensors, actuators, gyroscopes, flight control surfaces. Construction, Operation & Characteristics: • Potmeter, electrical processing and indication. • E-I, electr(on)ical processing • LVDT/RVDT, electr(on)ical processing, indication and control. • RVDT, electr(on)ical processing, indication and control. • Synchro, electrical processing, indication and control. Indication & Control: • Analoge display calibrated in degrees. • Control of instrument systems. Error behavior & Cross checks: • Wrong adjustment. • Cross checks with help of visual indicators.						
022 01 07 00	**Torque measurement**						
022 01 07 01	Different types, design, operation, characteristics, accuracy						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	General (Definition, Purpose & Application): • Define torque (T): two equal but opposite forces each acting on a different part of the same component. • A.k.a. twist or expressed as a forceless turning moment. • Units: Nm, foot-punds (ft lbs), braked mean effective pressure (psi), percentage of maximum torque (%). • To determine the output torque of a turboprop engine for indication and control. • Torque is a measure for engine power (P = T x rpm). • Too high torque causes engine and propeller damage. • Relation between torque, blade angle and rpm. • Engine torque: turboprops only Sensors (Construction, Operating principle, Characteristics & Error behavior): • Planetary gear system: measurement of oil pressure necessary to keep planetary gear system in position. • Electronic system: two inductive pick-offs measure twist in torsion shaft.						
022 01 07 02	Engine and or propellor torque system	x	x	x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • Measure oil pressure for engine condition monitoring. Construction, operation & characteristics: • Planetary gear system, hydromechanical processor and indicator. • Two gear-wheels with inductive pick-ups, electronic processing and indication. Indication & Control: • Digital and/or analogue display calibrated in psi, Nm or %. Error behavior & Cross checks: • Consequences of oil leak						
022 01 08 00	**Angular speed measurement (Tachometer)**						
022 01 08 01	Different types, design, operation, characteristics, accuracy						

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (Definition, Purpose & Application): • Measurement of angular shaft speed. • Units: revolutions per minute (rpm) for piston engines and percentage of maximum rated speed (%) for gasturbine engines. • Engine condition- and performance monitoring and control. Sensors (Construction, Operating principle, Characteristics & Error behavior): • Mechanical tachometers: o Centrifugal tachometer: springloaded fly-weights. o Eddy-current tachometer: induction of eddy currents set-up in a sprinloaded cup. • Electrical tachometer: o DC-tachometer: measurement of DC voltage. o AC-tachometer: measurement of induced single-phase AC voltage. o Rotary-current tachometer: frequency based measurement of induced three-phase AC voltage. • Electronic tachometer: o Tachoprobe: frequency based measurement of induced AC voltage.						
022 01 08 02	Tachometer piston engines	x	x	x	x	x	

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Syllabus reference	Syllabus details and Learning Objectives	Aeroplane ATPL	Aeroplane CPL	Helicopter ATPL/IR	Helicopter ATPL	Helicopter CPL	IR
LO	General (definition, purpose & application): • Tachometer must show the engine rpm. Operating principle & Construction: • Centrifugal tachometer, mechanical processing and indication, possible connection with hour meter • Eddy-current tachometer, mechanical processing and indication. • DC-tachometer, electrical processing and indication. • AC-tachometer, electrical processing and indication. Indication & Control: • Analog display calibrated in rpm. • Red arc: area in which continuous operation may cause vibration and must be avoided Error behavior & Cross checks: • Maximum cable length between sensor and processor 2 m. • Effect of electrical line resistance.						
022 01 08 03	Tachometer gasturbine engine	x	x	x	x	x	

Mise en forme : Puces et numéros

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Tachometers for gasturbine engines must be able to measure rotational speeds up to several ten-thousands rpm. • For each shaft there is one tachometer. Design (construction & operation) • Rotary-current tachometer, electrical processing and electromechanical indication with eddy-current head. • Tachoprobe, electronical processing and indication, frequency converter, DC amplifier, servo-driven indicator or eletronic display. Indication & Control: • Depending on type: digital- and analog display calibrated in % of the maximum rated rpm. • Indications in fan rpm, rotor rpm, propellor rpm or just n1, n2 and (sometimes) n3 • Trailing pointer which can be reset by crew. Error behavior & Cross checks: • Usually different shaft speeds measured, check for interrelation.						
022 01 08 04	Synchroscope						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (definition, purpose & application): • Sysnchroscopes are used to manually or automaticaly synchronise propellers. • Synchronised propellers produce less noise and vibration. • Applied in multi-engined propeller driven aeroplanes. General (construction & operation): • A rotary-current tachometer on each engine supplies its signals to synchroscope • Synchroscope consists of three-phase stator and three-phase rotor • When rotating stator field en rotor field have the same speed, rotor does not turn. • Rotor connects to indicator. Indication & Control: • Analogue pictorial display. • Possibility to automatically control synchronisation. Error behavior & Cross checks: • Use synchroscope in comparison with rpm indicators. • Nearly synchronised propellers will cause an audible beat frequency.						
022 01 09 00	**Vibration monitoring**	x	x	x	x	x	
022 01 09 01	Different types, design, operation, characteristics, accuracy						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General (Definition, Purpose & Application): • Change in amplitude at a relative high frequency. • Vibration may cause mechanical damage to components. • Engine condition and trend monitoring. Sensors (Construction, Operating principle, Characteristics & Error behavior): • Inductive pick-off: EMF by induction, magnetic proof-mass suspended in coil. • Quartz crystal: F=m.a, generation of AC-voltage when subjected to vibration (piezo-electricity).						
022 01 09 02	Inductive pick-off	x	x	x	x	x	
LO	General (definitions, purposes, applications) • To measure engine radial shaft vibration for engine condition and trend monitoring • Engine radial shaft vibration: Turbofan en turbojet engines • State that on turbofan/jet engines vibration sensors may be located on all shafts (N1, N2, etc) • State usually two perpendicular sensors per shaft • Continuous indication of vibration level of all engines • Vibrating frequency depends on rpm, • Calibration in amplitude, speed or in units • Procedure when too high vibration. • Vibration may be caused by mechanical damage or wear						

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		Aeroplane		Helicopter			IR
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Operating principle & Construction: • Inductive pick up: AC output, filtering, integration, amplification, electrical indication. • Quartz crystal: AC output, filtering, integration, amplification, electronic indication. Indication & Control: • Separate indicator or part of electronic engine display system. • Digital and/or analogue display calibrated in milli-inches, milli-inches per second (mils) or in units. • In case of too much vibration > alert. • Registartion in ACMS or FDR datalink Error behavior & Cross checks: • Reducing engine power usually helps to reduce the vibration level.						
022 01 10 00	**Time measurement**						
022 01 10 01	Different types, design, operation, characteristics, accuracy						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	General (definition, purpose & application): • Definition of time: ongoing process divided in units that allow counting • Purpose: to structure life, organise things • Application: worldwide, industryFlight deck: time: local, UTC, stopwatch, flight time, elapsed time, timed turns, engine operating hours. Sensors (Construction, Operating principle, Characeristics & Error behavior): • Wounded spiral spring that slowly unwinds in time. • DC supplied quartz crystal with internal battery that supplies AC pulses in time • Wounded spring tends to leave its strenght in time • wrong insertion of time.						
022 01 10 02	Clock	x	x	x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • Show different times: UTC. Operating principle & Construction: • Spiral spring: mechanical processing and indication (gears, levers, pointers) • Quartz chrystal: electronic processing and indication (counter, amplifier, indication). Indication & Control: • Digital and/or analogue display calibrated in hours, minutes and (tenth of) seconds. • Winding knob. • Setting knobs. • FT, ET button. • Stopwatch/timer function: start-stop-reset. • Flight time based on airspeed or ground/flight switch. Error behavior & Cross checks: • Not wounded. • Internal back-up battery empty. • Crosscheck with FMS or GPS time. • Wrong insertion of time.						
022 01 10 03	Engine hour meter	x	x	x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application: • Instrument that counts engine operating time. • Used to administrate engine hours. • Applied in aircraft with piston engines. Operating principle & Construction: • Quartz crystal, electronic processing and indication (pulse counter). Indication & Control: • Separate or integrated in rpm indicator, digital display calbrated in hours and tenth of hours. • Controlled via oil pressure, rpm and sometimes via airspeed switch. Error behavior & Cross checks: • Cross check with time written down in logbook.						
022 02 00 00	**MEASUREMENT OF AIR DATA PARAMETERS**						
LO	Study the ICAO Standard Atmosphere with regard to relationship between altitude and pressure, temperature and density in the troposhere and in the stratosphere. Understand interrelation between pressure, temperature and density. Give the values for pressure, temperature and density at MSL in the ISA.						
022 02 01 00	**Pitot-static system**						
022 02 01 01	General: definitions, purpose, applications, operating principle	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Define total pressure (pitot pressure) and static pressure. A pitot-static system is a system that measures and supplies both total pressure and static pressure to the related aircraft instruments and -systems. The pitot-static system must measure the total pressure and the static pressure. State that in larger aeroplanes more than one pitot-static system is installed. Pitot-static system uses of a pitot tube to stop the airflow in order to measure total pressure and uses static sources to measure the pressure of the undisturbed airflow in order to measure static pressure.						
022 02 01 02	Design, different types, construction, operation	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	Pitot tube: • Outside boundary layer, head and mast, location on aircarft, opening parallel to airflow, stagnation wall, water drain, head & mast, electrical heating elements, low speed and high speed design, effect of heater and water drain on sensed pressure. Static source: • opening perpendicular to airflow, electrical heating elements, location on aircraft. Pitot/static probe (pressure head): • Combined pitot tube and static source(s), loaction on aircraft. Pipelines: • Water traps, static balancing. • State that in modern aircraft the pipelines are replaced by electrial wires because of the use of electronical pressure transducers with built-in fault correction and A/D conversion directly connected to the pitot and/or static sources. Pitot-static system small, unpressurised aeroplane: • Pitot tube, two interconnected static sources to compensate for side slip, pipelines, water traps, alternate static source and selector valve in cabin. Pitot-static system of a large, pressurised aeroplane: • Pitot tube or pitot/static probe, two interconnected static ports to compensate for side slip, pipelines, water trap.						
022 02 01 03	Indication & Control	x	x	x	x	x	x
LO	Pitot /static source heater on/off plus alert. Alternate static source selector valve (unpressurised aircraft).						
022 02 01 04	Error behavior, accuracy, cross-checks						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State the effects of a malfunction of the pitot tube and/or static source heating elements. Cross check heater operation with standby magnetic compass reading or Amp-meter. State the effect of blocked pitot tubes and/or static ports. State the effect of a leakage of the pitot and/or static lines in both a pressurised and non-pressurised aircraft. Explain when the alternate static source is required. State that when alternate static source is used the sensed cabin presuure is usually lower than static pressure. Explain static source error (static pressure error) plus possible corrections (AFM). Mention parameters that affect static source error.						
022 02 02 00	**Air temperature measurement: Aeroplane**						
022 02 02 01	General: definitions, purpose, application	x	x				
LO	State the different definitions and their relationship: OAT, TAT, SAT, Recovery factor, ram rise. State that air temperature is needed for aircraft and engine performance calculations, anti-ice control, calculation of TAS.						
022 02 02 02	Designs, different types, principle of operation	x	x				

