Subject No 14 Aircraft Technical Knowledge (Helicopter)

Each subject has been given a subject number and each topic within that subject a topic number. These reference numbers will be used on 'knowledge deficiency reports' and will provide valuable feed back to the examination candidate. This is based on a typical light piston-engine helicopter.

Sub Topic	Syllabus Item
	PART I Technical Knowledge
14.2	**Engines - General**
14.2.2	Identify typical cylinder configurations used for aircraft piston engines (eg radial, in-line, horizontally opposed).
14.2.4	Identify and state the purpose of the major components of a four-stroke piston engine (cylinders, pistons, connecting rods, crankshaft, crankcase, camshaft, valves, spark plugs).
14.2.6	With the aid of diagrams, explain the basic principle of operation of the four stroke internal combustion engine.
14.2.8	In broad terms, explain the need for valve timing (i.e. valve lead, lag and overlap).
14.2.10	Describe the principal features of a typical ignition system (dual, independent, engine-driven magneto systems with two spark plugs per cylinder).
14.2.12	State the purpose and principle of an impulse coupling.
14.2.14	Describe the operation and correct handling of a rotary ignition/starter switch (including the starter warning light).
14.2.16	Explain the purpose and a typical procedure for conducting magneto checks.
14.2.18	State the correlation between engine rpm and power output.
14.4	**Carburation**
14.4.2	State the purpose of carburation.
14.4.4	With the aid of a diagram, explain the operating principle of a simple float-type carburettor.

Sub Topic	Syllabus Item
14.4.6	State the purpose of the following systems within the carburettor; atomisation and diffusion; idling; accelerating; enrichment (at high power); mixture control and idle cut-off.
14.4.8	Explain the correct operational use of the idle cut-off.
14.4.10	Describe the effects of excessively rich or lean mixtures on engine operation.
14.4.12	In simple terms, describe the abnormal combustion conditions detonation and pre-ignition, and distinguish between them. State the causes and likely effects of these conditions and the measures which can be taken to avoid them.
14.4.14	Explain the formation of refrigeration, throttle and impact ice in a carburettor and intake system.
14.4.16	State the: (a) atmospheric and throttle setting conditions conducive to the formation of carburettor ice; (b) symptoms of carburettor ice formation; (c) correct use of carburettor heat for de-icing, and as an anti-icing measure (i.e. normal operation) including interpretation and use of a carburettor air temperature gauge.
14.4.18	In simple terms, describe the operation of a fuel-injection system. State the advantages and disadvantages of fuel-injection versus carburettor systems.
14.6	**Fuel Systems and Fuel**
14.6.2	Describe the function of the following components of a simple fuel system: (a) fuel tank, sump, drain point, supply line standpipe, vents, overflow drain; (b) fuel selector valve, supply line, strainer and strainer drain; (c) fuel primer, engine-driven pump, auxiliary (boost) pumps; (d) fuel quantity indicators.
14.6.4	Describe the correct management of the fuel system, including fuel selection and handling of priming and auxiliary pumps.
14.6.6	State the common grades of AVGAS with their colour identification.

Sub Topic	Syllabus Item
14.6.8	Distinguish between the different characteristics of AVGAS, MOGAS and AVTUR, and state the precautions regarding the use of MOGAS in aero-engines.
14.6.10	State the common contaminants of AVGAS and the precautions which can be taken to avoid them.
14.6.12	Describe the procedure to be used for a fuel drain check.
14.6.14	State the general rules for fuelling of aircraft, including the use of dipsticks and the special precautions for the use of drum stock, and plastic containers.
14.8	**Lubrication and Cooling**
14.8.2	State the functions of engine oil (lubrication – reduction of friction, assisting with cooling, removal of contaminants, and sealing).
14.8.4	Explain the term viscosity and the effect of temperature on the lubricating qualities of oil.
14.8.6	Briefly describe the function of the following components of an oil system: (a) wet sump; (b) dry sump, scavenge pump, tank; (c) engine-driven pump, pressure relief valve; (d) oil lines, passages and galleries; (e) oil cooler, bypass valves; (f) oil pressure and temperature gauges.
14.8.8	State the importance of using the correct type and grade of oil for a particular aircraft, and of checking the correct quantity before flight.
14.8.10	Identify the possible oil system malfunctions indicated by the following, and state the actions (if any) that the pilot can take to rectify the problem. (a) low/zero oil pressure; (b) high oil pressure; (c) fluctuating oil pressure;