Supprimé : S

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Small aeroplanes • OAT indicator: bi-metallic type sensor with mechanical processing and indication or thermistor type sensor with electrical processing and indication Large aeroplanes: • TAT probe: aspirated, non-aspirated, thermistor, heater, operation, ram rise, recovery factor, electronical processing in ADC, separate or integrated combined TAT/SAT indicator. Design: Sensor, processor, indicator.						
022 02 02 03	Display and control	x	x				
LO	Separate OAT indicator: digital and/or analogue display calibrated in degrees C and/or F. Separate or integrated in EFIS, digital TAT/SAT dispaly calibrated in degrees C.						
022 02 02 04	Error behavior, accuracy & Cross checks						
LO	Mention possible countermeasures against influence of direct sunlight, M/airspeed, boundary layer, recovery factor. State accuracy of separate OAT indicator and of combined TAT/SAT indicator.						
022 02 03 00	**Air temperature measurement: Helicopter**			x	x	x	
022 02 03 01	General: definitions, purpose, applications & operating principle			x	x	x	
LO	State the different definitions and their relationship: OAT, TAT, SAT, Recovery factor, ram rise. State that air temperature is needed for helicopter and engine performance calculations, anti-ice control, calculation of TAS.						
LO	Understand that in addition to the normal outside air temperature gauge the latest helicopters have additional sensors for FADEC and Air Data Unit.			x	x	x	
022 02 03 02	Design: different types, construction & operation			x	x	x	

Supprimé : Displays

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Small helicopters • OAT indicator: bi-metallic type sensor with mechanical processing and indication or thermistor type sensor with electrical processing and indication Large helicopters: • TAT probe: aspirated, non-aspirated, thermistor, heater, operation, ram rise, recovery factor, electronical processing in ADC, separate or integrated combined TAT/SAT indicator. Design: Sensor, processor, indicator.						
022 02 03 03	Display and control						
LO	Separate OAT indicator: digital and/or analogue display calibrated in degrees C and/or F. Separate or integrated in EFIS, digital TAT/SAT dispaly calibrated in degrees C.						
022 02 03 04	Error behavior, accuracy, cross-checks						
LO	Mention possible countermeasures against influence of direct sunlight, M/airspeed, boundary layer, recovery factor. State accuracy of separate OAT indicator and of combined TAT/SAT indicator.						
022 02 04 00	**Angle of attack measurement**	x	x	x			
022 02 04 01	General: definitions, purpose, applications, principle of operation						
LO	Angle between undisturbed airflow and main wing chord. State purpose: indication and control Mention applications: ADS, SWS, GPWS.						
022 02 04 02	Designs: different types, construction & operation						

Supprimé : slot

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Small aeroplanes: Whistle: system that responds to pressure difference between upper part and lower part of wing. Flapper switch: heated springloaded electric contact in leading edge of wing. Large aeroplanes: Vane: heated symmetrical triangular shaped vane that aligns itself with the airflow. null-seeking probe: double slotted probe with a differential pressure sensor and an electric motor.						
022 02 04 03	Display & control						
LO	Separate AoA indicator: analogue display calibrated in degrees. AoA indicator integrated in EFIS: digital and/or analogue display calibrated in degrees.						
022 02 04 04	Error behavior , accuracy, cross checks						
LO	Two installed systems allow for cross check. Understand relation between weight, speed and angle-of-attack						
022 02 05 00	**Pressure Altimeter**						
022 02 05 01	General: definitions, purpose, applications, principle of operation	x	x	x	x	x	x
LO	State the definitions of the different barometric references: QNH, QFE and STD (1013.25 hPA), height, indicated altitude, true altitude, pressure altitude and density altitude. Principle of operation: pressure measurement acc ISA. Electric pick-off of pressure altitude for ATC-transponder (encoding altimeter).						
022 02 05 02	Designs: different types, construction, operation	x	x	x	x	x	x

Supprimé : "girouette".

Supprimé : Standard atmosphere

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Sensitive pressure altimeter: • Stack of temperature compensated aneroid capsules, compensation for non-linear pressure-altitude relation, mechanical processing and indication, subscale + knob . Servo-driven altimeter: • Stack of temperature compensated aneroid apsules, compensation for non linearity, E-I pickoff, mechanical processing and indication, electric pick-off for ATC transponder and FDR, vibrator, subscale + knob.						
022 02 05 03	Display & control	x	x	x	x	x	x
LO	Separate altimeter, linear scale, analogue and digital presentation, pointer system, low altitude warning flag, vibrator failure flag, use of subscale + knob, location of subscale knob, range of subscale, calibration of subscale in in HG and/or hPa, calibration of altitude scale in ft.						
022 02 05 04	Error behavior, solutions, accuracy, cross checks	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Explain the instrument errors that affect the altimeter: • Mechanical friction, solution vibrator. • Lag in indication during rapid descents. • Decreasing sensitivity at increasing altitudes. List the atmospheric errors that affect the altimeter: • Deviations from ISA > P and T > P: subscale setting (procedures) and T: no compensation other than bij calculation > nav comp > or rule of thumb State the effects of errors of the pitot-static system that affect the altimeter during straight and level flight and during climb and descent. State advantages of servo-driven altimter over mechanical pressure altimeter State the tolerances at MSL of the different altimeters in use: 30,000 ft range: 60 ft at MSL, 50,000 ft range: 80 ft at MSL servo driven altimeters: 30 ft at MSL. State that in RVSM airspace pressure altimeters must have a smaller tolerance. Cross-check possibility with second altimeter, standby altimeter and radio altimeter.						
022 02 06 00	**Vertical Speed Indicator (VSI)**						
022 02 06 01	General: definitions, purpose, applications, principle of operation	x	x	x	x	x	x
LO	State the purpose of the VSI is to sense, process and indicate the aeroplane's vertical speed. The vertical speed is defined as the change in altitude per unit of time. The VSI measures the change in static pressure per unit of time according to ISA. Explain how VSI compensates for non-linear pressure-altitude relation in ISA.						
022 02 06 02	Design: different types, construction, operation	x	x	x	x	x	x

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Capsule-type VSI: Differential pressure capsule, temperature compensated orifice (calibrated leak), blade spring to allow logaritmic scale, adjuster screw. Capsule type Instantaneous VSI (IVSI) : Same as VSI plus springloaded pistion in cylinder acting as a vertical accelerometer.						
022 02 06 03	Indication and control						
LO	Separate analogue indicator, calibrated in feet per minute (ft/min or fpm), logarithmic scale, one pointer, zero when horizontal.						
022 02 06 04	Error behavior, solutions, accuracy, cross checks						
LO	Explain the instrument errors that affect the VSI: • Slow response (time lag) of the VSI of up to several seconds. • State the purpose of the zero adjustment screw. List the atmospheric errors that affect the VSI. State the effects of errors of the pitot-static system that affect the VSI during straight and level flight and during climb and descent. State the maximum permissible tolerance of the VSI as ± 30 fpm for the first 500 fpm then 5% of indicated. Describe the behaviour of the IVSI during turns. State the effect of turbulence on the IVSI indication. Cross-check with second VSI, changing altitude on altimeter or on radio altimeter. State the generally accepted method and consequences of restoring blocked static ports by breaking the glass of the VSI in non-pressurised aircraft only.						
022 02 07 00	**Airspeed Indicator**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 02 07 01	General: definitions, purpose, application, principle of operation	x	x	x	x	x	x
LO	Define: Equivalent Air Speed (EAS), Indicated Air Speed (IAS) and Calibrated Air Speed (CAS). Compare values of IAS and CAS and required corrections between the speeds. Operating principle based on measurement of dynamic pressure (q) in the case of non-compressible airflows and impact pressure (q_C) in the case of compressible airflows based on difference between total pressure and static pressure (P_T - P_S). Airspeed indicator shows speed of aeroplane relative to the surrounding air for performance monitoring and control. Calibration in knots. Describe relationship between IAS and CAS, during climb and descent in the troposphere and in the stratosphere. Define v_{S0}, v_{S1}, v_{FE}, v_{NO}, v_{NE}, v_{LO}, v_{LE}, v_{YSE}, v_{MO} and M_{MO}.						
022 02 07 02	Design: different types, construction & operation.	x	x	x	x	x	x
LO	Distinguish between airspeed indicators for small aeroplanes and large aeroplanes. IAS meter: • Differential pressure capsule, blade spring, mechanical processing and indication. CAS meter: • Differential pressure capsule, blade spring, mechanical processing and indication. Maximum airspeed pointer: • Integral with airspeed indicator, aneroid capsule, mechanical processing and indication, barberpole.						
022 02 07 03	Indication & control	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Small aeroplanes: • Analogue circular linear or logarithmic scale calibrated in kts. • Explain the colour codings of the airspeed indicator. • Assign the following speeds to the colour codings: V_{SO}, V_{S1}, V_{FE}, V_{NO}, V_{NE}, V_{YSE}. Large aeroplanes: • Analogue circular linear or logarithmic scale calibrated in kts. • Maximum speed indicator (V_{MO}/M_{MO} pointer or barberpole). • Adjustable speed bugs. • Speed selector with indicator to allow the setting of a reference speed for indication and control.						
022 02 07 04	Error behavior, solutions, accuracy, cross-checks						
LO	List the instrument errors that affect the airspeed indcator. List the atmospheric errors that affect the airspeed indicator. State the effects of errors of the pitot-static system that affect the airspeed indicator during straight and level flight and during climb and descent. Cross-check airspeed with pitch and power. Cross-check airspeed with TAS, Mach number and groundspeed.						
022 02 08 00	**Machmeter**						
022 02 08 01	General: definition, purpose, application & operating principle	x	x				

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Mach number is the true airspeed of the aeroplane in relation to the local speed of sound (M = TAS/a). Since the local speed of sound depends on temperature, the Mach number is also temperature dependent. The Mach number is used because of its relation with compressibiliy effects to take place. The measurement of the Machmeter is based on the ratio between airspeed and altitude: M ~ $(P_T – P_S)/P_S$. Describe relationship between IAS, CAS, and M during climb and descent in the troposphere and in the stratosphere.						
022 02 08 02	Design: different types, construction & operation	x					
LO	Mach meter: • Total pressure and static pressure, differential pressure capsule, blade spring, aneroid capsule, mechanical processing and indication. Mach-airspeed indicator: • Total pressure and static pressure, differential pressure capsule, blade spring, aneroid capsule, mechanical processing and indication. • State the operating principle of the V_{MO}/M_{MO} pointer in the Mach-airspeed indicator.	x					
022 02 08 03	Indication & control	x					
LO	Digital and/or analogue display calibrated in units of Mach number.						
022 02 08 04	Error behavior, accuracy & cross-checks						

Supprimé : Refer to LO 022 02 01 00.

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	List the instrument errors that affect the Machmeter. List the atmospheric errors that affect the airspeed indicator. State the effects of errors of the pitot-static system that affect the Machmter during straight and level flight and during climb and descent. Cross-check M with airspeed and TAS. State the accuracy of the Machmeter.						
022 02 09 00	**True Air Speed**						
022 02 09 01	General: definition, purpose, application, operating principle						
LO	The TAS meter determines the true airspeed by correcting the Mach number for the local speed of sound (TAS = M.a). State the relation between true airspeed, wind and groundspeed. Describe relationship between IAS, CAS, TAS and M during climb and descent in the troposphere and in the stratosphere.						
022 02 09 02	Design: different types, construction, operation						
LO	TAS meter: • Differential pressure capsule, blade spring, aneroid capsule, temperature capsule, mechanical processing and indication. Combined CAS/TAS indicator: • Airspeed indicator with subscale + knob that allows for setting of pressure altitude versus temperature to allow reading of TAS.						
022 02 09 03	Indication & control						
LO	Digital and/or analogue dispaly calibrated in knots. Understand the use of the subscale knob in case of the combined CAS/TAS indicator						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 02 09 04	Error behavior, solutions, accuracy, cross-checks						
LO	List the instrument errors that affect the TAS meter. List the atmospheric errors that affect the TAS meter. State the effects of errors of the pitot-static system that affect the TAS meter during straight and level flight and during climb and descent. Cross-check TAS with airspeed and Mach number (at 25,000 ft. TAS ≈ 600.M). State the accuracy of the TAS meter.						
022 02 10 00	**Air Data Computer**						
022 02 10 01	General: definitions, purpose, applications, operating principle	x		x	x		
LO	Computer that holds several modules to process air data parameters for monitoring and control. The ADC uses a limited number of inputs to calculate a large number of outputs. Describe the inputs and outputs of the ADC: • Input modules: o total pressure, static pressure, temperature and angle of attack, barometric reference, power supply. • Processing modules: o Static Source Error Correction (SSEC), monitor (BITE). • Output modules: o Pressure altitude, altitude, vertical speed, airspeed, Mach number, V_{MO}/M_{MO}, overspeed, true airspeed, SAT, TAT and corrected angle of attack.						
022 02 10 02	Design: different types, construction, operation	x		x	x		

Supprimé : Refer to LO 022 02 01 00 and to LO 022 02 02 00.

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Central Air Data Computer (CADC): • Analogue, electromechanical computer with several modules to calculate analogue output parameters that are sent to servo-driven indicators and to other systems. Digital Air Data Computer (DADC): • Digital computer with several modules to calculate digital output parameters that are sent to EFIS and to other systems. • Two types exist: type with built-in pressure transducers and with external pressure transducers. Air Data Inertial Reference Unit (ADIRU): • DADC and Inertial Reference Unit • DADC part is digital computer with several modules to calculate output parameters.						
022 02 10 03	Indication, control						
LO	State that ADC outputs are sent to servo-driven indicators or EFIS, ATC transponder, autoflight system, EGPWS, INS/IRS, FMS. Overspeed warning. Use of barometric reference knob.						
022 02 10 04	Error behavior, solutions, accuracy & cross checks						
LO	Internal monitor (BITE) to detect ADC failure Test switch that drives outputs to predetermined value. Describe the effect of loss of one or more input/output signal of the ADC to the pilot's instrument indication. Cross-check with standby air data instruments.						
022 03 00 00	**MAGNETISM – DIRECT READING COMPASS AND FLUX VALVE**						

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	Formulas are not required for this topic. It is expected that students already have a basic understanding of magnetism, such as: • Definition and properties of a magnet. • Hard iron and soft iron. • Make distinction between permanent magnetism and electro-magnetism. • Relation between magnetic flux, magnetic density, magnetic field strength and permeability.						
022 03 01 00	**Earth magnetic field**	x	x	x	x	x	x
LO	(Change of) Location and meaning of Magnetic North Pole and Magnetic South Pole. Resolution of the earth's total magnetic field (T) into a vertical component (V) and a horizontal component (H). Define the dip angle (inclination). Define the term variation. State that variation depends on location on earth and changes with time. Define isogonals. Define the magnetic equator. Area of uncertainty around the magnetic poles.						
022 03 02 00	**Aircraft magnetic field**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Explain and distinguish between hard iron and soft iron magnetism on aircraft. State that aircraft magnetic field can be resolved in three vectors (P, Q and R) along the three aircraft axes (X, Y and Z). Distinguish between permanent magnetic field and temporary magnetic fields. Explain deviation as the influence of the aircraft magnetic field on the magnetic compass. Mention the change of deviation with change of latitude and with change in aircraft's heading. State the importance of keeping magnetic materials clear of the compass. State that the compass swing procedure is used to minimise the deviation. State the situations requiring a compass swing. State that residual deviation is plotted on a deviation correction card or curve mounted on the flight deck.						
022 03 03 00	**Direct reading magnetic compass**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	General: definitions, purpose, application, operating principle • Direct Reading Magnetic Compass (DRMC) often called standby compass. • Measure and show direction of horizontal component of earth's magnetic field. • Internal magnets are free to align themselves with horizontal component of earth's magnetic field. • Normally used as a standby magnetic compass. Design: different types, construction, operation • E-type compass only: o Pendulous suspended magnets, fluid filled bowl, looking glass with lubber line, diaphragm, illumination, magnetic deviation compensation device (adjustable N-S and E-W magnets) Indication, control: • Analogue display with scale graduated every 5 degrees and letters at the cardinal headings N, E, S and W. Error behavior, accuracy, cross-checks: • Describe and interpret the effects of the turning and acceleration errors. • Describe and interpret the effect of the deviation. • Describe and interpret the effect of the aircraft attitude on the compass reading (attitude error) • Interpret the deviation correction card or -curve. • State the maximum permissible values for deviation. • State the possible effect of illumination on the compass reading. • Cross check with heading indicator. • Identify the geographical areas where the magnetic compass is unreliable.	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 03 04 00	**Flux valve**						
022 03 04 01	General: definitions, purpose, location, application, operating principle	x	x	x	x	x	x
LO	Wherever flux valve is stated one can also read flux gate! The flux valve is an electromagnetic field sensor. The flux valve is located as far as possible from disturbing magnetic fields, preferably in the tip of the wing or vertical stabiliser. The flux valve must measure the direction of horizontal component of earth's magnetic field. Operation based on measurement of the direction of the earth magnetic field that saturates electromagnetic fields set up in the flux valve.						
022 03 04 02	Design: different types, construction, components, operation						
LO	Pendulous suspended electromagnetic field sensor, 25-30 degrees in freedom in pitch and roll, no freedom around vertical axis, fluid filled bowl, electromagnetic deviation compensation device.						
022 03 04 03	Indication, control						
LO	No indicator; flux valve output is used to stabilise the gyromagnetic compass or to supply some inertial navigation systems with Magnetic Heading (MH).						
022 03 04 04	Error behavior, accuracy, cross-checks						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Describe and interpret the effects of the turning and acceleration errors. Describe and interpret the effect of the deviation. Describe and interpret the effect of the aircraft attitude on the flux valve (attitude error). State that because of the electromagnetic deviation correction, the flux valve output does not need a deviation correction card or –curve. Identify the geographical areas where the flux valve is unreliable.						
022 04 00 00	**GYROSCOPIC INSTRUMENTS**						
022 04 01 00	**Gyroscope: basic principles**						
022 04 01 01	General: definition, purpose, application, operating principle	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Define a gyroscope and its components (fast spinning mass (rotor/disc/wheel) around a spinaxis) Explain the power supply: ▪ Pneumatically with a regulated differential pressure of ≈ 5 “ Hg caused by a mechanically or electrically driven vacuum or pressure pump. ▪ Electrically wheras the gyro is the rotor of a DC or AC electric motor. ▪ Compare both types of power supply with respect to rpm and altitude behavior. Explain the following gyroscopic properties: ▪ Rigidity, using the first gyro law H = I. $_{G}$ ▪ Precession, using the second gyro law $_{P}$ = T/H. ▪ Drift (wander and topple), distinguish between real drift and apparent drift. o Apparent drift: distinguish between earth rate and travel rate (transport wander). Explain the relationship between rigidity and precession. Explain how rigidity and precession can be increased/decreased.						
022 04 01 02	Design: different types, construction, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Explain a free (space) gyro and an earth gyro.						
	Explain the suspension of a gyro in one or two gimbals.						
	Define a Single Degrees of Dreedom gyro (SDF) (a gyro with only one gimbal and one sensitive (measuring) axis that makes use of precession.						
	Define a Two Degrees of Freedom gyro (TDF) (a gyro with two perpendicuar gimbals and two sensitive measuring axes that makes use of rigidity).						
	Note: By convention the degrees of freedom of a gyroscope does not include its spin axis!						
	Explain a vertical gyro and a horizontal gyro.						
	Explain the construction and operating principle of a rate gyro (SDF gyro with spring attached to gimbal that is used to measure an angular rate).						
	Explain the construction and operating principle of rate integrating gyro (SDF gyro in casing which is surrounded by temperature controlled fluid that is used to measure an angular displacement θ).						
	Explain the construction and operating principle of a Ring Laser Gyrsocope (RLG).						
	Explain the construction and operating principle of a Fibre Optic Gyroscope (FOG).						
	Compare the conventional gyroscope with the RLG and the FOG.						
022 04 01 03	Operational use: indication, control						
LO	State the monitoring options for gyro instruments: ▪ Electrically driven gyroscopes: flag warning. ▪ Pneumatically driven gyroscopes: air pressure indicator.						
	State that pneumatically driven gyroscopes have an alternate power supply that is manually selected.						
022 04 01 04	Error behavior: accuracy, cross checks	x	x	x	x	x	x

Mise en forme : Puces et numéros

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Describe gimbal lock plus solutions (mechanical stops, extra gimbal). Describe gimbal flip. Describe the effects of gyro drift. Describe cross-coupling. Describe the effect of a defective power supply on the gyro instruments. Describe how a defective power supply can be detected: ▪ Electrically driven gyroscopes: flag warning. ▪ Pneumatically driven gyroscopes: air pressure indicator. Explain the reasons for using different types of gyro power supply on an aircraft.	x	x	x	x	x	x
022 04 02 00	**Rate of Turn indicator**						
022 04 02 01	General: definition, purpose, application, operating principle	x	x	x	x	x	x
	A.k.a. turn and bank indicator or turn and balance indicator. Purpose is to show the angular speed around the local vertical axis when flying a coordinated (balanced) turn. Define a rate-one turn and a two-minute turn. Operating principle based on the precession of rate gyroscope when performing a turn. Pneumatic or electric power supply. Explain the relation between bank angle, rate one turn and true airspeed. Slipball shows coordinated (balanced) flight.						
022 04 02 02	Design: different types, construction, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Rate of turn indicator: ▪ SDF horizontal rate gyro, spinaxis aligned with lateral axis of aircraft, gimbal aligned with longitudinal axis of aircraft, forward rotating gyro, reversing mechanism, damper and pointer. Turn co-ordinator: ▪ SDF horizontal rate gyro, spinaxis aligned with lateral axis of aircraft, rearward tilted gimbal, forward rotating gyro, reversing mechanism, damper and pointer symbol. Slipball: ▪ Curved concave glass tube filled with a damping fluid and a ball. ▪ Distinguish between slip and skid. Compare the rate of turn indicator with the turn co-ordinator with respect to the direction of the sensitive axis.						
022 04 02 03	Operational use: indication, control						
LO	Rate of turn indicator: ▪ Display with vertical pointer, left and right marking and slipball. Turn co-ordinator: ▪ Display with aeroplane symbol and slipball Interpret the indication of the rate of turn indicator and the turn co-ordinator during a co-ordinated turn and during non co-ordinated turns. Explain how to correct slip and skid in order to achieve co-ordinated flying.						
022 04 02 04	Error behavior: accuracy, cross checks						