Sub Topic	Syllabus Item
	(d) low oil temperature;
	(e) high oil temperature.
14.8.12	Briefly describe the main means for air cooling an engine (cooling fans, baffles, and fins).
14.8.14	State the importance of having an engine rundown period after flight.
14.10	**Transmission Systems**
14.10.2	State the purpose of a helicopter transmission system.
14.10.4	Briefly describe the function(s) and operation of the following transmission system components:
	(a) main rotor gearbox;
	(b) clutch (belt drive, and centrifugal);
	(c) freewheeling unit;
	(d) rotor brake;
	(e) tail rotor drive and gearbox;
	(f) chip detectors.
14.12	**Rotor Systems**
14.12.2	Briefly describe the construction of modern rotor blades.
14.12.4	Explain the terms feathering, flapping, and lead-lag.
14.12.6	Outline the basic features of the following systems:
	(a) rigid rotor;
	(b) semi-rigid rotor;
	(c) fully articulated rotor;
	(d) tail rotor.
14.12.8	With respect to helicopter controls, explain the purpose and the basic principle of operation of the following:

Sub Topic	Syllabus Item
	(a) collective control;
	(b) cyclic control;
	(c) twist grip throttle; including its effect on manifold pressure, and rpm;
	(d) tail rotor pedals;
	(e) rotor brake.
14.12.10	Describe the purpose and basic principle of operation of the:
	(a) swashplate;
	(b) pitch link advance angle.
14.12.12	Describe the need for imposing limitations on rotor rpm, and explain the typical markings and correct interpretation of a dual needle tachometer.
14.12.14	Explain the need for reporting any damage to rotor components that has not been marked as being previously assessed.
14.14	**Electrical System**
14.14.2	State the types of service which are typically electrically operated in a light helicopter.
14.14.4	Explain the function of the following components in a typical light helicopter electrical system:
	(a) battery;
	(b) alternator (and generator);
	(c) bus bar;
	(d) voltage regulator, voltmeter or overvoltage light;
	(e) ammeter (left zero and centre zero);
	(f) master switch (or battery/alternator switch);
	(g) fuses, circuit breakers and overload switches.
14.14.6	State the precautions to take during normal operation of the electrical system, including:
	(a) avoiding prolonged operation of electrical systems on the ground before

Sub Topic	Syllabus Item
	start; (b) starting with radios and other unnecessary equipment switched off; (c) avoiding prolonged operation of the starter motor; (d) releasing the starter once the engine is running; (e) checking satisfactory operation of the system after start, and monitoring during flight; (f) switching off ancillary equipment before shut-down; (g) switching the battery master switch off before leaving the aircraft.
14.14.8	Identify the cockpit indications of the following electrical system malfunctions, and state the actions available to the pilot to deal with the problem; (a) excessive alternator/generator charge rate; (b) lack of alternator/generator charge; (c) blown fuse or popped circuit breaker.
14.16	**Pressure Instruments**
14.16.2	Identify the three basic instruments which rely on air pressure for their operation.
14.16.4	Describe static pressure and dynamic pressure, and the main factors which affect them.
14.16.6	Explain the operation of a pitot-static system, including: (a) static vent(s); (b) pitot tube; (c) combined pitot-static head; (d) drain holes, heating, pitot cover.
14.16.8	With respect to the airspeed indicator, describe the: (a) basic principle of operation;

Sub Topic	Syllabus Item
	(b) colour coding, and the meaning of VNE;
	(c) IAS/TAS/groundspeed relationship;
	(d) errors affecting the ASI.
14.16.10	With respect to the altimeter, describe the:
	(a) basic principle of operation;
	(b) subscale settings and the meaning of QNH, QFE and QNE;
	(c) errors affecting the altimeter, including subscale setting error.
14.16.12	With respect to the vertical speed indicator, describe the:
	(a) basic principle of operation;
	(b) errors affecting the VSI.
14.16.14	Indicate the normal checks for serviceability of the pitot-static system, both pre-flight and during operation.
14.16.16	Identify the cockpit indications of the following pitot-static system malfunctions:
	(a) blockage of the pitot tube;
	(b) blockage of the static source.
14.18	**Gyroscopic Instruments**
14.18.2	Outline the basic principle of operation of the vacuum system, and state the likely effects of reduced or nil suction.
14.18.4	Describe the gyroscopic properties of rigidity and precession.
14.18.6	With respect to the turn indicator/coordinator:
	(a) explain the basic principle of a rate gyroscope;
	(b) with the aid of a diagram, differentiate between the different indications of the
	turn indicator and turn coordinator;
	(c) state the function, indication and correct use of the coordination (balance)