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State the indication during a failure of the power supply (instrument air indicator or flag warning) State the behavior of the instrument in the event of a failure. State the instrument only shows corect for one TAS. State the instrument only shows correct when flying co-ordinated. Cross-check possibility with the stopwatch and heading indicator.						
022 04 03 00	**Attitude indicator**						
022 04 03 01	General: definition, purpose, application, operating principle	x	x	x	x	x	x
	A.k.a artificial horizon or Attitude Director Indicator (ADI). The attitude indcator shows both pitch attitude and roll attitude. Pneumatic or electric power supply. The attitude indicator makes use of TDF vertical gyro that is (kept) erected with help of an erection mechanism. Describe the prupose of the erection system (compensate for drift (topple)). Describe the principle of operation of the erection mechanism (makes use of gravity and precession). State different types of erection mechanism (pendulous vanes, ball erection system, electric system with liquid level switches and torque motors). State the erection speed of an artificial horizon (2-4 º/s)						
022 04 03 02	Design: different types, construction, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Mechanical attitude indicator: • Sensor, processor and indicator in one housing in cockpit • TDF vertical gyro, mechanical or pneumatical erection system, inner horizontal gimbal and outer vertical gimbal aligned with the longitudinal axis of the aircraft, pitch reversing mechanism, attitude scale, skypointer. Remote horizon: • Sensor in remote vertical gyro unit. • TDF vertical gyro, electrical erection system, inner horizontal gimbal and outer vertical gimbal aligned with the longitudinal axis of the aircraft, electrical transmission with synchros to indicator. • Servo-driven attitude sphere in Attitude Director Indicator (ADI).						
022 04 03 03	Operational use: indication, control						
LO	Attitude display: • Aircraft symbol. • Pitch scale: markings every 2.5 degrees. • Roll scale: markings from 10, 20, 30, 45 and 60 degrees. • Explain the purpose of the test function in the remote horizon system. • State the purpose of the adjuster knob for the aircraft symbol and the purpose of the knob for fast erection. • State the function of the caging mechanism. Describe the monitoring indications (instrument air indicator or flag warning).						
022 04 03 04	Error behavior: accuracy, cross checks						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State the disadvantage of the erection system (sensitive to horizontal accelerations). Describe the effect of longitudinal and lateral accelerations (take-off and turns). Explain how compensations for turn and acceleration errors are achieved in both pneumatically and electrically driven horizons (counterweight, PECO and RECO switches). Explain the behaviour of the artificial horizon in the event of a gyro failure (low air pressure, flag warning , decreased rigidity). Decsribe the behavior during a looping (gimbal lock and gimbal flip). Cross-check with rate of turn indicator.						
022 04 04 00	**Directional gyroscope**						
022 04 04 01	General: definition, purpose, application, location, operating principle	x	x	x	x	x	x
	A.k.a heading indicator or gyrocompass. The Directional Gyro (DG) shows the heading of the aircraft. State the power supply (pneumatic or electric). The directional gyro makes use of TDF horizontal gyro that must be manually kept aligned in a N-S direction. State the need for an erection system (compensate for drift). Distinguish between drift around the vertical axis and the horizontal axis. Describe the methods to solve for drift around the vertical axis (latitude nut, electrical system with liquid level switches and torque motor) Describe the methods to solve for drift around the horizontal axis (wedge, electrical system with liquid level switches and torque motor). State the erection speed of the directional gyro (2-4 °/s).						
022 04 04 02	Design: different types, construction, components, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Ring-type DG: • Sensor, processor and indicator in one housing in cockpit • TDF horizontal gyro, erection system, inner horizontal gimbal and outer vertical gimbal aligned with the vertical axis of the aircraft, erection system, horizontal ring-type heading scale. Card-type DG: • Sensor, processor and indicator in one housing in cockpit • TDF horizontal gyro, erection system, inner horizontal gimbal and outer vertical gimbal aligned with the vertical axis of the aircraft, erection system, vertical card-type heading scale.						
022 04 04 03	Operational use: indication, control						
LO	Heading display: • Aircraft symbol. • Heading scale: markings every 5 degrees. • State the purpose of the adjuster knob for the compass card. • State the function of the caging mechanism. Describe the monitoring indications (instrument air indicator or flag warning).						
022 04 04 04	Error behavior: accuracy, cross checks						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Compare the indications of a directional gyro and a magnetic compass during a turn and acceleration, and compare the accuracy of the indications over a lengthy period. Describe the behaviour of the instrument in the event of a gyro failure. (decreased rigidity) Define gimbal error and explain the effects (during pitch and roll manoeuevrs at headings other than N, E, S and W the DG will rotate around its vertical axis and show a false heading). Explain the necessity and time interval to re-set the DG against the magnetic compass. Describe the adjustment procedure (in unacellerated level flight). Calculate apparent drift of an uncompensated directional gyro (no real drift or travel rate (transport wander) at a given earth position.						
022 04 05 00	**Slaved gyrocompass**						
022 04 05 01	General: definition, purpose, application, operating principle	x	x	x	x	x	x
LO	A.k.a gyrosyn compass or remote reading magnetic compass (RRMC). State the purpose of the slaved gyro compass (show gyro-stabilised magnetic heading). Explain the principles of operation of the slaved gyro compass Describe in general terms the signal flow. Using a block diagram, explain the operation of a remote compass system Comparator that compares magnetic heading from flux valve with heading from DG						
022 04 05 02	Design: different types, construction, components, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Gyromagnetic compas: • Remote earth magnetic field sensor (flux valve). • Integral Directional Gyro, TDF horizontal gyro, electrical erection system, inner horizontal gimbal and outer vertical gimbal aligned with the longitudinal axis of the aircraft, card type indicator. • Differential synchro-servo system with torquer on horizontal gimbal. Remote heading reference unit: • Remote earth magnetic field sensor (flux valve). • Remote TDF horizontal gyro, electrical erection system, inner horizontal gimbal and outer vertical gimbal aligned with the longitudinal axis of the aircraft, electrical transmission with synchros to indicator. • Differential synchro-servo system with torquer on horizontal gimbal. • Servo-driven compass card in Horizontal Situation Indicator (HSI).						
022 04 05 03	Operational use: indication, control						
LO	Heading display: • Aircraft symbol. • Heading scale: markings every 5 degrees. Integral or separate compass control unit: • Fast slave knob. • Slaving indicator. • Free-slaved switch. Describe the different modes of operation. Describe the monitoring indications (instrument air indicator or flag warning).						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 04 05 04	Error behavior: accuracy, cross checks						
LO	Describe the behaviour of the instrument in the event of a gyro failure (decreased rigidity). Describe the behavior of the instrument when the flux valve input is disconnected (behave like a DG). Cross-check with direct reading magnetic compass.						
022 05 00 00	**INERTIAL NAVIGATION AND REFERENCE SYSTEMS**						
022 05 01 00	**Gyro-stabilised inertial platform**						
022 05 01 01	General: definition, purpose, application, operating principle	x		x			
LO	Autonomous navigation system. Outputs: navigation parameters (position, track, ground speed, drift angle, wind and attitude (pitch, roll and heading). Large transport aeroplanes. 1, 2 or 3 system installed. Double integration of accelerations in 3D space. State that a gyrostabilised inertial platform also holds a lateral flight plan computer that allowed for the programming of up to ten waypoints.						
022 05 01 02	Design: different types, components, construction, operation	x		x			

Supprimé : Refer to LO 022 05 00 00

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	North seeking system, Azimuth free (Azimuth wander) system Describe the platform stabilisation with help of three rate integrating gyroscopes or two TDF gyroscopes, a resolver, a computer and platform servomotors. Describe the attitude measurement function with help of three synchros. Describe the navigation with help of three accelerometers, accelerometer corrections and a computer. Describe the platform alignment: phases, gyros started, gimbals perpendicular, insertion of present position, auto detection of latitude, application of apparent drift corrections, alignment time.						
022 05 01 03	Operational use: indication, control, outputs						
LO	MSU: rotary switch (OFF-SBY-ALGN-ATT) and annunciators (ALGN, BAT). CDU: displays, function knobs, operating modes, operational use and flight plan function. ADI (pitch and roll) and HSI (heading or track). Autoflight systems, GPWS.						
022 05 01 04	Error behavior: accuracy, cross checks						
LO	Schuler oscillation, platform drift, accelerometer error. Corrections for following accelerations: centripetal, Corioli and gravity. Baro-inertial altitude and baro-inertial vertical speed.						
022 05 02 00	**Strapped-down inertial platform**						
022 05 02 01	General: definition, purpose, application, operating principle	x		x			

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Autonomous navigation system. Outputs: navigation parameters (position, track, ground speed, drift angle, wind and attitude (pitch, roll and heading). Large transport aeroplanes. 1, 2 or 3 system installed. Double integration of accelerations in 3D space.						
022 05 02 02	Design: different types, components, construction, operation	x		x			
LO	Inertial Reference System (IRS), Attitude Heading Reference System (AHRS) Describe the platform stabilisation with help of three ringlaser gyroscopes or three fibre optic gyros and computer. Describe the attitude measurement function with help of the computer. Describe the navigation with help of three accelerometers, accelerometer corrections and a computer. Describe the platform alignment: phases, insertion of present position, auto detection of latitude, application of apparent drift corrections, alignment time.						
022 05 02 03	Operational use: indication, control						
LO	MSU: rotary switch (OFF-ALGN-ATT) and annunciators (ALGN, BAT). CDU: displays, function knobs, operating modes, operational use. EADI (pitch and roll) and EHSI (heading, track, wind, ground speed, drift).						
022 05 02 04	Error behavior: accuracy, cross checks						
LO	Schuler oscillation, platform drift, accelerometer error. Corrections for following accelerations: centripetal, Corioli and gravity. Barometric corrections for vertical accelerometer measurement.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 06 00 00	**AEROPLANE: AUTOMATIC FLIGHT CONTROL SYSTEMS**						
	No MCQ's will refer to operational, type related values/limits (eg speed, distance and angle of interception in the LOC mode or V/S in the ALT mode).						
022 06 01 00	**General**						
022 06 01 01	Control system theory	x	x				
LO	Static stability and dynamic stability. Blockdiagrams. Symbols. Open loop and closed loop. Feed-back and feed-forward. Servo loop, inner loop, outer loop. PID-controller.						
022 06 01 02	Sensor systems						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State that the FD and/or AP can receive information from the following instrument systems: • Vertical gyro (pitch, roll), • Inertial navigation reference system: aircraft attitude and rate signals (pitch, roll, and heading), acceleration; • Gyromagnetic compass system: magnetic heading; • Navigation receivers: VOR, LOC, G/S, MLS and GPS deviation signals, DME distance and MB info; • Flight management system: TKE, XTK, DSTK; • Air data computer: altitude, vertical speed, speed, Mach number, angle of attack; • Radio altimeter: height.						
022 06 01 03	FD and/or AP modes						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Distinguish between basic modes and upper modes: • Basic pitch mode pitch hold (non-integrated concept) and V/S HOLD (integrated concept) • Basic roll mode WINGS LEVEL (non-integrated concept) and HDG HOLD (integrated concept) Distinguish between roll (lateral) modes, pitch modes and comon modes: • Describe the arming, capture and tracking criteria of the following roll modes of the FD and/or AP: • Wings level or Turn knob (hold & select), • Heading (hold & select), • VOR/LOC/Back beam, • LNAV (NAV). • Describe the arming, capture and tracking criteria of the following pitch modes of the FD and/or AP: • Pitch attitude (hold, select), • Vertical speed (hold, select), • VNAV (Profile), • (Flight) Level change, • Altitude (hold & select), • IAS or Mach (hold, select), • GS MAN, GS AUTO. • Describe the arming, capture and tracking criteria of the following common modes of the FD and/or AP: • Approach (LAND, ILS, MLS, GPS). • Take-Off/Go around.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 06 02 00	**Flight Director**						
022 06 02 01	General: definition, purpose, application, operating principle	x	x				
LO	State that the FD gives pitch and roll steering commands in order to increase the stability and to fly the aircraft along a specified path or attitude. State that the FD pitch and roll steering signals are sent to the FD indicator and to the AP. Name the following components of a flight director: computer, control panel, flight Mode Annunciator (FMA), FD command indicator (crossbars/V-bar). Closed loop control						
022 06 02 02	Design: different types, components, construction, operation	x	x				
LO	State that the flight director computer has a pitch channel and a roll channel. State that the commands of the flight director are given in such a way that structural limits of the aircraft for pitch and bank attitude will not be exceeded Name the task of the gain program in the approach mode as being to reduce the command bar deflections during approach based on marker beacons, radio altitude or DME distance. State the task of the beam sensors as being to switch from an armed (standby) condition to a capture (acquire or intercept) condition in radio mode (VOR, LOC, G/S) when reaching a certain threshold value. State that the effects of disturbances such as cross winds and changes in centre of gravity, landing gear position, flaps, slats and (spoilers) speed brakes can be compensated for with the flight director. State that in the flight director computer, actual values are compared with reference values and displayed as control commands.						
022 06 02 03	Operational use: indication, control, outputs						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	The FD modes are selected from the FD and/or AP control panel. State that per channel (pitch/roll) only one mode at a time active can be active. State that the FD switch on the control panel enables the FD. State that the control commands of the flight director are displayed as pitch and roll commands, located in the (Electronic) Attitude Director Indicator (ADI) or Primary Flight Display (PFD). List that the mode annunciation can be given either by electromechanical devices, annunciator lights or as an electronic indication on the Primary Flight Display of the EFIS system. Describe the indications on the Flight Mode Panel (FMP) with respect to the FD: use of colours, symbols, armed (standby), capture (acquire or intercept) and active (track or hold) modes. Name that the flight director indication on the ADI or PFD can be given as two rectangular cross bars or as a V-shaped command bar. Describe the operation of the FD modes in the following flight phases: take-off, climb, cruise, descent, approach, land, go-around.						
022 06 02 04	Error behavior: accuracy, cross checks						
LO	State that the flight director monitors: power supply, input signals, computer and display. State and interpret the following monitoring options: warning flag, bar removal, annunciator.						
022 06 03 00	**Automatic Pilot**						
022 06 03 01	General: definition, purpose, application, operating principle	x	x				

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State that the autopilot gives elevator, aileron and rudder steering signals to fly the aircraft along a specified path or at a specified attitude. An AP channel is a closed loop control system that controls one aircraft axis (pitch, roll, yaw). State that an AP computer consists of one or more channels. Non-integrated concept: one computer per channel (pitch, roll and yaw computer). Integrated concept: FD and AP channels in one computer (APFD computer with pitch, roll and yaw channel). Name the following component units of an autopilot: sensor, computer, control panel, autopilot actuator, Flight Mode Annunciator Describe a three channel AP using a simplified block diagram consisting of sensor inputs, actuators, computer, control panel and indicators. State the AP compares actual values with reference values and passes control commands to the AP actuators. State the JAR-OPS requirement the installation of an AP: (single pilot IFR or at night: AP at least heading hold and altitude hold.						
022 06 03 02	Design: different types, components, construction, operation	x	x				

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Describe AP gain programming with respect to the servo-, inner- and outer loop. Describe and distinguish between AP pitch-, roll- and common (mixed) modes. AP actuators: • Types: electric, hydraulic, pneumatic, • Components: clutch, motor, position sensor, rate sensor, • Describe series and/or parallel control together with applications. State that when engaging the AP, the clutches are engaged. AP engaged in Command (CMD) or in Control Wheel Steering (CWS). State that when AP engaged in CMD, the AP is supplied by the FD pitch and roll commands. State that when AP engaged in CWS, the AP is supplied by force transducers on control column and on control wheel. State CWS creates pitch rate and roll rate signals. State the relation between the AP pitch computer/channel and the roll computer/channel with respect to lift compensation during turns (1/cosφ). State the relation between the AP roll computer/channel and the YD computer/channel with respect to turn coordination. State the relation between the AP pitch computer/channel and the auto pitch trim computer/channel with respect to automatic pitch trim. Automatic synchronisation when disengaged or mode not selected. Describe how to handle a non self-synchronising AP before engagement using AP trim indicators. Describe the Fly By Wire (FBW) system.						
022 06 03 03	Operational use: indication, control	x	x				

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Describe the controls and indications of the FMP with respect to AP (dis)engagement in CMD or in CWS. Describe the indications on the FMP with respect to the APuse of colours, symbols, armed (standby), capture (acquire or intercept) and active (track or hold) modes. AP normally (dis)engaged from FMP. Quick release buttons on either control wheel. AP annunciations on FMP. Aural and visual warning on AP disengagement. Describe the AP operation of the FD pitch and roll modes during the following flight the phases: take-off, climb, cruise, descent, approach, land, go-around. State that an AP can only be selected in CMD when in flight.						
022 06 03 04	Error behavior: accuracy, limits, cross checks						
LO	Decsribe the relation between the AP with the automatic pitch trim system. No take-off use of AP in CMD. Describe the AP monitor function together with the automatic cut-out in case of a failure. Describe the engage interlock system. Torque limiter on AP servo's to prevent hard-overrides and slow-overrides. State the AP override requirement: must always be possible to override the AP. State that a fail safe autopilot automatically disengages whenever a failure occurs. State the AP pitch (+20º and -10º) and roll (35º) limits. Bank angle limiter (manual/automatic). State that the AP is programmed to prevent overload of the control surfaces and structure.						
022 06 04 00	**Automatic landing**						

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Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
	A basic knowledge of the minima for the low visibility take-off and landing procedures can be given to the students. No MCQ will refer to such a knowledge.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Ref. JAR-AWO.						
	Study the fail passive and fail operational (fail active) concept.						
	Describe the following AP categories: CAT 1, CAT 2 and CAT 3A, -B and –C.						
	State the minimum requirements for making an autoland.						
	Explain a typical autoland sequence with respect to the APFD pitch channel, roll channel, yaw channel and the autothrottle.						
	APFD pitch channel: glideslope > flare > touchdown > nose lowering mode > roll-out > manual disengage.						
	APFD roll channel: localiser > touchdown > roll-out > manual disengage.						
	APFD yaw channel: align (decrab) > roll-out > manual disengage.						
	Autothrottle: speed > retard > automatic disengage upon touchdown.						
	Decsribe the role of the pitch trim system during an autoland.						
	Describe the use, the operation and the indication of the autoflight system during an autoland.						
	State that the approach/land mode is a common mode, which requires localiser and glide slope reference signals.						
	State that during an approach/autoland and go-around more than one autopilot can be used.						
	State the importance of equalisation when more AP computers operate simultaneously.						
	Name the task of the gain programming in the approach/land mode.						
	State the role of the radio altimeter during an autoland.						
	State that below a certain radio altitude the autoland can only be interrupted when disenganing the AP or selecting go-around.						
	Describe the consequence of an AP failure during an autoland.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 07 00 00	**HELICOPTER: AUTOMATIC FLIGHT CONTROL SYSTEMS**						
022 07 01 00	**General principles**						
022 07 01 01	Stabilisation			x	x	x	
LO	Understand the simularities and differences between SAS and AFCS the latter can actually fly the helicopter to perform certain functions selected by the pilot. Some AFCS's 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. Understand the importance of not engaging the AFCS until after take-off and to dis-engage before landing.						
022 07 01 02	Reduction of pilot work load			x	x	x	
LO	Appreciate how effective the AFCS is in reducing pilot work load by improving basic aircraft control harmony and decreasing disturbances.						
022 07 01 03	Enhancement of helicopter capability			x	x	x	
LO	Understand how the AFCS improves helicopter flight safety with the following: • increases the capability for search and rescue • flight by sole reference to instruments • under slung load operations white out conditions in snow covered landscapes and lack of visual cues on approach to land						
022 07 01 04	Failures			x	x	x	
LO	Understand the various redundancies and independent systems that are built into the AFCS's.			x	x	x	
LO	Appreciate that the pilot can override the system in the event of a failure.			x	x	x	
LO	Understand a series actuator 'hard over' which equals aircraft attitude runaway.			x	x	x	

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Understand the consequences of a saturation of the series actuators.			x	x	x	
022 07 02 00	**Components – Operation**						
022 07 02 01	Basic sensors			x	x	x	
LO	Understand the basic sensors in the system and their functions			x	x	x	
LO	Understand that the number of sensors will be dependant on how many couples modes are in the system			x	x	x	
022 07 02 02	Specific sensors			x	x	x	
LO	Understand the function of the micro switches and stain gauges in the system which sense pilot input to prevent excessive feed back forces from the system			x	x	x	
022 07 02 03	Actuators: - parallel and series, spring box and clutches, trim system			x	x	x	
LO	Understand the principles of operation of the series and parallel actuators, spring box clutches and the auto trim system.			x	x	x	
022 07 02 04	Pilot/System interface						
LO	Describe the typical layout of the AFCS control panel.			x	x	x	
LO	Understand the system indications and warnings.			x	x	x	
022 07 02 05	Operation						
LO	Understand the functions of the redundant sensors simplex and duplex channels (single/dual channel)			x	x	x	
022 07 03 00	**Stability Augmentation System (SAS)**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 07 03 01	General principles and operation - 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	Understand and describe the general working principles and primary use of SAS by damping pitch, roll and yaw motions caused by gusts			x	x	x	
LO	Describe the simplest SAS with forced trim system, which uses magetic clutch and springs to hold cyclic control in the position where it was last released.			x	x	x	
LO	Understand the interaction of trim with SAS/SCAS/ASS stability system.			x	x	x	
LO	Appreciate that the system can be overridden by the pilot and individual channels deselected.			x	x	x	
LO	Understand that the system should be turned off in severe turbulence or when extreme flight attitudes are reached.			x	x	x	
LO	Understand the safety design features built into some SAS's to limit the authority of the actuators to 10% to 20% of full control throw, to allow the pilot to override if actuators demand an unsafe control input.			x	x	x	
LO	Understand how cross coupling produces an adverse affect roll to yaw coupling, when the helicopter is subject to gusts.			x	x	x	