Sub Topic	Syllabus Item
	ball;
14.18.8	With respect to the attitude indicator (or artificial horizon); explain: (a) the basic principle of operation (earth gyroscope); (b) with the aid of a diagram, how pitch attitude and bank angle are displayed; (c) the pilot checks for serviceability;
14.18.10	With respect to the heading indicator (or DGI), explain: (a) the advantages of a gyroscopic heading indicator (versus a compass) (b) the need for, and method of synchronising the HI with the compass; (c) the pilot checks for serviceability.
14.18.12	Briefly explain the errors likely to occur if the gyro rotor rpm is low; the indication of power failure on electrically-driven instruments; and the indications of toppling.
14.20	**Magnetic Compass**
14.20.2	Describe the earth's magnetic field, and: (a) distinguish between the true and magnetic poles; (b) define magnetic variation, isogonals, and deviation; (c) given a sample deviation card, show how to apply corrections.
14.20.4	Briefly describe the construction of a modern direct-reading compass.
14.20.6	Explain magnetic dip; how it is compensated for; and define residual dip.
14.20.8	State the effects of: (a) acceleration error; and (b) turning error.
14.20.10	State the compass pre-flight serviceability checks, and the precautions when carrying magnetic items.

Sub Topic	Syllabus Item
	Part II Principles of Flight
14.22	**The Atmosphere**
14.22.2	State the principal gases which constitute the atmosphere (nitrogen and oxygen, plus small amounts of others).
14.22.4	In general terms, describe air density, and how it varies with altitude in the atmosphere.
14.22.6	State the relationship between pressure/temperature and the density of an air mass.
14.22.8	Outline how pressure, temperature and density normally vary in the atmosphere.
14.22.10	Outline the basis for the International Standard Atmosphere, and state the assumed standard sea level pressure and temperature conditions, together with their lapse rates up to the tropopause.
14.24	**Basic Aerodynamic Theory**
14.24.2	State what an aerofoil is and distinguish between symmetrical and non-symmetrical sections.
14.24.4	Define: (a) leading edge; (b) trailing edge; (c) chord; (d) thickness; (e) camber.
14.24.6	Define relative airflow and angle of attack.
14.24.8	State Bernoulli's Theorem in simple terms.
14.24.10	Define streamline flow around an aerofoil, and explain the changes which occur to dynamic and static pressure wherever the speed of the airflow is:

Sub Topic	Syllabus Item
	(a) increased;
	(b) decreased.
14.24.12	With the aid of diagrams, explain:
	(a) venturi effect;
	(b) the pressure distribution around an aerofoil which is producing lift.
14.24.14	Define the terms total reaction (TR) and centre of pressure (CP), and describe how TR and CP change with increasing angle of attack (for a lifting aerofoil).
14.24.16	Show how movement of the CP varies between symmetrical and non-symmetrical aerofoils.
14.24.18	Define the lift and drag components (of TR).
14.24.20	State the lift formula and summarise the factors affecting lift (angle of attack, aerofoil shape, IAS).
14.24.22	Define in simple terms, the coefficient of lift (CL) and describe a typical CL versus angle of attack curve. On this curve, identify the critical (stalling) angle.
14.24.24	State the precaution against flying with ice, frost, snow or other contamination of the aerofoil surfaces.
14.24.26	Distinguish between parasite drag, induced drag, and profile drag, and list the elements of the latter (form drag and skin friction).*
	*[Students should be aware that there are other ways of categorising drag.]
14.24.28	State the factors affecting parasite drag, and profile (form and skin friction) drag.
14.24.30	Explain the cause of induced drag, and state how induced drag is related to blade tip vortices, and varies depending on:
	(a) CL and angle of attack of the rotor blade;
	(b) aspect ratio.
14.24.32	With the aid of a diagram, identify curves of parasite, profile, induced, and

Sub Topic	Syllabus Item
	total drag versus airspeed.
14.24.34	Identify a curve of lift/drag (L/D) ratio versus angle of attack for a symmetrical aerofoil, and state the approximate angle for best L/D ratio.
14.26	**Rotary Wing Aerodynamics**
14.26.2	With respect to a helicopter rotor, define the following terms: (a) tip path; (b) tip path plane; (c) axis of rotation; (d) shaft axis; (e) chord line; (f) blade (or pitch) angle; (g) angle of attack; (h) feathering axis; (i) coning angle; (j) disc area; (k) flapping; (l) lead-lag (dragging).
14.26.4	For a nil-wind hovering condition, and with the aid of a diagram: (a) identify the following vectors – rotational flow, induced flow, and relative airflow; (b) identify pitch angle, inflow angle, and angle of attack.
14.26.6	For a given blade section, and with the aid of a diagram, identify the total aerodynamic reaction force (TR) and its components, rotor thrust and rotor drag.
14.26.8	Define total rotor thrust, and rotor drag (torque). For steady hovering flight, explain the balance of forces between rotor thrust and gross weight, rotor drag and engine power.