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Have an understanding of 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 - Long term attitude hold - Fly through - Changing the reference (beep trim, trim release)			x	x	x	
LO	Understand the general principles related to: - Long term attitude hold - Fly through - Changing the reference (beep trim, trim release)			x	x	x	
022 07 04 02	Basic mode (three axis/four axis) - AFCS operation on cyclic axis (pitch/roll), yaw axis, collective (fourth axis)			x	x	x	
LO	Understand the AFCS operation on cyclic axis (pitch/roll), yaw axis, collective (fourth axis).			x	x	x	
022 07 04 03	Automatic guidance/modes of AFCS: - Altitude hold - Airspeed hold - Heading hold - V/S hold - Navigation coupling - VOR/ILS coupling - SAR modes, Automatic transition to hover			x	x	x	

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Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Understand the function of the attitude hold system in an AFCS.			x	x	x	
LO	Understand the function of the heading hold system in an AFCS.			x	x	x	
LO	Understand the function of the vertical speed hold system in an AFCS.			x	x	x	
LO	Understand the function of the navigation coupling system in an AFCS.			x	x	x	
LO	Understand the function of the VOR/ILS coupling system in an AFCS.			x	x	x	
LO	Understand the function of the SAR mode (Automatic transition to hover) in an AFCS.			x	x	x	
022 07 04 04	Flight director - Monitoring - Guidance			x	x	x	
LO	**LOs TO BE DEFINED**						
LO	Understand that some helicopters have the addition of a collective setting bar indication on the Flight Director.			x	x	x	
022 07 05 00	**Fly by wire – Enhanced Control laws**						
022 07 05 01	General principles and operations: - multiplex system - fail safe system - limitations			x	x	x	
LO	Appreciate the principles of the current civil helicopter developments and the current military helicopter use of 'fly by wire' control systems: - multiplex system - fail safe system - limitations			x	x	x	

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		Aeroplane		Helicopter			IR
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Understand the fly by wire system literally replaces phsical control of the aircraft with an electrical interface.			x	x	x	
LO	Understand the pilot inputs go through an electronic interface to operate actuators at each control surface.			x	x	x	
LO	Understand that actuators initially were hydraulic, but in recent years are fully electronic actuators.			x	x	x	
LO	Understand that the autopilot is now part of the electronic controller.			x	x	x	
LO	Understand that hydraulic circuits are similar except that mechanical servo valves are replaced by electronically controlled servo valves.			x	x	x	
LO	Understand that fly by wire systems are triply or quaderuply redundant, they have 3 or 4 computers in parallel and as many wires to each contrl surface			x	x	x	
LO	Appreciate the software can prevent pilots exceeding the flight envelope.			x	x	x	
LO	Understand limitations in regard to electromagnetic control interference.			x	x	x	
LO	Appreciate future developments are moving towards fly by optics which transfer data at higher speeds. The wires cables are replaced with fibre optic cables. Advantages include immunity to electromagnetic control interference.			x	x	x	
022 07 05 02	Rate command attitude hold (RCAH)			x	x	x	
LO	Understand the functions of RCAH systems in helicopters.			x	x	x	
022 07 05 03	Attitude command attitude hold (ACAH)						
LO	Understand the functions of ACAH systems in helicopters.			x	x	x	
022 08 00 00	**TRIMS – YAW DAMPER – FLIGHT ENVELOPE PROTECTION**						
	Aerodynamic notions may be used to introduce the following paragraphs but no MCQs will refer to aerodynamic.						
022 08 01 00	**Trims**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	The purpose is to neutralise the elevator control forces necessary to maintain a desired pitch attitude. Elevator control forces are trimmed away by adjusting the angle of incidence of the horizontal stabilizer or elevator trim tab. Name the following possible tasks of the pitch trim system: automatic pitch trim, manual electric pitch trim, Mach trim. Describe the interaction between the autopilot and the pitch trim system. Explain the pitch trim system using a simplified block diagram: input signals, computer, control panel, stabiliser trim indicator and actuator. Inputs: elevator position, Mach number, manual electric pitch trim switches. State that the pitch trim computer compares reference signals with actual signals and passes control commands to the pitch trim actuator. State the task of the airspeed input (gain programming). Pitch trim actuator: parallel actuator that controls the horizontal stabiliser or the elevator trim tab. Pitch trim engage switch. Two in series connected manual electric pitch trim switches on either control wheel. Stabiliser trim indicator: function of green band and CoG range. Out-of-trim alert light. State the consequence of a pitch trim system failure. State the alert when there is a excessive pitch trim command.						
022 08 02 00	**Yaw damper**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Name the following possible tasks of the yaw damper: Dutch roll damping, N-1 compensation, turn coordination. Describe the interaction between the autopilot and the YD. Explain the yaw damper using a simplified block diagram: input signals, computer, control panel, YD indicator, YD servo. Inputs: yaw rate (rate gyro), engine out (N-1) and roll or lateral acceleration (turn coordination). State that the yaw damper computer compares reference signals with yaw rate and passes control commands to the yaw damper servo of the rudder State task of airspeed input (gain programming). Yaw damper servo: series actuator that adds/subtracts the YD input to/from the rudder deflection controlled by the autopilot or rudder pedals. Control and indication: YD switch, YD indicator that shows YD input to rudder and YD failure light. State that during a stall warning the YD is disabled. State the consequence of a yaw damper failure.						
022 08 03 00	**Flight envelope protection**						
LO	Describe flight envelope protection as a protection against: extreme attitudes, exceeding the aircraft ceiling, too low speeds, too high speeds, too high angle-of-attacks, high positive and negative G-forces. State and explain the following input data: AoA, speed/Mach number, altitude, attitude, acceleration. State and explain the following output data: flight director commands, flight control surface (rate) limit signals, autothrottle system, speed limits on EFIS speed tape.						
022 09 00 00	**AUTOTHROTTLE – AUTOMATIC THRUST CONTROL SYSTEM**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 09 01 00	**Autothrottle**						
LO	State that the auto-throttle computer compares actual values with reference values and passes control commands to the servomotors of the throttles.						
	Explain the engagement of the autothrottle from the FMP and the disengagement from the disconnect buttons on the throttles.						
	State the use, location and operation of the TO/GA button on the throttles.						
	State the autothrottle system operates in the thrust mode or in the speed mode.						
	Monitoring: FMP, EFIS, ERP/MCDU, local light.						
	Explain the fast/slow indicator on the ADI.						
	Describe the use of the auto-throttle system during flight: take-off, climb, cruise, descent, holding, approach and land.						
	Describe the autothrottle system using a simplified block diagram: inputs/outputs, computer, control panel, indications.						
	Automatic or manual mode selections via the thrust rating function.						
	State that there is a rate feedback in order to control throttle speed.						
	Explain the clamp mode.						
	Explain the thrust latch mode (alpha floor).						
	Explain the windshear escape mode.						
	Explain the retard mode.						
	Distinguish between an approach autothrottle system and a full-flight regime autothrottle system.						
	State the role of the PMC in the autothrottle system.						
022 09 02 00	**Automatic thrust control**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State parameters that affect required (target) power calculation and maximum (limit) power calculation: ambient conditions, engine rating selection, selected performance mode and selected speed/Mach number.						
	Name and explain the following engine ratings including time limits: Take-Off (TO), Go-Around (GA), Max. Continuous Thrust (MCT), Climb (CL), Cruise (CRZ), Flexible Take Off (FLX TO).						
	Distinguish between thrust command system (N1, EPR or TRQ) and speed command system (speed or Mach number).						
	Automatic and manual thrust and/or speed/Mach selections.						
	Thrust ratings selected from the engine rating panel (separate or integral with FMS CDU)						
	Describe the autothrust system using a simplified block diagram: inputs/outputs, computer, control panel, indications.						
	Speed/Mach selected from FMP or through the FMS CDU.						
	Describe the engine rating function using a simplified blockdiagram showing engine rating computer based on comparison of set values versus measured values.						
	Control and indications on engine rating panel (separate or integral with FMS CDU), Flight Mode Annunciator						
	List the outputs of the power computation system: target and limit values for N1, EPR or TRQ, auto thrust system, engine rating panel, F/S indicator.						
	List the inputs for a thrust rating (limit) computer: bleed valve position, engine rating selection, altitude, Mach number, airspeed, TAT and actual N1/EPR/TRQ.						
	Describe the use of the power computing system during flight: take-off, climb, cruise, descent, holding, approach and land.						
	Monitoring via N1, EPR or TRQ indicators, FMA and engine rating panel.						
	State the role of the FADEC in the autothrottle system.						
	Make a comparison between autothrottle and automatic thrust control system.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 10 00 00	**COMMUNICATION SYSTEMS**						
022 10 01 00	**Radio transmitters/receivers**	x		x			
	State components of radio equipment: control panel, transmitter/receiver, transmisison lines, antennas. Radio transmitter/receiver: oscillators (LC-circuit, quartz crystal, magnetron), modulator/demodulator, amplifiers, filters, beat frequency oscillator (BFO).						
022 10 02 00	**VHF and HF Communication (VHF-COM and HF-COM)**	x		x			
LO	VHF: • Frequency band: 118 – 137 MHz. • Channel separation: 8.33 kHz. • Control panel: standby-active frequency display, channel selector, squelch, volume control. HF: • Frequency band: 3 –30 MHz. • Channel separation 100 kHz. • HF sensitivity switch. • Explain SSB and DSB. • State HF civil is USB, HF military is LSB. • AM = DSB, USB = SSB. • Control panel: standby-active frequency display, channel selector, squelch, volume control.						
022 10 03 00	**Satellite comunication (SAT-COM)**	x					

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Global coverage multi channel system through ground earth stations via orbiting satelites. Voice and data communication. Duplex voice and data communication to (pre)selected adresses (telephone numbers). Components: satellite data unit and MCDU.						
022 10 04 00	**ARINC Communication, Adressing and Reporting System (ACARS)**	x					
	Two-way digital communication between aircraft and ground data networks (uplink and downlink). Manual and automatic downlink. Makes use of VHF-COM, HF-COM or SAT-COM radio's. Radio's must be set from VOICE to DATA. Components: ACARS management unit and MCDU. Messages: flight log, meteo reports, free text messages, time base. Overview of organisations using the datalink transmission: ATSU/DCDU, the ATN program and its network.						
022 10 05 00	**Future Air Navigation System (FANS)**	x					

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	

LO	Definition, Purpose & Application:
	• FANS covering Communications, Navigation, and Surveillance (CNS) + Air Traffic Management (ATM)
	• Air Traffic Control (ATC) and Airline Operational Control (AOC)
	• Use of:
	  • ARINC Communication, Adressing and Reporting System (ACARS)
	  • Satellite Communication (SATCOM)
	  • Global Postioning System (GPS)
	  • Global Navigation Satellite System (GNSS)
	  • Aeronautical Telecommunications Network (ATN)
	  • Free flight concept
	  • Automatic Dependent Surveillance type B (ADS-B)
	  • Controller Pilot Data Link Communications (CPDLC)
	  • VHF Data Link (VDL) modes 1, 2, 3 and 4
	  • VHF Digital Radio (VDR)
	Operation, construction, indication, control, error behavior & cross checks
	• ACARS, SATCOM and VDR
	Multi-function Control and Display Unit (MCDU)						

022 10 06 00	**SELCAL/CALSEL**	x					

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Selective calling and Calling a selective station. HF and VHF. Ground stations desiring communication with the aircraf can use SELCAL. Aircraft desiring communication with a ground station can use CALSEL. Audio and visual alert on incoming call.						
022 10 07 00	**Interphone**	x		x			
	Flight interphone: communication between flight crew members and with ground personnel near the nose wheel. Service interphone: communication between maintenance personnel at various locations around aircraft. Cabin interphone: comunication between flight deck and flight attendant stations Call system: informs flight crew that communication is desired from the ground or from the cabin.						
022 10 08 00	**Passenger adress system**	x					
	Alows cabin annoncements to be made from the flight deck or from the flight attendant stations. When making a PA announcements all other conversations are overridden.						
022 11 00 00	**FLIGHT MANAGEMENT SYSTEM (FMS)**						
022 11 01 00	**Flight Management Computer (FMC)**						
022 11 00 01	General: definition, purpose, application, operating principle	x		x	x		

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Goals, design, operation : Functions and modes of operation will be studied but the systems used by the F.M.S. (the systems and the input/ouput components) will be just listed. They are studied according to the syllabus in the relevant topic. As no standard of FMS can be defined, the ability for each manufacturer to define a specific system for each customer will be highlighted : the FMS is not related to an aeroplane but to a customer. - inputs, data computation and functions, outputs and display units. position computations (multi-sensors), flight management, definition of the cost index, lateral/vertical navigation and guidance, interfaces with AFCS and auto thrust/auto throttle systems : presentation of the three types of links with AFCS : targets, steer through and hybrid. fuel computations, radio tuning (Comm, Nav), datalink (AOC/ATC) control and display, EFIS, CMU.						
022 11 00 02	Different types, components, construction, operation						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Types: Flight Management System (VNAV + LNAV) and Navigation Management System (LNAV only).						
	Input- and output modules, microprocessor and databases.						
	Input modules: MCDU, IRS, ADS, Radio receivers (GPS, VHF-NAV).						
	Databases: aircraft database, engine database and navigation data base.						
	Navigation database 28 days validity.						
	Contents of Navigation database.						
	State the different operating modes of an FMS.						
	Cost index vs minimum time, minimum fuel and economy mode.						
	Strategic, tactical and situational modes.						
	Multi sensors: FMC position calculated out of inertial and/or radio position.						
	Computations based on measured data (use of sensors): ETA (Estimated Time of Arrival), TTG (Total Time to Go), RTA (Requested Time of Arrival).						
	Computations based on stored information (data base): fuel computations, VNAV path predictions, wind models.						
	Operational limits of an FMS : accuracy of the data, reliability,						
	Identify the parameters that relate to the vertical flight profile: speed/M, altitude, path (open loop (air mass referenced) and closed loop (earth referenced).						
	Identify the parameters that relate to the lateral flightplan: desired track, track, track angle error, cross track distance.						
	Automatic tuning of radiobeacons based on Figure of Merit and Lines of Position (LOP).						
	Navigation accuracy and approach capability.						
	Interface with Automatic Flight System:						
	• LNAV/NAV outputs to autoflight system aileron channel.						
	VNAV/PROF outputs to autoflight system elevator channel and thrust control system.						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 11 00 03	Indication and control						

LO	*General overview, examples will be given for information only, but no MCQ will refer to a specific system!*
	Multifunction Control- and Display Unit:
	• Display unit:
	  • Title field, scratch pad, left and right columns consisting of 6 lines.
	  • Line Select Keys (LSK).
	  • Symbols: dashes, brackets, small and large fonts.
	  • Scroll buttons and previous and next page buttons.
	• Keyboard:
	  • Function & Mode keys, Alphanumeric keyboard, Annunciators.
	  • Cursor Control Device and interactive display units (touchscreen).
	• General FMS alert.						

022 11 00 04	Error behavior: accuracy, cross checks						
LO	Degraded modes of operation: Inertial only, Radio only or back up navigation, use of raw data (Dead Reckoning (DR). RAIM function for RNAV procedures. Fuel: independance between FMS computations and fuel system totalizer. Examples with non standard configurations: One engine out, landing gear down, flaps down, increases of consumption due to a CDL item, use of anti-ice systems, etc. Explain the differences between dual mode and independent mode.						
022 11 02 00	**Operational use of the FMS**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Multifunction Control and Display Unit (MCDU) as interface with FMS. Understand/explain menu structure: index page, subpages. Explain the use of the function- and mode buttons. Use of execute button Use of alphanumeric keyboard. Make distinction between computations based on measured data (use of sensors) versus computations based on database information Computed data/information displayed: checking and confirmation with LSK. Use of (M)CDU to create and modify a lateral and vertical flight plan: use of keyboard commands, interpret display and annunciations. Interface with Flight Mode Panel: LNAV/NAV mode and/or VNAV/PROF mode, relation with altitude select function, Speed/M window blanked when FMS in control. Interface with EFIS: EADI (PFD): FD & FMA, EHSI (ND): Map mode & Plan mode (colors, symbols). Cross check possibility of stored flight plan with help of EFIS Plan mode. Check for discontinuities. Possible consequences of wrong navigation database. Consequences of selection and insertion of wrong waypoint (with same name but different location). State the importance of situational awareness by interpretation of other navigation sources/methods.						
022 12 00 00	**ALERTING SYSTEMS, PROXIMITY SYSTEMS**						
022 12 01 00	**Alerts**						

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Refer to AMJ 25.1322 Alerting systems, with respect to use of colours: red, amber, green, blue, white. State other kinds of warning indications: warning flag, bar removal, pointer mask, aural warnings (bell, buzzer etc.), removal of information, drawing a red cross on cathode ray tube or liquid crystal display, vibration (stick shaker for stall warning).						
022 12 02 00	**Flight Warning system**						
022 12 02 01	Definition, Purpose & Application	x		x	x	x	
LO	State that the FWC is a dual channel computer. State that the FWC monitors the operational status of aircraft systems and gives a visual and aural alert in case of a system failure. State that the FWC uses 12 flight phases for the inhibiting function which are detected automatically by the FWC using several input signals from other aircraft systems. State that the FWC generates standard attention getting sounds (attensons) or chimes. State that the FWC generates aural alerts for specific situations: autopilot disconnect, overspeed, excessive pitch trim and altitude alert. State that the FWS makes use of an annunciator panel for back-up purposes. Describe the operation of the Master Caution Light and Master Warning Light. Define the ARINC classifications of level 0, 1, 2 and 3 alerts. Standardisation of coloured visual and aural alerts. State that a FWC single channel failure does not cause system degradation. State that a FWC dual channel failure causes visual alerts only to be presented on the annunciator panel.						
022 12 03 00	**Stall warning & protection**						
022 12 03 01	Definition, Purpose & Application	x	x				

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Define a stalled wing and state the consequences. State the stall warning system is used to give a prestall warning when exceeding the critical angle of attack. State how the stall warning is given. State the JAR-25 requirements regarding a stall warning system in an operational environment.						
022 12 03 02	Construction & Operation						
LO	Describe the stall warning system of a small aeroplane, consisting of a flapper switch and warning horn or a whistle. Describe the operation of the stall warning system with help of a simplified blockdiagram which at least includes: inputs, computer, outputs. Inputs: AoA, wing configuration, aeroplane weight, ground inhibit, ground test Describe the need for an altitude compensation too prevent a slow response at high altitudes. Outputs: stick shaker, flight warning system, EFIS, stick pusher, autopilot disconnect. Describe the operation, construction and location of the stickshaker. State some aeroplanes have a stickpusher as a stall recovery system. State that the stickpusher has a disconnect facility.						
022 12 03 03	Control & Indication						
LO	An impending stall is indicated by both visual and aural means. EFIS equipped aeroplanes have a marking on the pitch scale of the attitude indicator and along the speed tape that must prevent a too high angle of attack or a too low speed. Test switch.						
022 12 03 04	Error behavior & Cross checks						

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		Aeroplane		Helicopter			IR
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Understand the relation between AoA, airspeed and attitude.						
022 12 04 00	**V_{MO}/M_{MO} warning**						
LO	State the consequences of exceeding V_{MO}/M_{MO}. State that the overspeed warning system warns the pilot aurally that airspeed is above maximum allowable speed v_{MO} or maximum allowable mach number M_{MO}. Name that the warning is typically an interrupted sound (clacker) made by the FWC. State that the FWC receives the V_{MO}/M_{MO} directly from the ADC. State the use of the test button. State that the maximum allowable speed is shown on the Mach/airspeed indicator.						
022 12 05 00	**Take-off warning**						
LO	State the consequence of taking-off with an aeroplane not being in the correct take-off configuration. State visual and aural alert when throttles are advanced on ground and aircraft is not in correct take-off configuration. Mention monitored parameters.						
022 12 06 00	**Altitude alert system**						
LO	State visual and aural alert when aircraft acquires or deviates from a pre-selected baro altitude. State altitude alert is not given when in approach configuration. State altitude alert system independent from AP. State the JAR-OPS requirements regarding the altitude alert system.						
022 12 07 00	**Radio-altimeter**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Measures height. Based on measurement of radio frequency difference. Low range radio altimeter only. 2,500 ft. FMCW. Accuracy. SHF > 4200 - 4300 MHz > 4250 MHz, 100 MHz sweep. Components: Tx antenna, Rx antenna and transceiver. Illustrate and interpret different types of indication. R/A indicator: circular scale, straight scale and EFIS. Outputs: R/A indicator, EGPWS, Autoflight. Decision height visual and aural alert. Aircraft Installation delay. Cross checks.						
022 12 08 00	**Ground proximity warning systems**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	EGPWS, GPWS, GCAS, TAWS and differences. Purpose. Operating range. Difference between GPWS and EGPWS. Warning modes. Warning mode modulation. Inputs and outputs. Simple blockdiagram. Control and indication. JAR-OPS requirements. Test.						
022 12 09 00	**Airborne Collision Avoidance System (ACAS/TCAS)**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition, Purpose & Application • ICAO > JAR-25 > ACAS • TCAS II version 7 to prevent mid-air collisions Operation & Construction • Resolution Advisory (RA), Traffic Avisoriy (TA), Proximity traffic and Non-threat traffic • Corrective and preventive RA's: pitch channel only • Coordination link • Components: TCAS computer, top and bottom antenna, control panel, Mode-S transponder • Capacity, range • Quadrantal scan with directional antennas • Interrogation of transponders • Calculation of time to closest point of approach out of : altiutde, altitude rate, relative bearing, distance, relative speed • Inhibits at low altitude Indication & Control • Outputs: visual and aural alerts, indicators, symbols Error behavior & (Cross) checks • Test function • Explain that the pilot must not interpret the horizontal track of an intruder on the display						
022 12 10 00	**Rotor/engine overspeed alert system**						
022 12 10 01	Design, operation, displays, alarms			x	x	x	