Sub Topic	Syllabus Item
14.26.10	State the effect of the following on total rotor thrust: (a) air density (altitude); (b) rotor rpm; (c) blade angle; (d) disc area.
14.26.12	Explain the effect of total rotor thrust and centrifugal force in determining coning angle, and the need to apply wash-out in the design of rotor blades.
14.28	**The Anti Torque (Tail) Rotor**
14.28.2	Briefly describe the torque couple (origin, direction, and strength).
14.28.4	State the purpose of the anti-torque (tail) rotor, and describe the demand of anti torque for power.
14.28.6	Describe the effect of wind on tail rotor thrust, including: (a) possible loss of tail rotor effectiveness; (b) effect on power required to hover.
14.28.8	Explain translating tendency (tail rotor drift) and common design methods used to correct for it.
14.28.10	Explain rolling tendency and the design features/procedures used to reduce it.
14.28.12	Describe the effect of tail rotor failure in flight, and actions available to the pilot to reduce or eliminate the effect.
14.30	**Hovering Flight**
14.30.2	Briefly explain the effect of the following factors on hovering flight: (a) density altitude; (b) weight; (c) ground effect.

Sub Topic	Syllabus Item
14.30.4	Describe: (a) recirculation; (b) overpitching, and the recovery from it.
14.32	**Forward Flight**
14.32.2	Identify the forces acting on the helicopter in steady forward flight.
14.32.4	Briefly explain the following: (a) dissymmetry of lift; (b) flap-back (or blow-back); (c) translational lift.
14.32.6	State the meaning of: (a) best range speed; and (b) best endurance speed.
14.32.8	Explain how the flare results in changes to the following: (a) airspeed and groundspeed; (b) rotor rpm.
14.34	**Climbing and Descending**
14.34.2	Define; (a) rate of climb; (b) angle of climb.
14.34.4	State the effect of wind on angle of climb.
14.34.6	State how changes in airspeed influence angle of descent (constant power/zero wind).
14.34.8	State the effect of wind on angle of descent.
14.36	**Turning**

Sub Topic	Syllabus Item
14.36.2	With the aid of a diagram, identify the forces acting on a helicopter in a level turn.
14.36.4	State the effect of angle of bank on power required, rate and radius of turn, and load factor.
14.36.6	Define standard rate (rate 1) and double standard rate (rate 2) turns.
14.36.8	For climbing and descending turns, describe: (a) the effect of bank on rate of climb/descent; (b) the requirement for increased power.
14.38	**Autorotative Flight**
14.38.2	Define autorotation.
14.38.4	With the aid of a diagram, identify the stalled, driving and driven regions of the rotor disc.
14.38.6	Explain the need to lower the collective at the start of an autorotation.
14.38.8	Briefly describe the effect of variation of the following on rate of descent and distance covered in an autorotation: (a) airspeed; (b) all-up-weight; (c) altitude; (d) wind velocity.
14.38.10	Explain the principle features of a height-velocity diagram.
14.40	**Hazardous Flight Conditions**
14.40.2	Briefly state the conditions leading to, the symptoms, and pilot actions to avoid and/or recover from the following: (a) vortex ring state; (b) loss of tail rotor effectiveness;

Sub Topic	Syllabus Item
	(c) ground resonance;
	(d) blade sailing;
	(e) dynamic rollover;
	(f) cyclic limitations;
	(g) mast bumping;
	(h) exceeding rotor rpm limits;
	(i) rotor stalls.
14.42	**Performance**
14.42.2	State the general effect of variation in the following on helicopter performance:
	(a) QNH;
	(b) ambient temperature;
	(c) humidity.
14.42.4	Define pressure altitude, and:
	(a) calculate aerodrome pressure altitude, given aerodrome elevation and prevailing QNH;
	(b) explain how to determine pressure altitude by using an altimeter.
14.42.6	Define density altitude and, given pressure altitude, calculate the:
	(a) deviation of ambient temperature from ISA;
	(b) density altitude.
14.42.8	State the effect of the following variables on helicopter take-off and/or landing performance:
	(a) gross weight;
	(b) pressure altitude;
	(c) temperature;
	(d) moisture content of the air.

Sub Topic	Syllabus Item
14.44	**Aircraft Loading**
14.44.2	State the general reasons for operating with correct loading (controllability, avoiding structural overstress, satisfactory performance).
14.44.4	Define the following loading terms: (a) basic empty weight ; (b) zero fuel weight; (c) gross weight; (d) maximum certificated take-off weight (MCTOW); (e) the moment of a force; and (f) moment arm.
14.44.6	State the effect on stability and control of a helicopter if flown with the CG: (a) at the forward limit; (b) at the aft limit; (c) at a lateral limit.
14.44.8	Define the meaning of: (a) datums (longitudinal and lateral); (b) moments (about those datums); and (c) aircraft station (STA).
14.44.10	With the aid of typical loading and performance data/graphs from a typical manual for a single-engine helicopter, demonstrate an ability to calculate: (a) aircraft AUW; (b) take-off and landing performance, under given conditions.