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Understand the basic design principles, displays and warning/alarm systems fitted to different helicopters						
022 12 11 00	**Laser obstacle detector**						
022 12 11 01	Design, operation, displays, limitations			x	x	x	
LO	**(NOTE WAITING FOR INFORMATION REGARDING THIS SUBJECT)**						
022 13 00 00	**INTEGRATED INSTRUMENTS – ELECTRONIC DISPLAYS**						
022 13 01 00	**Display Units**						
022 13 01 01	Cathode Ray Tube (CRT): • Construction, principle of operation • Monochrome and full colour CRT • Stroke writing and raster writing Liquid Crystal Display: • Construction, principle of operation • Normal LCD and Active Matrix LCD Compare CRT with LCD with respect to: • Viewing angle, power consumption, weight, temperature, cooling requirement, glare, radiation, backlighting, missing pixels. Give examples: EFIS, EICAS/ECAM/MFDS, MCDU	x	x	x	x	x	x
022 13 02 00	**Integrated Instrument System (IIS)**						
022 13 02 01	IIS predecessor of EFIS. Electromechanical ADI and HSI. Inputs/outputs.	x	x	x	x	x	x

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 13 03 00	**Electronic Flight Instrument System (EFIS)**						
LO	List and describe the function of each of the EFIS system components: • Computer: symbol generator unit or display management computer • Display units: EADI or PFD and EHSI or ND • Control panel switches: brightness control, mode selection, range selection, display options • (Remote) light sensor on glarehield for automatic brightness control. PFD/ND: flight instruments and flight mode annunciator. ND/EHSI: (radio)navigation information. Source select buttons. List inputs, describe outputs. Information displayed. JAR-25 color coding Brightness control: brightness switch, remote light sensor, integral light sensor. DU failure: indication, DU transfer, composite display. Failure of electronics unit Failure of one or more sources/inputs. Simple block diagram of a typical aircraft installation. Compare EFIS with IIS.	x		x	x		
022 13 04 00	**Systems and procedures displays (EICAS, ECAM, MFDU)**						

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Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Purpose: common display system of engine and system parameters and alerts. State that FWS makes use of EICAS/ECAM for display of alerts. Components: computer(s), display units, control panel (switches: brightness control, system pages, Cancel and recall). List inputs; describe outputs. DU: warning or primary display and system or secondary display. DU failure: indication, DU transfer or composite display. Selection of pages: manual or automatic. Simple block diagram of a typical aircraft installation.	x	x	x	x	x	x
022 13 05 00	**Head Up Display (HUD)**						
LO	Different presentation types: projection or generation. Purpose: enhance safety during Take-off or CAT 3 approaches under low visibility conditions. Displayed parameters. System requirements: collimator, contact analogue presentation, eye reference position.	x	x				
022 13 06 00	**Engine First Limit Indicator**						
022 13 06 01	Design, operation, indications and displays						
LO	Understand the principles of design, operation and compare the different indications and displays available in the industry.			x	x	x	
LO	Understand what will be displayed on the screen, when in the limited screen composite mode.			x	x	x	
LO	Understand how the engine first limit indicator system is now being integrated into some flight management systems.			x	x	x	
022 13 07 00	**Night vision goggles**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
022 13 07 01	Design, operation, displays, limitations			x	x	x	
LO	Understand the function of night vision goggles and the basic design concepts, each eye tube intensifies the available light source more than 3000 times.			x	x	x	
LO	Understand the limitations of NVGs • minimum 2 minilux level needed for effective use • lack of depth perception (two dimensional image) • limited field of view • need to reduce bank angles to avoid risk of spatial disorientation • fatigue of neck muscles with prolonged use, due to extra weight on helmet			x	x	x	
LO	Understand the importance of proper training before using in flight and the NAA's regulations governing the use of NVGs.			x	x	x	
LO	Understand the importance of logging battery usage and changing batteries at correct intervals.			x	x	x	
LO	Understand the danger of mis-handling of Lithium bateries (used on some NVGs).			x	x	x	
LO	Appreciate the high cost of conversion (panel lights) of the aircraft prior to NVG use			x	x	x	
022 14 00 00	**MAINTENANCE, MONITORING AND RECORDING SYSTEMS**						
	No JAR-OPS knowledge will be tested in these MCQs						
022 14 01 00	**Cockpit Voice Recorder (CVR)**						

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State the JAR-25 requirements concerning the CVR. To register all voice conversation from the pilot stations on a shock-, fire- and water resistant medium in order to facilitate accident or incident investigation. State that the voice recorder is designed to record: direct conversation between crew members and all aural warnings in the cockpit, communications received and transmitted by radio, intercom conversations between crew members, announcements transmitted via the passenger address system. Record on endless magnetic tape with a 30 minute capcity or in solid state memory with a capacity of 2 hours. Components: Area microphone, Crashproof four track recorder located in the aft section of the aircraft near the pressure bulkhead, underwater locater beacon working with ultrasonic waves. Start on ground with at least one fuel lever open, stop whenboth fuel levers closed. State that many aircraft have a switch to start recording already before the fuel lever is set to open. State the possibility to erase the recording with the erase button and only when on ground and the parking brake set.	x		x	x	x	
022 14 02 00	**Flight Data Recorder (FDR)**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	State the JAR-25 requirements concerning the installation of a FDR. State the recording of mandatory system related parameters. Early type FDR is analogue scratch foil (metal) recorders with a maximum capaity of 400 hours. Modern digital FDR is a solid state design recorder with a capacity of 25 hours. Name the following components of a flight data recorder: shock-, temperature- and fire-proof recording unit, underwater locater beacon working with ultrasonic waves. State that the flight recorder obtains its operating voltage from the emergency power supply. State that the flight recorder operates as soon as electric power is on and a fuel lever is open. State that the scratch foil recorder has a control panel in the cockpit that allowed the tape to be marked prior to each flight with help of thumbwheels. State that in modern aircraft the FMS is used to mark the recording medium prior to each flight. Mention the function of the event button. State that the FDR is monitored and in case of malfunction an alert is given to the pilot.	x		x	x	x	
022 14 03 00	**Combination recorder**	x					
LO	State that a combination recorder is a recorder that records all parameters that are required by a CVR and by a FDR.						
022 14 04 00	**Maintenance and Monitoring systems**						

CHAPTER 17: DETAILED THEORETICAL KNOWLEDGE SYLLABUS AND LEARNING OBJECTIVES
Subject – 022 – Aircraft General Knowledge - Instrumentation
See Appendix 1 to JAR-FCL 1.470 and JAR-FCL 2.470

		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Aircraft Integrated Data System (AIDS) and Aircraft Condition Monitor System (ACMS). Components: Flight Data acquisition unit (FDAU), Central computer, CDU (separate or integral with MCDU), Airborne printer, Flight maintenance recorder or Quick Access Recorder (QAR). State that AIDS incorporates the FDR and the QAR including devices for system control, input and presentation of data . State that the FDR and the QAR records inputs from ADC, compass system, engine instruments, navigation receiver, COM receiver, flight controls positions, aircraft configuration, g-forces etc. State that data from the flight maintenance recorder can be printed out for purposes of maintenance. State that aircraft relevant data can be transmitted from the aircraft integrated data system system in certain intervals to ground for an engine trend monitoring. State that the following information is entered into a flight maintenance recorder: day, month, flight number, take-off weight.	x	x	x	x	x	
022 14 05 00	**Weight and Balance system**						
LO	Function. Determines aircraft gross weight and center of gravity. Gear mounted sensors. Control and indication via MCDU.						
022 15 00 00	**DIGITAL CIRCUITS AND COMPUTERS**						
022 15 01 00	**Digital techniques**						

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Subject – 022 – Aircraft General Knowledge - Instrumentation
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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Mention the difference between analogue and digital technique. Explain and convert the following number systems: decimal, binary. Mention the following number systems: decimal, binary, octal, hexadecimal. Mention the difference between positive logic and negative logic Mention the use of the following binary codes: BCD, 2 out of 5 (MOON), GRAY, ASCII. Describe the difference between a BIT and a BYTE. Explain the difference between kiloBytes, MegaBytes, GigaBytes and TeraBytes.	x		x	x		
022 15 02 00	**Digital circuits**	x		x	x		
LO	Explain the following logic gates together with their symbols: INVERTER (NOT), (N)AND, (EX)(N)OR. Using RDL-technique, explain a logic ‘0’ and a logic ‘1’. Describe an Integrated Circuit (IC). Mention the applications of IC’s: logic circuits, micro-processor, memories, converters, etc. Describe the Analog-to-Digital Converter with respect to the sampling process and the quantification process. Describe the multiplexer and demultiplexer. Describe the ARINC-429 Digital Information Transfer System (DITS). Describe the difference between the ARINC-429 and ARINC-629 data bus with respect to speed, capacity, number of wires. Describe the following memories: ROM, PROM, EPROM, EEPROM. Describe the following properties of a memory: RAM, Sequential Access, Read/Write. Explain that memory capacity is expressed in BYTES.						
022 15 03 00	**Architecture of a computer**						

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Definition: A computer is a machine that makes use of a stored programm to processes data. Application: Aircraft and engine systems (autoflight systems, air data systems, warning systems etc. Name the difference between an analogue computer and a digital computer. Define a microcomputer. Describe the basic operating philosophy of the micrcocomputer with help of Von Neumann (fetch, decode, execute). Describe the peripheral equipment: sensors, keyboard, display units etc. Name the consisting parts of a microcomputer in terms of I/O modules, microprocessor (central processor unit or CPU) and memories. Describe the I/O modules. Explain the function of the CPU. Define the instruction set of a CPU. Name the components of the CPU and their functions as being: control unit, Arithmetic and Logic Unit (ALU) and registers. Mention the following registers and state their function: Instruction-register, Program-counter, Accumulator. Describe the following buses with their purpose which are used for the communication between the different components: control-bus, adress-bus, data-bus. Distinguish between background memory and internal memory.	x		x	x		
022 15 04 00	**Software**	x		x	x		

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		Aeroplane		*Helicopter*			*IR*
Syllabus reference	**Syllabus details and Learning Objectives**	ATPL	CPL	ATPL/IR	ATPL	CPL	
LO	Describe the term ‘software’. Mention the difference between software and hardware. Define the term ‘operating system’. Explain the difference between machine-code, assembler and compiler.						

/End